RAILROADS AND ECONOMIES OF SCALE AND SCOPE IN U.S. MANUFACTURING INDUSTRIES: 1850-1880. CHANDLER REVISITED

by

MICHAEL KALSON

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2010

© 2010

MICHAEL KALSON

All Rights Reserved

This manuscript has been read and accepted for the
Graduate Faculty in Economics in satisfaction of the
dissertation requirement for the degree of Doctor of Philosophy.

Michael Edelstein

Date

Chair of Examining Committee

Merih Uctum

Date

Executive Officer

Michael Edelstein

Elizabeth Field Hendrey

Simone Wegge

Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

Abstract

RAILROADS AND ECONOMIES OF SCALE AND SCOPE IN U.S. MANUFACTURING INDUSTRIES: 1850-1880. CHANDLER REVISITED

by

Michael Kalson

Adviser: Professor Michael Edelstein

This study concerns the measurement and quantification of the relationship between railroadization in the United States in the mid-19th century and the subsequent evolution of the modern, large-scale, corporate form of industrial business organization marked by significant economies of scale and scope, as described in various writings by Alfred Chandler. Focusing on American industry as it developed from 1850-1880 using data uniquely suited to empirical analysis of economies of scale and scope, its aim is to determine whether the growth of the American railroad network, as Chandler contended, expanded markets and augmented the American financial sector such that the result was a more concentrated, large-scale mode of industrial organization characterized by extensive and increasing economies of scale and scope in sync with the growth of its extensive railroad system.

Apart from some positive results found in the scope analysis of Chapter 6 showing an ascending scope pattern from 1850-1880 in a few key industries, our findings indicate an overall gloomy prognosis for the empirical validity of the Chandler hypothesis. With the cross-country analyses of Chapters 2 and 3 showing no evidence of a greater expansion of the railroad systems of the United States and Germany at mid-century and resultant vastness thereof with respect to Britain *circa* the 1870's as contributing to a more concentrated industrial sector in those countries, and the mixed evidence in support of a rise in efficient scale in American industry from 1860-1880 as shown in Chapters 4 and 5, not to mention the omnipresent dips at 1870 seen in both the scale and scope estimates, our findings reflect poorly upon Chandler's idea of that date as the

benchmark period in which to begin to expect to see the effects of transportation improvements upon scale and scope economies in American industry. Rather, they indicate a far greater impact of the Civil War aftermath shock than Chandler accounted for—perhaps one that persisted on until the 1880's--and suggest a much later date of the full impact of the railroads upon scale and scope of industry than Chandler bargained for—perhaps 1900 as indicated by Atack (1985).

TO MY PARENTS

PREFACE AND ACKNOWLEDGEMENTS

This thesis had a long gestation period. It began as independent study readings in the history of industrial technology as part of graduate studies in economics at City University of New York exploring the paradoxical development of Britain's failure to maintain the position of supremacy it had achieved in the earlier iron-, coal-, and steam-based industries of the "First Industrial Revolution" of the 18th century later on in the science-based industries of the "Second Industrial Revolution" that emerged in the late 19th century; for example electricity, chemicals, and technology centered around the internal combustion engine, when it was faced with formidable new competition from later industrializers; most notably the United States and Germany. The contention of many authors that Britain's "early start" in industrialization may have actually conferred disadvantages upon it in development of these later technologies, and created opportunities for latecomers that were shrewdly exploited by the United States and Germany provided me with the initial research aim of examining the various arguments in support of this theory and assessing their strengths.

The primary focus of this research was the industrial applications of electrical technology and developments therein, starting from the discovery of the scientific principles upon which the modern electrical industries were based—approximately Michael Faraday's discovery of the principle of electromagnetic induction in 1831--up until the beginning of WWI, the period that essentially encompasses the time during which the basic parameters of the industry were established and its clear leaders going into the 20th century emerged.

Although this initial research identified a few hypotheses that connected Britain's early start to its relative electrical failings, the one that formed the predicate of the study you are about to read is that raised by Alfred Chandler in his 1994 book, *Scale and Scope: The Dynamics of Industrial Capitalism*. (Cambridge: Harvard University Press, 1994.) which addressed the issue of economies of scale and scope in the production of electrical technologies among many other industries, and raised the question of whether failure to achieve such economies explains any of the British retardation in the large-scale, capital intensive science-based industries of the late nineteenth century, and if so, can any of that failure be traced to Britain's early start. Chandler believed that economies of scale and scope were an essential feature crucial for success in these modern sectors, and that Britain failed to develop substantial industrial structure of this type due, in no small part, to a lesser impact of the railroads on its industrialization.

Since Chandler believed this lesser impact of the railroads was in itself a function of Britain's early start, this book provided me with an as-of-yet untested hypothesis that appeared ripe for empirical enquiry and examination. My research on the electrical industry revealed that failure to achieve economies of scale and scope therein was indeed a stumbling block for Britain in the late nineteenth century, as it also was for Britain in most other large-scale, capital intensive science-based industries at that time. Economies of scale, efficiencies in production that tend to be captured by larger firms capable of producing in large volume, figure prominently in electrical industries, particularly in electric power distribution, where it has been observed that larger utilities serving an extensive network of customers are able to transmit power at a lower cost per kilowatt-hour than utilities serving a smaller network of subscribers. Economies of scope,

efficiencies in production that tend to be captured by larger, more integrated firms capable of joint production and distribution of many different, but interrelated products, figure prominently in electrical technology due to the tremendous interdependence of the various components of the industry. Standardization of current, voltage and frequency characteristics is essential to ensure that machinery and appliances are manufactured so as to be compatible with the form of power supply in use, and vice versa. Larger electrical firms capable of branching out and producing a diverse array of products have an advantage in this respect in their ability to market a working system of compatible apparatus to consumers. In examining the research of many historians of industrial technology, there was a consensus that the British electrical industries in the late nineteenth century were, on the whole, smaller scale than their American and German counterparts, with a greater assortment of voltages, frequencies and currents in use, and it has been argued that this factor contributed to the less rapid development of this technology in Britain.

Thus my challenge as a scholar lay clearly before me—to construct and conduct some kind of empirical analysis to see if there was in fact, this positive correlation between the impact of the railroads on the industrial development of these three key nations of the United States, Germany and Britain, and economies of scale and scope achieved in their industry in the wake of that impact. It is exactly in this manner that this study came to be.

Before we proceed to that analysis, there is an extensive literature that that while it did not play that important a role in the main study itself, was nonetheless crucial in

that it provided the necessary background, inspiration and motivation responsible for its birth. It is therefore worthy of mention here.

Besides Chandler's analyses, there is an extensive literature surrounding Britain's decline as the industrial leader in the 19th century, and the relationship between Britain's early start and its weakness in the more modern industrial sectors that formed the background for this study. Much of it concerns the legacy of its early start and its implications on the size and scale of its industry, which is explained in general economic histories such as David S. Landes' *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present*. London: Cambridge University Press, 1969, and *The Wealth and Poverty of Nations: Why Some are so Rich and Some so Poor*. New York: W. W. Norton, 1998. Other noteworthy volumes in this vein are H. J. Habakkuk's *American and British Technology in the Nineteenth Century: The Search for Labour-saving Inventions*. Cambridge: Cambridge University Press, 1962, and Sidney Pollard's *The Development of the British Economy, 1914-1950*. London: E. Arnold, 1962 and *Britain's Prime and Britain's Decline: The British Economy 1870-1914*. London and New York: E. Arnold, 1989.

The interdependent nature of electrical technology, and its characteristics that favor large integrated systems, receives emphasis in many of these studies; a discussion that is continued in depth by Nathan Rosenberg in *Technology and American Economic Growth*. New York: Harper & Row, 1972 and, with David C. Mowery, *Technology and the Pursuit of Economic Growth*. Cambridge and New York: Cambridge University Press, 1989 and *Paths of Innovation: Technological Change in 20th Century America*. Cambridge and New York: Cambridge University Press, 1998. This discussion is

developed in further detail as part of a comprehensive historical analysis of the electrical industries by Thomas P. Hughes in *Networks of Power: Electrification in Western Society, 1880-1930*. Baltimore: Johns Hopkins University Press, 1983. Hughes was an indispensable source for the background of this study because it consists, to a large degree, of a comparison of the development and growth of American, German and British electrical industries in the 19th and early 20th century.

Britain's meanderings in a miasma of small-scale electrical firms and a maze of competing systems in this era is given extensive treatment in Hughes and the general histories cited above, and especially in business histories of the electrical industries. Some key readings in this area are Byatt, I. C. R., *The British Electrical Industry, 1875-1914: The Economic Returns to a New Technology*. Oxford: Oxford University press, 1979; Ballin, H. H. *The Organisation of Electricity Supply in Great Britain*. London: Electrical Press, Ltd., 1946; Hannah, Leslie. *Electricity Before Nationalisation: A Study of the Development of the Electricity Supply Industry in Britain to 1948*. London: Macmillan,1979, and Hall, Peter and Paschal Preston. *The Carrier Wave: New Information Technology and the Geography of Innovation 1846-2003*. London and Boston: Unwin Hyman, 1988.

The theoretical discussion of the economic issues surrounding adoption of standards in interdependent technological systems contained in the following citations provided me with further valuable insight as background for this study because it thoroughly and accurately identifies and explains how the problem of the need for compatibility in complex systems can often assume a dimension of market failure that points to the need for coordination and planned investment, which favors large integrated

firms with significant economies of scale and scope in order to better expedite the diffusion of an interdependent technology. See Scitovsky, Tibor. "Two Concepts of External Economies." In *Papers on Welfare and Growth* by Tibor Scitovsky. Stanford: Stanford University Press, 1964; Kindleberger, C. P. "Standards as Public, Collective and Private Goods." *Kyklos*, Vol. 36, 1983; Berg, S. V. "The Production of Compatibility: Technical Standards as Collective Goods." *Kyklos*, Vol. 42, 1989; Farrell, J., and G. Saloner. "Standardization, Compatibility and Innovation." *Rand Journal of Economics*, Vol. 16, No. 1, Spring, 1985, and three articles by M. L Katz and C. Shapiro: "Network Externalities, Competition, and Compatibility." *American Economic Review*, Vol. 75, No. 3, June, 1985, "Technology Adoption in the Presence of Network Externalities." *Journal of Political Economy*, Vol. 94, No. 4, 1986, and "Systems Competition and Network Effects." *Journal of Economic Perspectives*, Vol. 8, No. 2, Spring, 1994.

For a discussion of these topics specifically pertaining to the German electrical industries, see Brady, R. A. *The Rationalization Movement in German Industry: A Study in the Evolution of Economic Planning*. New York: H. Fertig, 1974.

In the course of composition of this study, I had the good fortune to receive the assistance of many a friend, colleague, and mentor for whose great efforts I would like to express my thanks. In my task of mobilizing the main data set of the study for analysis herein, these being the Bateman-Weiss and Atack-Bateman Samples from the Manuscript Censuses of Manufactures, 1850-1880, I was fortunate to have received the undivided attention of one of its principal architects, Prof. Jeremy Atack of Vanderbilt University,

who took the time to answer a myriad questions about these data, and was generous in sharing his insight and technique in their application to his own research.

In a similar capacity, I owe a tremendous debt of gratitude to Prof. Brian Mitchell of Trinity College, Cambridge for taking the time to answer questions concerning the data in the statistical volumes he authored that are used and cited in this study. Also in these regards, I would like to thank Prof. Rainer Fremdling of Zedat, Free University of Berlin for helping me locate the sources of data on the German railroads used in this study, and for his patience in serving as a guide for me through these sources in light of my non-existent German.

In the statistical and quantitative analysis component of this study, I received tremendous assistance from within my own City University of New York in the form of Prof. David Gabel of Queens College and the Graduate School, who was considerate enough to take time out from his onerous responsibilities as Department Chair at the time this was written to provide me with considerable individual attention. I would also like to thank fellow graduate student Su Huang who was very generous with his time in sharing his knowledge in helping me with the computer-aided analysis used in this study. I would also like to thank some key members of the Information Technology Department at the Graduate School for their typesetting assistance in preparing this manuscript for final submission: Help Desk Technician Nino Imnaishvili, Training Coordinator Julie Rivera, and IT Training Consultant Andrea Allard.

In the process of conception of the empirical methodology of this study, there are several people whom I wish to thank who provided as much insight as they could in terms of guiding me towards appropriate readings that might assist me in those regards,

and helping to ensure a thorough investigation and scouring of the research in these areas leaving nothing uncovered. In the area of literature concerning changes in plant scale in 19th century U.S. manufacturing industries, I would like to thank Prof. Anthony Patrick O'Brien of Lehigh University, and Prof. John A. James of University of Virginia. In the area of modeling and testing the quantity of external finance of the railroads, and the degree to which it impacted financial intermediation and economies of scale and scope in industry in the United States in the latter half of the nineteenth century that made such a valuable contribution to this study, I would like to thank Prof. Jeffrey G. Williamson, Laird Bell Professor of Economics at Harvard University; Prof. Daniel Schiffman of Ariel University Center of Samaria, Israel; and Prof. Jim Cohen of John Jay College, City University of New York.

In a valiant, but vain attempt to locate firm- and/or plant-level data for Britain and Germany for the late 19th century similar to that contained in the Bateman-Weiss and Atack-Bateman Samples, I had recourse to become acquainted with some of the best minds in historical data for those countries who gave me their consultation for free. For Britain, I would like to thank Prof. Geoffrey Jones of Harvard Business School; Prof. Leslie Hannah of University of Tokyo; Prof. Stephen Broadberry of University of Warwick, England; and Prof. Peter Wardley of University of West of England, Bristol. For Germany, I must thank Prof. Jeffrey Fear, also of Harvard Business School.

The search for essential data for this study missing from the Bateman-Weiss and Atack-Bateman Samples that is described in Chapter Five led me on a sojourn that consumed considerable time and effort on my part. Along the way, I met several wonderful people whose professional assistance in this detective work of uncovering

whatever sources may have been available was of great comfort and support to me in a very difficult time. First and foremost, I would like to thank Mary Beth Bobish, Reference Section Head the of U.S. Documents & Newspapers division of the New York State Library in Albany who went to considerable pains and efforts on my behalf in combing through not only the resources of her own library, but also functioning as a guide to the holdings of virtually every obscure library, museum, and historical society in the state on my behalf. Special thanks is also owed to Edward H. L. Smith, Director of the Library and Research of the New York Genealogical and Biographical Society for granting me permission to visit the manuscripts division of the library and serving as a guide to the microfilm holdings of the New York State census records. I would also like to thank Patrice M. Kane and Vivian Shen of the Archives and Special Collections division of the Fordham University Library at Rose Hill, Bronx, NY for granting me permission to visit the Archives and serving as guides to the Hogan Steel Archives that are housed there.

Others who contributed help in these regards were Prof. Peter Temin of MIT; Jonathan R. Stayer, Head of the Reference Section of the Pennsylvania State Archives, Pennsylvania Historical and Museum Commission, Harrisburg; Prof. Anne K. Knowles, Middlebury College, Middlebury, VT; John Hannigan, Reference Archivist at the Massachusetts Archives, Boston; Eva Murphy, Reference Librarian at the State Library of Massachusetts, Boston; Mary B. Dunhouse and Betsey Lippmeier of the Government Documents Department at Boston Public Library; and Christopher T. Baer, Assistant Curator of the Manuscripts & Archives division of the Hagley Museum and Library, Wilmington, DE.

Special thanks is also owed to Wayne Olson, Reference Librarian at the National Agricultural Library of the U.S. Department of Agriculture in Beltsville, Maryland for helping sort out some of the confusion in the multifarious and outdated agricultural product units measurement codes used in the Bateman-Weiss and Atack-Bateman Samples as reported by the census takers of the time. Mr. Olson was extremely helpful in referring and directing me to appropriate sources for information on weights and measures used for agricultural commodities and appropriate conversion rates. I would also like to thank Stephen Paczolt, Senior Technical Information Specialist at the Geography and Map Division of the Library of Congress, Washington, D.C. and Ralph Ponemereo of University of Cologne for answering questions and guiding me to sources of data for sorting through the confusion of territorial data for Germany in its various incarnations throughout the nineteenth and early twentieth century.

Contents

One. INTRODUCTION 1

Two. DEVELOPMENT AND PHASES OF GROWTH OF THE AMERICAN, BRITISH AND GERMAN RAILROAD NETWORKS: THE CHANDLER HYPOTHESIS EXAMINED 10

Introduction and Literature Review *10*
I. Railroadization and Initial Industrialization *17*
II. Railroadization and Economies of Scale and Scope: Is There Synchronicity? *22*
III. Effects of Railroadization on Industrial Composition *29*
IV. Derived Demand Effects: A Faulty Omission? *33*
V. Derived Demand Continued: Physical Capital Inputs *39*
VI. Summary and Conclusion *48*
VII. Tables, Chapter Two *54*

Three. EFFECTS OF THE RAILROADS UPON FINANCIAL INTERMEDIATION 69

Introduction *69*
I. Chandler on the Effects of the Railroads on Capital Markets in Britain, the United States, and Germany: Empirical Validation? *70*
II. Britain and the United States: Chandler vs. the Scholars *75*
III. Railroads and the Growth of the National Capital Market in Britain *94*
IV. Britain and Germany: Chandler vs. the Scholars *115*
V. Financial Intermediation Effects: Theoretical Framework For Empirical Analysis *130*
VI. Empirical Results and Analysis *140*
VII. Alternative Methodology: Physical Capital as a Percentage of National Output *146*
VIII. Summary and Conclusion *155*
IX. Tables and Illustrations, Chapter Three *160*

Four. **ECONOMIES OF SCALE ESTIMATION** 172

Introduction--Minimum Efficient Scale—Quantification of Economies of Scale *172*
I. Introduction to Literature of Methodology: The "Survivor Technique" Explained *173*
II. Literature Review and Analysis of Applied Methodology *177*
III. Description of Precise Method and Data *186*
IV. Results and Analysis *191*
V. Summary and Conclusions *204*

Five. **ECONOMIES OF SCALE REVISITED: TAKING A CLOSER LOOK** 207

Introduction—Data and Measurement Problems *207*
I. Supplementation of Table 4.2: Sample Size, Truncation of Range Distribution, and MES *220*
II. Sub-Sector MES Analyses: High Pace of Technological Progress/High Impact of Transportation and High Pace of Technological Progress/Low Impact of Transportation (Column 1, Table 4.1) *227*
III. Sub-Sector MES Analyses: Low Pace of Technological Progress/High Impact of Transportation and Low Pace of Technological Progress/Low Impact of Transportation (Column 2, Table 4.1). *232*
IV. Remaining Unpaired and Unanalyzed: Low Pace of Technological Progress/High Impact of Transportation and Low Pace of Technological Progress/Low Impact of Transportation (Column 2, Table 4.1). *247*
V. Summary and Conclusions *252*

Six. **ECONOMIES OF SCOPE ESTIMATION** 257

Introduction—Quantification of Economies of Scope *257*
I. Cost Function Discussion *261*
II. Data Discussion *263*
III. Empirical Results and Analysis *284*
IV. Summary and Conclusions *296*

Seven. **CONCLUSION** 298

Appendix to Chapter Six 303
Final Assembly of Data Set

Bibliography 416

Tables and Illustrations

Table 2.1—Railway mileage for Great Britain (UK), the United States (US), and Germany (GR), every five years, 1830-1914. *55-57*
Table 2.2—Gross reproducible (physical) railway capital formation/expenditure (total capital flow) for Great Britain (UK), the United States (US), and Germany (GR) listed in pounds, dollars, and marks, respectively, 1830-1914. *58-62*
Table 2.3—Total value of reproducible (physical) railway capital formation/expenditure (total capital stock) for Great Britain (UK), the United States (US), and Germany (GR) listed in pounds, dollars, and marks, respectively, for every five years, 1830-1914. *63-65*
Table 2.4—Summary Output of Regression Analysis of Gross reproducible (physical) railway capital formation/expenditure (total capital flow) with respect to year for Great Britain (UK), the United States (US), and Germany (GR), 1830-1914. *66-67*
Table 2.5—Summary Output of Augmented Dickey-Fuller test for stationarity of data for Gross reproducible (physical) railway capital formation/expenditure (total capital flow) for Great Britain (UK), the United States (US), and Germany (GR), 1830-1914. *68*

Table 3.1—Total stock of Railway Financial Capital for Great Britain (UK) and the United States (US), including Decadal Growth Rates, listed in pounds, dollars, and marks, respectively, for every five years, 1830-1914. *160-61*
Table 3.2—Gross National Product for Great Britain (UK), the United States (US), and Germany (GR) listed in pounds, dollars, and marks, respectively, 1830-1914. *162-66*
Table 3.3—Total stock of Railway Financial Capital as a percentage of Gross National Product for Great Britain (UK) and the United States (US) for every five years, 1830-1914. *167*
Table 3.4— Gross reproducible (physical) railway capital formation/expenditure (total capital flow) as a percentage of Gross National Product for Great Britain (UK), the United States (US), and Germany (GR), 1830-1914. *168-70*
Chart 3.1—Gross reproducible (physical) railway capital formation/expenditure (total capital flow) as a percentage of Gross National Product for Great Britain (UK), the United States (US), and Germany (GR), 1830-1914. *171*

Table 4.1--Technological Change, Transportation, and the Adjustment to 1870 Optimal Plant Sizes, 1900. *187*
Table 4.2--Minimum Efficient Scale (MES) for Selected Industries, 1860-1880 in Constant 1860 Dollars. *192*

Table 5.1--Minimum Efficient Scale (MES), Sample size, and Range distribution for Selected Industries, 1860-1880 in Constant 1860 Dollars. *221*
Table 5.2--Minimum Efficient Scale (MES), Sample size, and Range distribution for Iron & Steel,1860-88/90, in Constant 1860 Dollars, using Bureau of Labor Data. *224*
Table 5.3--Minimum Efficient Scale (MES), Sample size, and Range distribution for Tobacco Manufacture, 1860-1880 in Constant 1860 Dollars. *230*
Table 5.4--Minimum Efficient Scale (MES), Sample size, and Range distribution for Textiles, 1860-1880 in Constant 1860 Dollars. *235*

Table 5.5--Minimum Efficient Scale (MES), Sample size, and Range distribution for Printing and Publishing, 1860-1880 in Constant 1860 Dollars. *240*
Table 5.6--Minimum Efficient Scale (MES), Sample size, and Range distribution for Fabricated Wood, 1860-1880 in Constant 1860 Dollars. *242*
Table 5.7--Minimum Efficient Scale (MES), Sample size, and Range distribution for Fabricated Metal, 1860-1880 in Constant 1860 Dollars. *246*

Table 6.1--Industry Groupings and Output Vectors for Scope Analysis. *270*
Table 6.2--Industry Groupings Scope Analysis Estimates, 1850-1870 [1880]. *285-88*

Table A.6.1-- Shoes. *327-57*
Table A.6.2 --Flour. *358-87*
Table A.6.3--Men's clothing. *388-91*
Table A.6.4-- Millwork. *392-93*
Table A.6.5 --Furniture. *394-96*
Table A.6.6--Tobacco*. *397-406*
Table A.6.7--Foundaries*. *407-09*
Table A.6.8--Meat*. *410-15*

Chapter One: INTRODUCTION

This thesis concerns the measurement and quantification of the relationship between railroadization in the United States in the mid-19th century and the subsequent evolution of the modern, large-scale, corporate form of industrial business organization marked by significant economies of scale and scope as described in various writings by Alfred Chandler. Chandler's idea that the railroads were a great impetus to market expansion and the emergence of a highly concentrated, large-scale mode of industrial organization characterized by extensive recourse to outside sources of finance, and that these, in turn, promoted economies of scale and scope implies a correlative cause-and-effect hypothesis that has never been subjected to rigorous empirical analysis using data. This thesis attempts to remedy that deficiency with an empirical methodology that tests Chandler's hypothesis in its rudimentary form with regards to American industry in the mid-to-late 19th century, and a comparison of the development and growth of the American, British and German railroad networks in order to determine if Chandler's claim that the American industrialization of the mid-to-late nineteenth century was particularly heavily impacted by the railroads has any validity.

*

Many researchers have attempted to explain Britain's failure to maintain the position of supremacy it had achieved in the earlier iron-, coal-, and steam-based industries of the "First Industrial Revolution" of the 18th century later on in the science-based industries of the "Second Industrial Revolution" that emerged in the late 19th century. For example, in the electricity and chemical industries as well as the early automotive industry, Britain

began to face formidable new competition from later industrializers; most notably the United States and Germany. This is paradoxical and counter-intuitive not only when one considers Britain's greater experience with factory production technologies and larger accumulated capital base, but also when one considers the fact that Britain was one of the major birthplaces of modern experimental science. How is it that two countries which were, firstly, later to industrialize, and secondly, relatively deficient (almost completely lacking in the case of the United States) in resources for scientific inquiry, able to make such a tremendous leap in such a short period of time over the "mother nation" of modern industrial technology; the nation that had given birth to modern industrial capitalism and seemingly possessed the greatest potential for success in the very industries it lost ground in—those that combined scientific knowledge with practical industrial know-how? In an attempt to resolve this paradox, many authors have contended that Britain's "early start" in industrialization may have actually conferred disadvantages upon it in development of these later technologies, and created opportunities for latecomers that were shrewdly exploited by the United States and Germany. This thesis will conduct an empirical examination of the hypotheses connecting Britain's early start to a general failure to achieve economies of scale and scope in industry in order to determine if any of its relative backwardness in industrialization can be traced to that early start.

The main hypotheses that point to this linkage are those of Alfred Chandler in his 1994 book, *Scale and Scope: The Dynamics of Industrial Capitalism,*[1] in which he argues that economies of scale and scope were an essential feature crucial for success in the large-scale, capital intensive science-based industries of the late nineteenth century, and

[1] Chandler, Alfred D. *Scale and Scope: The Dynamics of Industrial Capitalism.* Cambridge: Harvard University Press, 1994. Hereafter *Scale and Scope.*

that Britain failed to develop substantial industrial structure of this type due, in no small part, to its early start. Because Britain industrialized before the transportation and communication revolution of the mid-19th century—that is, the coming of the steamship, telegraph, cable, and most of all, the railroads--it did not respond as vigorously to the opportunities for expansion of markets that the railroads bequeathed to other countries; the United States and Germany in particular. Since the United States and Germany were undergoing their initial industrialization at the time these transportation innovations were being made, they were able to build their initial industrial structure in a manner more suitable for effective exploitation of the opportunities for economies of scale these innovations created. While Britain's older, smaller-scale, pre-existing industrial structure could perhaps have, with extensive investment and modification, expanded in a similar manner, its opportunity to do so was circumscribed by the fact that the railroads in Britain did little more than cement its pre-existing commercial channels that had been established under the age-old transportation methods provided by animal, wind and current. These trading channels were too restrictive to maintain a level of throughput necessary to achieve the scale economies inherent in the new technologies. Consequently, Britain's early start condemned its industry to a scale too small for efficiency in the modern industrial sectors such as electricity.

Furthermore, because the American and German initial industrializations occurred in tandem with the building of their railroads, the organizational and structural revolutions associated with the railroads were at the core of their industrialization process from its inception. All of the requisite tools and apparatus for the building and maintenance of other large-scale, capital intensive industry, including the necessary

financial mechanisms, arose along with the railroads, and were instrumental in their subsequent rapid industrialization based on the modern production technologies. The massive capital needs of the German and American railroads, too great for the lone entrepreneur to muster, called for the evolution of incorporated joint-stock enterprise owned by numerous scattered shareholders. Thus, the essential structural parameters for success in the modern industries such as electricity were established and formed the bedrock of American and German industry. In Britain, a smaller scale mode of industrial organization based on individual proprietorships, partnerships, and family-owned firms that had sufficed for the earlier production technologies of the First Industrial Revolution was firmer in the saddle at the time the railroads began to stimulate organizational changes there. Furthermore, due to the smaller and more compact nature of the British railroad network, its capital requirements were modest in comparison to the German and American networks, therefore capable of being financed by more traditional, local mechanisms. Consequently, the railroads in Britain stimulated far less organizational and structural change in British industry, which may have created disadvantages in later years when efficiency and competitiveness called for enterprise of the mammoth corporate variety.[2]

Two fundamental assumptions underlie Chandler's analysis: the railroad is correlated with, firstly, an expansion of markets and secondly, a more concentrated, large-scale mode of industrial organization characterized by extensive recourse to outside sources of finance. Therefore, in order to determine whether a smaller and more compact

[2] While these are broad themes that are developed and supported throughout *Scale and Scope*, some key sections that emphasize these points can be found on pp. 12, 54-58, 62-63, 89, 235-42, 249-55, 266-68, 281-86, 291-94, 397, 410-19, 497-502, 595-96.

railroad network in Britain was responsible for its economy's failure to develop such characteristics, it is necessary to determine the nature and extent of this correlation. For if this relationship is weak, it casts doubt upon Chandler's theories as acceptable or plausible explanations for the failure of British industry to achieve the necessary scale and scope advantages crucial for success in many of the industries of the Second Industrial Revolution.

For instance, it would be necessary to determine if the above correlation is one which holds in general, across a broad spectrum of industries, or merely within the railroad itself and a few closely related industries. It is possible, for instance, that Britain did experience some widening of markets as a result of the railroads, and it learned about the organizational and financial methods necessary in constructing large scale capital intensive enterprise, yet many segments of its industry remained small scale for internal reasons unrelated to market size or lack of appropriate financial apparatus. Conversely, if Britain was able to build its relatively smaller, but still vast railroad network with traditional local means of finance, it is a puzzle as to why it would be unable to build other large-scale industry using similar methods. If it were found that Germany and the United States had also constructed their even vaster railroad networks without extensive recourse to outside capital, it would serve to show that claims of the railroads as having been the catalyst to the modern industrial corporate structure of enterprise have been greatly exaggerated. All such above evidence constitutes weakening of the empirical chain between the railroads and the evolution of the apparatus of large scale corporate enterprise, and would serve to discredit any hypotheses linking lesser impact of the

railroads on Britain's economy with less industry of this type, and any backwardness in its modern sectors lack of such industry may have produced.

In this study, we attempt to determine the nature and extent of this correlation between the railroads and economies of scale and scope by focusing on American industry in the mid-to-late nineteenth century. In the second chapter, we conduct a comparison of the development and growth of the American, British and German railroad networks in order to determine if Chandler's claims that British industrialization of the mid-to-late nineteenth century was less heavily impacted by the railroads has any validity. In Chapter Three, we continue this comparison in an attempt to determine whether the American and German railroad systems were in fact constructed using more extensive recourse to outside sources of finance.

In the following chapters, we focus on American industry as it developed from 1850-1880 using data uniquely suited to empirical analysis of economies of scale and scope in order to determine whether the growth of the American railroad network did, in fact, expand markets and augment the American financial sector such that the result was a more concentrated, large-scale mode of industrial organization characterized by extensive and increasing economies of scale and scope in sync with the growth of its extensive railroad system. Lack of appropriate data preclude a similar analysis for British and German industry as they developed during this period, and for American industry after 1880 until well into the 20th century. However, the period of 1850-80 spanned by our data is a sufficiently broad enough expanse of time for a test of this hypothesis as it concerns the United States. Chandler believed that the great railroad boom of the middle of the 19th century was the catalyst to the market expansion and financial augmentation

that brought this large-scale mode of industrial organization characterized by extensive economies of scale and scope into existence by about 1870. In these empirical analyses, we use these data sources to construct quantitative estimates of the degree of economies of scale and scope achieved in various American manufacturing industries over successive time periods within this period to test this theory. Starting from the beginning of when these effects were purported to have begun, until 1870 which is identified as the benchmark period in which to expect to see the lagged effects of these transportation improvements upon industrial size and performance, and on until 1880 by which time they ought to have been in full bloom, we obtain quantitative measures of the degree of economies of scale and scope in various industries in order to see if this theory of a lagged, correlative cause-and-effect relationship between the growth of the railroads and economies of scale and scope has any empirical validity; something that previous analyses of the impact of the railroads on industrial size and performance in the 19th century do not contain. Since the electrical and chemical industries were in their infancy at the time of the rapid take-off of the railroads, there is little or no evidence of the growth of these industries in 1850 or 1860 that we can use to take a retrospective look at and compare to their growth achieved by 1870 or 1880. Consequently, our study has been confined to industries that were in full-fledged existence in 1850 for which sequential growth in association with the railroads for the full period from the beginning of the impact of the railroads to the final period can be ascertained.

Chapter Four introduces the measure of economies of scale achieved by various industries at any given time used in our analysis that is termed “Minimum Efficient Scale” (MES); the minimum plant size (in valued added) within the minimum size class

range that increased its total percentage of industry value added over a designated time period. This is predicated on the notion that if economies of scale are present and increasing, larger firms ought to acquire greater market share as time passes. By computing MES over successive time periods spanning the late nineteenth century, we obtain a quantifiable measure of the degree of economies of scale achieved in various American manufacturing industries.

Chapter Five continues the discussion of economies of scale by taking a closer look at the anomalous results our analysis in Chapter Four produced that showed declines in MES over the time period surveyed in six of eight key industries that Chandler said were the great industries that experienced the greatest impact of the decline in transport costs and technological advance that led to large-scale production methods. In Chapter Five, we try to make sense of the anomalous results of Chapter Four by examining our data more closely, and attempt to "repair" those data sets found to be flawed by conducting new analyses using new superior data where available, organizing our data into more specific industry groupings, and conducting analyses of more industry groups with which to compare to the results of Chapter Four.

In Chapter Six, we introduce the measure of economies of scope achieved by a given multi-product industry at any given time used in our analysis that consists of estimating a cost function for each industry at each time period, computing the individual costs of producing each product independently that the given industry produced, subtracting from that the total combined costs of producing that bundle of goods jointly, and dividing that difference by the total combined costs of producing that bundle of goods jointly, yielding a measure of the percentage cost savings (increases) that are due

to joint production. By doing this over successive time periods spanning the late nineteenth century, we obtain a quantifiable measure of the degree of economies of scope achieved in various American manufacturing industries. Our data used in these analyses, and the empirical results of these said economies of scale and scope computations will be reviewed and discussed, and an attempt is made to determine whether our empirical results confirm or contradict the beliefs of Chandler as to which industries experienced these rising economies of scale and scope advantages that were said to have occurred over this period, and when they occurred.

The thesis concludes with a summary of the overall findings of these empirical analyses in order to assess the degree to which they support or contradict those of Chandler. An appendix follows that describes and delineates the construction of the data used in Chapter Six in greater detail.

Chapter Two: DEVELOPMENT AND PHASES OF GROWTH OF THE AMERICAN, BRITISH AND GERMAN RAILROAD NETWORKS: THE CHANDLER HYPOTHESIS EXAMINED

Introduction and Literature Review

The starting point of our analysis of Chandler's claim that the British industrialization of the mid-to-late nineteenth century was less heavily impacted by the railroads than that of the United States and Germany is to juxtapose the timing of effects of the railroads on the industrial development of these countries with data concerning the development of the railroads themselves. For instance, in order to determine whether Chandler's claim that the railroads had a greater impact on the industrialization of the United States and Germany because they were built during their initial industrialization is true, we need to juxtapose the data and phases of mileage of the three countries with the revealed history of the industrial growth of these nations. Or if we are to check the empirical validity of Chandler's idea is that the railroads expanded markets, which led to increased opportunities to exploit economies of scale and scope, and that these effects were greater in the United States and Germany, we must do likewise. Is there coincidence between the period of the most rapid expansion of the railroad systems of the United States and Germany and the expansion of markets that gave impetus to the growth in scale and scope of these enterprises? Or was there a lag between this expansion and its effect, culminating in their leapfrog over Britain? Or was there any effect of this kind at all? Only by examining Chandler's claims as to when the rapid industrialization of the United States and Germany based on the new technologies occurred, and then looking back at the chronology of the phases of growth of railroad mileage and capital flow and

accumulation can we determine whether there does, in fact, exist this synchronicity of development between the railroads and other large-scale industrial enterprise.

We will also use this methodology to determine the validity of another theory that points to a linkage between the railroads and scale and concentration in non-financial industry; one that is largely overlooked by Chandler, yet has been addressed so extensively by other authors that it deserves a place in our analysis. Any study that seeks to understand the relationship between the railroads and the development of large industrial corporations in the 19th century must consider the role of the railroads in stimulating demand for the inputs or intermediate goods involved in their construction (such as iron, coal, timber, etc.), hence growth in these industrial sectors. It is important to realize that another consequence of the railroads borrowing heavily in the capital markets (besides the financial intermediation effect of enlarging the financial capital industry and stimulating industry this way), is that this capital, along with other capital raised in other ways, was spent again on the intermediate goods necessary for the construction of the railroads themselves, thus stimulating scale and concentration in these industries. Consequently, the railroads may have been responsible in another important way for increases in scale and concentration appearing in these sectors in the wake of their mid-19th century investment and construction boom.

The method of juxtaposition of data of phases of mileage of the three countries with the revealed history of the industrial growth of these nations again comes into play here. The larger and more extensive a nation's railroad system, the greater its need for capital inputs. If there were any validity to the theory that a larger and more extensive railroad system in the United States and Germany stimulated greater demand-side effects

upon the growth of these input-producing industries, we would expect there to exist this same synchronicity between the growth of these railroad systems and factor-producing industries as produced by market expansion and financial intermediation.

This analysis of comparative derived demand effects across nations makes a valuable contribution to this study because the magnitude of these effects, particularly insofar as they affected the American railroad system, is a historical controversy in the relevant literature whose resolution has grave implications for the purposes of this study. It is important in this study to determine the relative magnitude of the derived demand effects of the railroads on American industry vis-à-vis the British and German because if these effects were significant, it would weaken Chandler's contention that the market expansion and financial intermediation effects of the railroad were predominant. Or if they were found to be insignificant in comparison to the British, it would demand a re-thinking of Chandler's hypothesis of the lesser impact of the railroads on British industrial development.

This is essentially the crux of the debate over derived demand effects that is contained in the relevant literature. In assessing the degree of these derived demand effects and their contribution to the American take-off into sustained economic growth in the nineteenth century, Rostow (1960) [1] claimed that the railroads' demand for capital was the primary impetus in the United States' great "take-off" into the era of modern economic growth, and precipitated its great structural transformation from a primarily agricultural to industrial economy. However, the overall consensus of the work since

[1] Rostow, W.W. *The Stages of Economic Growth: A Non-Communist Manifesto*. Cambridge University Press, 1960.

Rostow [2] appears to be that these effects of the railroads were relatively small in comparison to all the other factors that contributed to the growth of these modern industrial sectors, which is perhaps part of the reason that Chandler is relatively mute on the whole issue, and it doesn't form part of his argument about why the railroads were such an important factor in revolutionizing the scale and structure of modern industry. In his discussion of factors stimulating the American steel industry, Chandler notes that Carnegie, while initially experiencing great growth in his works in catering to the enormous demand created by the railroad boom of the 1880's, increasingly by the 1880's and 1890's had begun to diversify into products such as boiler tanks and ship plates as opposed to railroad rails. However, he does credit his placement of blast furnaces to produce pig iron next to the steel-producing Bessemer converters in his new Edgar Thompson rail works in 1879 as the factor making him the world's most efficient steel-rail producer. Furthermore, he mentions that when the Illinois and Lorain Steel Companies merged in 1898, Illinois acquired its rail-building facilities, so this perhaps signifies some association between the demand of the railroads for inputs and things that promoted scale and concentration in industry, because Chandler does cite merger and acquisition as a major factor contributing to larger, more integrated facilities that were able to more efficiently exploit economies of scale and scope in production in the late 19th century. Little can be learned from Chandler about a particularly strong railroad demand for steel having contributed a lot to scale and concentration in the American steel industry. As for the stimulating effect of the British railroads on its iron and steel industries, Chandler also says little. In particular, regarding its steel industry, he notes

[2] See Fishlow, Albert. *American Railroads and the Transformation of the Antebellum Economy*. Harvard University Press, (Cambridge, 1965) and Fogel, Robert William. *Railroads and American Economic Growth*. Johns Hopkins Press, (Baltimore, 1964).

that by the time the British steel industry got going, most of its railroads had been completed (using iron, not steel for rails), so there were little expansionary effects from the railroad in Britain in those regards.[3]

The main detractors of Rostow's theory, however, are Fishlow (1965) and Fogel (1964). The crux of their argument *contre* Rostow is that the United States' structural transformation and "take-off" of economic growth based on these new modern industries actually occurred a lot earlier—before the advent of the iron horse. Since these industries completed the lion's share of their initial growth spurt before the railroads, it shows that these input demand (and perhaps also market expansion and financial intermediation) effects of the railroads on the great American industrial expansion of the 19th century were weak. They also refute Rostow by presenting data on the percentage of output of these key industries that went into the railroads at the time of their great mid-century boom, showing that it was small. With respect to the iron industry in particular, in an extensive analysis that covers an entire chapter in his book, Fogel points out that since this percentage was not a huge one out of the total output of the American iron industry at the time the railroads were being built, there is little growth in the iron industry at that time that can be attributed to the railroads.[4] Fishlow believes that the railroads did not becomes huge "eaters" of the output of these key industries until the post-Bellum era, way after the initial surge of railroad production in the United States.[5] Fishlow also presents an extensive analysis showing that despite the fact that the railroads were heavy consumers of industrial capital like iron and coal, they were still a primarily labor-

[3] *Scale and Scope*, pp. 128-30, 281-83.
[4] Fogel, Ch. 4, pp. 130-203, and in its summary/conclusion, pp. 230-35.
[5] See Fishlow, pp. 13, 100-60; also Fogel, pp. 13-14, 114, 129-30, 140-46, 265-66, 228-35.

intensive industry.[6] Fogel contests the Rostow theory further by pointing out that the railroads did not play a huge role in stimulating the boom in the iron industry at mid-century in the United States because much of the "new" rails that were produced each year were actually old rails that were re-rolled into new ones. Thus demand for rails did not have such a great effect on the level of production in the smelting sector.[7]

Then there is the issue that the American railroad industry did not stimulate the iron or steel industry that much because the United States imported a large part of its iron for rails from Britain initially.[8] The United States purportedly had the larger and greater railroad system; but if it got most of its rails from the British iron industry, then the expansion of the American railroad system may have had more of an expanding effect upon the British than the American iron industry. Fishlow believes that part of the boom in the American iron industry that occurred seemingly because of the demand of the railroads was actually created by a substitution effect that occurred due to a rise in the price of British iron. So the United States merely substituted domestic iron for rails for imported iron. So it was really because of a price rise that this happened, not because of demand of the railroads *per se*; if the price hadn't risen, they would probably have continued to import their iron to build their rails. And since this price rise affected an increase in demand for all domestic iron produced in the United States, one cannot pinpoint one particular demand source as having been the causal factor behind the growth of the American iron industry.[9]

---

[6] Fishlow, pp. 100-60.
[7] See Fogel, pp. 204-06; also Fishlow, pp. 5, 130-49.
[8] Fishlow, pp. 5, 130-49, 260; Fogel, pp. 200-01, 232. See also Hawke, G. R. *Railways and Economic Growth in England and Wales, 1840-1870*. Clarendon Press, (Oxford, 1970), pp. 25, 409.
[9] Fishlow, pp. 260, 302-03.

There was also relatively less stimulation of the American coal industry from the railroads than in Britain, owing to the fact that wood was used more for fuel in the United States than in Britain, whose forests were depleted. As an aside, this did little to stimulate the American timber processing industry as this wood for fuel was not manufactured lumber that came out of mills.[10]

It appears perhaps that the derived demand effects of the railroads may have actually been stronger in Britain; and not merely in coal, as two preeminent scholars of the growth of the British railroad system, Bagwell (1974) and Hawke (1970), maintain.[11] Since the British iron industry not only produced the lion's share of its own rails that went into its railroad system, but also exported a great deal of rails to the United States and elsewhere, it might well be the case that the railroads had a greater affect upon British industrial development at mid-century; at least insofar as input demand effects are concerned. Bagwell and Hawke both take note of the considerable growth of the Welsh iron industry that served the Northern and Midlands manufacturing industries that included rails production. Bagwell reports that this industry grew considerably coincident with the construction of railroad lines connecting it to these manufacturing centers and that these transport lines were instrumental in its growth, which also points to significant growth from market expansion effects.[12]

This controversy surrounding the degree of impact of these derived demand effects on American industry vis-à-vis the British and German certainly merits some sort of further empirical analysis. If it were to be found that these effects were substantial, it

---

[10] See Fogel, pp. 130-37, 233-34; Fishlow, pp. 125-27, 156-58, 260; Hawke, pp. 296-97, 395-98. See also Bagwell, Philip S. *The Transport Revolution from 1770*. London, Batsford (1974), p. 88.
[11] See Bagwell, pp. 114-17, 132; Hawke, pp. 211-12.
[12] Bagwell, pp. 114-16. See also Hawke, pp. 213-16, 220-26, 230-35, 241-43, 392-93.

would certainly weaken not only Chandler's contention that market expansion and financial intermediation effects of the railroad were predominant, it would call into question Fishlow and Fogel's contention that these effects were weak in their impact on American industry. Or if these effects were felt more on the other side of the Atlantic, it might also demand a re-thinking of Chandler's hypothesis of the lesser impact of the railroads on British industrial development.

I. RAILROADIZATION AND INITIAL INDUSTRIALIZATION

The following tabular analyses constitute an empirical test of Chandler's theory that the British industrialization of the mid-to-late nineteenth century was less heavily impacted by the railroads than that of the United States and Germany through a juxtaposition of the timing of effects of the railroads on the industrial development of these countries with data concerning the development of the railroads themselves.

In Table 2.1 below, railway mileage for Great Britain, the United States, and Germany, every five years starting from 1830 until 1914 are delineated side-by-side as our starting point for this analysis. From examining the table, it can be seen that although Britain starts off in the lead as the pioneer of the railways, the United States clearly overtakes it in mileage completed by 1835, and maintains a strong lead over Britain and Germany thereafter to 1914. Germany's later start leaves it behind both Britain and the United States until the 1870's when it overtakes Britain. By 1875, a clear ranking order of the United States first, Germany second, and Britain third is established that is commensurate with what would be expected given the relative areas of national territory

of the three nations surveyed (see a precise measure of national territory for each nation juxtaposed to these mileage data in Table 2.1 as well).

Table 2.1 is quite helpful in addressing the main questions pertaining to our empirical analysis of Chandler's hypothesis of the impetus to economies of scale and scope the railroads may have afforded in terms of when and in which country(ies) these effects were most apparent and in which industries would they be most manifest. But our first use of this table is to address the question does the timing of these phenomena correspond to the Chandlerian hypothesis that because the railroads were built during the *initial* industrializations of the United States and Germany, they had a greater impact on their industrial development than they had in Britain, who had industrialized before the railroads? Since it is a given that these effects occurred long after Britain's initial industrialization, there is no need to examine this issue.

With regards to the United States, there is no inconsistency between Chandler's story of the genesis of American industry in relation to the railroads and the information as displayed in Table 2.1. The rapid growth of the American railroad system that is apparent by the 1850's-60's in Table 2.1 is consistent with the time period Chandler considers the United States' initial industrialization. In discussing the reasons that the railroads did not have as great an impact on British industrialization as they did on American industrialization, he states that part of the reason (besides the fact that its pre-railroad transport systems were more efficient than the American) is that Britain's industrialization preceded the building of its railroad network, implying that the United States' industrialization was concurrent with the building of its railroad system.[13] While Chandler does not explicitly pinpoint the exact time that the United States' "initial

[13] *Scale and Scope*, p. 254.

industrialization" occurred, our data leaves us with no other conclusion than it occurred at mid-century; a period not too far off the mark from what could be considered its early, if not initial industrialization.

However, in noting the lagged development of the railroads in Germany with respect to not only the United States, but Britain as well, a shadow of doubt is cast upon the notion that Germany's initial industrialization was concurrent with the railroads. Table 2.1 reveals the fact that Germany did not overtake Britain in railroad mileage until the 1870's. If Germany had already experienced significant industrialization by the 1870's that the railroads merely buttressed, then a "layering" effect similar to what transpired in Britain was also characteristic of the German industrial development. If Germany's industrial development more closely resembles that of Britain than that of the United States, then one of Chandler's premises or factors accounting for Germany's leapfrog over Britain at the end of the century is fraudulent; unless the period that we refer to as Germany's "initial industrialization" were moved up to a later date.

As it turns out, there is no need to "move" Germany's initial industrialization to a later date to salvage the theory of synchronicity between its early industrialization and railroadization. Despite the fact that Germany did not make the great final leap over Britain until the 1870's, it made some remarkable strides from the start of its railroad system in the late 1830's until the 1870's, which is a period that can certainly be called coincident with Germany's initial industrialization.

According to Chandler, prior to the boom of the 1870's, Germany experienced another earlier boom in railroad investment in the 1840's-50's.[14] It is apparent from examining Table 2.1 that growth of the railroad system was very rapid in Germany for

[14] Ibid., p. 414.

the whole period prior to the first year shown in which German mileage exceeds that of Britain, 1875. The rapid growth of the German railroad system that was apparent by the 1850's-60's is coincident with the time period during which Germany is considered to have experienced its initial industrialization, as is the similar growth of the railroads in the United States at that time. Although the great boom in which it overtook Britain did not occur until the 1870's, and the leap from 1870-75 is the greatest leap so far achieved by Germany, it certainly cannot be considered to be the leap that "made" Germany's railroad system. Overall, from examining the data in Table 2.1, it can be seen that the German railroad system was a great work in progress over the entire period prior to 1875, thus we can certainly say that this evolution was coincident with Germany's initial industrialization.

Moreover, in noting the railroad booms of the 1840's-50's and 1860's-70's going on in both the United States and Germany at the time, Chandler states that this is going on during both nations' initial industrializations. In fact, Chandler states that the rapid growth of the railroad network was an integral part of Germany's initial industrialization.[15] Since the period of rapid growth of the railroad network he is describing is one that extends from mid-century on into the 1870's, the 1870's can certainly be a period during which Germany can be said to still be experiencing lagged effects of railroadization in the wake of its initial industrialization. So there is no need to "move" Germany's initial industrialization to any later date in order to salvage Chandler's theory.

While there is no further need to reconcile this aspect of Chandler's theory with quantitative and historical evidence, it is worthy of noting here that the sustained boom in

[15] Ibid., pp. 411-12.

German railroad construction leading to its usurpation of Britain by the 1870's is coincident with the dawn of an era of rapid industrial progress greatly associated with the completion of Germany's railroad network that can in many ways, be considered the inauguration point of German industrialization *proper*. 1870 was a watershed year for Germany in that the said essential completion of its railroad network coincides with the unification of the German Empire, which hastened the integration, both physically and operationally, of the railroad network. With the large railroad network in place by 1870, the stage was set for the emergence of the large industrial corporation and the dramatic economic growth based on the new technologies that Germany experienced from that point on. 1870 can serve as a benchmark point at which to mark the inauguration of this great growth, because, as Chandler points out, Germany's G.D.P. was far lower than Britain's in 1870, but by 1914 had approached Britain's very closely, which implies that 1870 marks a beginning point of an era of rapid industrial and economic growth experienced by Germany. The impetus to the German steel industry provided by the railroads in the 1870's-80's that led to the evolution of large integrated steel mills there is just one example of the ways in which the railroads had, and continued to play, a tremendous role in the industrial growth of Germany that they had long ceased to play in Britain, and was one of the crucial factors, according to Chandler, that played a pivotal role in its usurpation of Britain in the role of Europe's supreme industrial leader.[16]

To summarize, there is no inconsistency between Chandler's claims that the American and German initial railroadizations and industrializations coincide with the mileage data contained in Table 2.1. For both the United States and Germany, Table 2.1 shows a rapid expansion in their railroad networks as having occurred at mid-century, a

[16] Ibid., pp. 281-82, 409-14.

period can be roughly designated as a take-off period of growth of large-scale industrial enterprise for both nations. While Germany's most rapid growth of its railroad system does not occur until slightly later, until the 1870's, it has been here revealed that this railroad growth is not too far off the mark from what can be termed Germany's "early industrialization" period in that it merely buttressed an earlier stage of growth of Germany's railroad system, and is coincident with what one might call a "second stage" of its early industrialization in which the effects of rapid railroadization upon its economy that may have been coincident with, or resultant from that earlier railroadization were realized.

II. RAILROADIZATION AND ECONOMIES OF SCALE AND SCOPE: IS THERE SYNCHRONICITY?

Our tabular/historical analysis of Chandler now continues with a juxtaposition of these mileage phases data for the three countries with historical claims made by Chandler regarding when the dramatic effect of the expansion of these railroad systems upon the scale and structure of industries was felt.

From examining Chandler's writings, in tandem with the information gathered from Table 2.1, the primary deduction gathered is that there was a lagged effect from the take-off period of the expansion of the railroads which occurred around mid-century, until the time at which the effects of this railroad construction on expansion of markets and financial intermediation had their effect upon the industry of these countries, which did not occur until after 1870. In accounting for the smaller scale, less concentrated structure of industry that had materialized in Britain by the latter 19th century as compared with the United States and Germany, Chandler implies that because Germany

and the United States received the market expansion and financial augmentation from the railroads at the time they were being built at mid-century, there was more of it at the end of the century. Whereas for Britain, due to the lesser impact of the railroads on its industrial development at mid-century, there were less of these effects later on, which is large part of what accounts for the American and German leapfrog in industrial development that occurred at that time. In terms of the consequences of this for particular industrial sectors, it is implied that their earlier-on effect was upon industries existent at the time (iron, coal, etc.), and because of less scale and scope achieved in these industries earlier on, Britain also did not get it later when the big growth industries were chemicals, electricity, etc. A further clear implication is that there was a lagged effect of the railroads on industrial structure equal to about twenty years or so from the rapid expansion of the railroads at mid-century until their concomitant market expansion and financial augmentation had their effects upon industrial growth by the latter part of the 19^{th} century.

Theoretical grounding in hand, we may now proceed to a more thorough check and verification of these accounts of Chandler's on the dates of when the effects of the railroads first appeared in each country as against our railroad mileage phases data in Table 2.1. In Table 2.1, the clear ranking order of the United States first, Germany second, and Great Britain third supports the general contention that the effects of railroadization were weaker in Britain relative to the other two countries. However, the fact that Germany *starts out* behind Britain, and does not overtake it until the 1870's, raises questions in terms of the premises of the Chandlerian hypothesis that need to be resolved. It makes no sense to speak of the greater preponderance of the railroads in

Germany vis-à-vis Britain, or any impetus to scale and scope this afforded German industry, until at least the 1870's. This is the case at least as far as we can determine from looking at raw mileage data. And, as further data in the series bears out, there appears to be a significant time gap in between the time at which the United States overtook Britain as the nation who was best poised to reap the greatest benefits from the railroads, which occurred perhaps as early as the 1840's, and the time at which any great advantages of this sort can be said to have been received by Germany, which seemingly did not occur until the 1870's.

Starting with Britain, in the introductory Part I of *Scale and Scope* that applies to all 3 countries, Chandler makes it pretty clear that the railroads did not effect their great revolutionary contribution to production and distribution methods until they had achieved their "completeness" which he considers as having been by the 1870's.[17] Since Chandler believes that Britain did not experience this radical transformation of its economy due to the railroads, I am assuming he means mainly the United States and Germany. However, in looking for a time period in which this "completeness" of the British railroad system ought to have had whatever impact it had on British industrial development, however meager it was, Chandler states that Britain's railroad network was nearly complete by the 1850's-60's, which appears to be accurate given a glance at Table 2.1, which shows that the growth of Britain's railroad system after 1870 is not as rapid as previously.[18] Consequently, it is pretty safe to assume that whatever impetus to economies of scale and scope the British railroads afforded, while they may have been gathering momentum in the 1850's and 1860's, ought to have been in full swing by the 1870's. Thus the 1870's are

[17] Ibid., p. 26.
[18] Ibid., pp. 262-63.

a benchmark decade in which to look for the beginning of the effects of economies of scale and scope on British industry in association with the opportunities for so presented by the railroads.

As for when the effects of this railroadization were made apparent in terms of the tremendous impetus to economies of scale and scope American industry was said to have experienced, the evidence from Chandler reveals a similar benchmark period of the beginnings of such growth in the 1860's, and a formal starting point of the acceleration of such growth that led to the evolution of the large industrial corporation in the United States of about 1870. The general evidence regarding the growth of railroads in the United States is that the effects of railroads upon economies of scale and scope in American industry ought to have been apparent by at least the same time as in Britain, say the late 1860's, and, if anything, continued to steamroll on throughout the century because, unlike the British, the American railroad system continued to experience rapid growth after the 1870's, and on until the turn of the century. In fact, even as early as the 1850's, the United States' railroads were increasing more rapidly than Britain's, as an inspection of Table 2.1 indicates.

For instance, in comparing the impact of the railroads and telegraph on the American and British economies and the economies of scale and scope it afforded both countries, Chandler compares mileage dates completed in both countries in 1860 and 1880. In noting the much greater mileage completed in the United States at both dates, he seems to imply that the more profound impact of the railroads on the American economy were already being felt by 1860.[19] Furthermore, Chandler notes the great stimulus to the American and German steel industries provided by their still rapidly

[19] Ibid., p. 53.

growing railroad systems in the 1870's-80's that led to the evolution of large integrated steel mills in those countries during this period. Chandler indicates that the British steel industry did not experience such a stimulus on account of the fact that most of its railroad system was complete by the 1860's. Consequently, there was far less incentive for British industrialists to make the investment in these large integrated facilities, so the German and American firms became the first movers in large batch-process steel production facilities during the 1870's-80's.[20]

Regarding the case of Germany, Table 2.1 reveals the fact that Germany did not overtake Britain in railroad mileage until the 1870's. So apparently, it would seem that the American phenomenon of a mid-century railroad boom, followed by an industrial expansion and modernization by the 1870's, could not have happened in Germany; at least not by 1870 as Chandler contends. Thus our railroad mileage data are apparently in conflict with Chandler's idea that because Germany and the United States received greater market expansion and financial augmentation from the railroads at the time they were being built at mid-century, there was more of it at the end of the century.

But as discussed above, 1870 is not a date too far off the mark from what can be termed Germany's "early industrialization" period to begin to look for traces of the effects of rapid railroadization upon its economy that may have been coincident with, or resultant from its earlier surge of railroad investment and construction of the 1840's-50's. And while my overall examination of Chandler indicates that the effects of railroadization appeared in Germany at a slightly later date than in the United States or Britain, they were not so much later that 1870 becomes ruled out as a reasonable

[20] Ibid., pp. 281-82.

benchmark starting point for looking for these effects to have begun to manifest themselves.

Chandler conducts a similar comparison of the effects of the railroads and telegraph on the German and British economies as done with respect to the United States and Britain above. Chandler points to the dates for Germany as having overtaken Britain in railroad mileage completed, and implied concomitant economies of scale and scope effects as having been achieved as being between 1880 and 1910, seeming to imply that the great effects of the railroads on German industrialization were not being felt until then.[21] In his analysis of German industrialization in association with the railroads, while making note of a great surge in railroad investment in Germany as having occurred in the 1840's and 1850's, he is far more cautionary insofar as asserting any dramatic expansionary stimulus in association with the railroads in Germany until 1880, upon which time he states that Germany had achieved a transportation system comparable to the United States in terms of permitting the cost advantages of economies of scale and scope inherent in the capital-intensive, high-volume technologies of production.[22]

But at the same time, Chandler acknowledges that since Germany's initial construction of its railroad network was indeed coincident with its early industrialization, this construction could have been producing effects that were of great importance and significance in terms of its later leapfrog over Britain, and that these effects could have been operating far earlier on than the 1880's. Besides the great surge in German railroad investment of the 1840's and 1850's, Chandler notes that by the 1870's, the German railroad managers had perfected the operating and organizational procedures needed to

[21] Ibid., p. 53.
[22] Ibid., p. 414.

assure a steady, fast, regularly scheduled flow of goods over Germany's new railroad network, and they had achieved this even earlier than their American counterparts, which suggests that economies of scale and scope effects due to enlargement of markets may have been operating in Germany by the 1870's. Moreover, he notes that German political unification, achieved by 1871, gave further impetus to these effects when the new Chancellor, Otto von Bismarck, made consolidation of the German railroads into a single system a priority of the new regime, thus hastening the integration, both physically and operationally, of the railroad network within Germany and with those systems of nations to the east and south.[23]

The overall experience of Germany with respect to the railroads, and expansionary impetus to economies of scale and scope afforded by the railroads, while pointing to perhaps a slightly later date at which to look for economies of scale and scope effects in association with the railroads than in the United States or Britain, perhaps the 1880's, does not direct us so far later in history that it calls for a radical forward shifting of the dates to look for empirical evidence of economies of scale and scope in association with the German railroads. 1870 is a reasonable enough benchmark date for which to anticipate these economies of scale and scope effects of the railroads in Germany, as it is for the other two countries. It certainly is no further far off the mark than for the United States or Britain, whom although we have picked that same date as a starting point for which to examine and look for these effects in, may have been experiencing them as early on as the 1850's.

[23] Ibid., pp. 412-13.

III. EFFECTS OF RAILROADIZATION ON INDUSTRIAL COMPOSITION

Equal in importance to the matter of *when* the effects of the railroads on economies of scale and scope in industry appeared for any empirical analysis of economies of scale and scope is the issue of *where* they appeared--in what industries, that is. A major component of Chandler's hypothesis concerning the American and German leapfrog over Britain by the end of the century is of a qualitative, not quantitative nature. According to Chandler, due to the lesser impact of the railroads on economies of scale and scope in British industry at mid-century, there were lesser economies of scale and scope in British industry later on when the big growth industries were chemicals, electricity, etc. Consequently, British industrial growth was not only quantitatively stymied, in that it was smaller-scale and less integrated by the end of the century, it was qualitatively less modern, and concentrated more in the traditional industries of its earlier industrialization. Chandler not only maintained that economies of scale and scope effects of railroads in Britain were quantitatively weaker than in the United States and Germany due to its earlier industrialization based on the earlier technologies, and its excellent pre-railroad transport systems; he also pointed out that they were *qualitatively* less modern, and concentrated in these older, labor-intensive technologies like textiles, shoes and food processing, rather than in the newer, scientific, capital-intensive technologies such as chemicals and electrical technology.

Chandler believed that since the railroads appeared in the United States and Germany during their initial industrializations, their industry evolved in a structure more suitable for exploiting the scale and scope advantages of these new transport innovations, and that new types of financial institutions evolved out of this that paved the way for

further large-scale industrialization. While there is no apparent reason why these effects ought to have appeared more prominently in the modern sectors than in Britain, other than perhaps that since they were industrializing for the first time, their industrialization would naturally be of a more up-to-date character, thus concentrated more heavily in the modern sectors than in Britain, whose pre-existing, older industrial sector would have been its greatest recipient of the economies of scale and scope opportunities presented by the railroads, it is a prominent theme running throughout Chandler that in the United States, the wave of technological and organizational changes precipitated by the transportation and communication revolutions were observed most prominently in the capital-intensive industries of the Second Industrial Revolution, in contrast to the British experience in which British entrepreneurs failed to make these essential investments most necessary to compete in the newer, more technologically advanced growth industries, such as chemicals, electrical equipment, and other machinery where complex facilities and highly specialized technical and managerial skills were essential in obtaining and maintaining market share. Consequently, it is in industries such as these that we ought to observe the greatest economies of scale and scope in association with the railroads in American industry.[24]

As indicated in the above section describing the impact of the railroads on the American and German steel industries, it is evident that in Germany, as in the United States, the wave of technological and organizational changes precipitated by the transportation and communication revolutions were observed most prominently in the capital-intensive industries of the Second Industrial Revolution. As Chandler describes, the basic story of the evolution of the modern industrial enterprise in Germany is very

[24] Ibid., pp. 62-63, 235-42.

similar to that of the United States in that it appeared quickly following the completion of the new transportation and communication network, and that these new manufacturing enterprises became clustered in the industries in which the technologies of production provided the cost advantages of scale and scope. By 1880, Chandler explains, Germany had achieved a transportation system comparable to the United States in terms of permitting the cost advantages of economies of scale and scope inherent in the capital-intensive, high-volume technologies of production.[25]

Again, although 1880 is a formal starting place Chandler designates for observation of these changes, 1870 is not too far off the mark either for a starting observation point, because it marks the inauguration of a new era in Germany's political and economic history—an era of mutual coincidence of the beginning of its political and economic unification, the completion of a significant portion of its transportation and communication network, the unification thereof, and the initiation of a period of rapid economic growth based on the new technologies that the railroads played a role in inaugurating. Chandler notes that during the years between 1870 and WWI, Germany, like the United States, quickly surpassed Britain in industrial output, and captured an increasing share of Britain's international and even domestic markets. At the core, this success rested on the ability of German entrepreneurs to adopt new technologies and build the organizations necessary to exploit them.[26] Germany's advances in those days may also be related to its high primary and secondary school enrollment rates, which, along with the United States', exceeded Britain's during most of the nineteenth century. We cannot ignore the importance of universal schooling to economic growth, as

[25] Ibid., pp. 398, 414.
[26] Ibid., pp. 428-29.

emphasized by Lindert (2004) in which he details how the British belief in private, voluntary education caused it to lag behind Germany and its other competitors in enrollment rates during these crucial years of 1850-1890 in which this industrial leapfrog took place. By making basic education more accessible to the masses, Germany may have achieved higher literacy among industrial workers, and thereby a more modern and efficient industrial sector than many of its competitors.[27]

The industries in which the German entrepreneurs excelled were those that lay at the heart of the Second Industrial Revolution—those that produced the materials and machinery so essential to the rapid industrializing and urbanizing of the economies—not only of continental Europe, but also of Britain and the United States. By WWI, Germany's industrial strength lay in what contemporaries called "the great industries". These included metals—iron and steel; heavy industrial machinery, particularly the new machines that generated, transmitted, and used electrical power; and the new chemical industries that produced man-made dyes, fibers, medicines, fertilizers, and materials used in a wide variety of industrial processes.[28] Clearly, then, for Germany, as for Britain and the United States, 1870 is a good benchmark starting point for looking for effects of the railroads upon economies of scale and scope in industries, and in the case of Germany, as in the United States, it is these modern technologies of the Second Industrial Revolution in which these ought to be most clearly manifest.

---

[27] Lindert, Peter. *Growing Public: Social Spending and Economic Growth Since the Eighteenth Century*. Two volumes. Cambridge University Press, 2004. Vol. 1, pp. 87-93, 113-15; Vol. 2, p. 33.
[28] *Scale and Scope*, pp. 428-29.

IV. DERIVED DEMAND EFFECTS: A FAULTY OMISSION?

The other important linkage between the railroads and scale and concentration in non-financial industry that was discussed earlier is the role of the railroads in stimulating demand for the inputs or intermediate goods involved in their construction (such as iron, coal, timber, etc.) hence growth in these industrial sectors, and thus increases in scale and concentration that may have appeared in these sectors in the mid-19th century coincident with, or immediately following the construction of the railroads. Another consequence of the railroads borrowing heavily in the capital markets (besides the financial intermediation effect of enlarging the financial capital industry and stimulating industry this way), is that this capital, along with other capital raised in other ways, was spent again on the intermediate goods necessary for the construction of the railroads themselves, thus stimulating scale and concentration in these industries. Consequently, the railroads may have been responsible for increased scale and concentration in industry in another important way.

What follows are analyses of the railroad mileage phases data already presented in Table 2.1 along with data on railroad mileage per thousand square miles of national territory for Great Britain, the United States, and Germany and railroad physical capital investment data for the three countries. These are juxtaposed to the history as accounted for by Chandler and other authors to help us gain a better understanding of the magnitude of these derived demand effects across each country for the sake of international comparison.

The essential theoretical underpinnings that tie these data together in an analysis of these derived demand effects of the railroads across countries is that growth in

railroad-input producing industries that stemmed from production of inputs that actually ended up being produced for railroads would be evidenced by a high fraction of the output of these industries ending up as railroad inputs, which would be a function of a larger and more extensive railroad system. Or, in reverse, the larger and more extensive a nation's railroad system, the greater its need for capital inputs, thus the greater the degree to which inputs involved in the construction of that system contributed to the growth of the input-producing industries. According to Chandler, it was on account of the fact that the United States' railroad system was larger and more extensive than Britain's that the railroads had a greater impact upon industrialization in the United States than in Britain. Although he did not point to the effect of input demand to a great extent as a factor contributing to this phenomenon, measuring the degree of railroadization with track mileage provides an adequate initial yardstick with which to see if the same properties of the railroad that Chandler believed led to industrial growth through market expansion and financial intermediation could have also had these effects via input demand. This is thus just as much of a scathing examination of Rostow's theory as that of Chandler's. Consequently, we need to look at physical extent of the railroad system in Table 2.1 again to assess the relative impact of the railroads on American industrial development vis-à-vis that of Britain and also Germany.

In re-examining Table 2.1, it can be seen that there is greater physical expansion of the railroads in the United States and Germany. This initial surface examination would support the contention that these countries would have greater demand-side stimulus emanating from the railroads themselves as factors abetting economies of scale

and scope in those countries and contributing to their technological leapfrog over Britain in the late 19th century.

Mileage alone, however, is an incomplete picture of the story. As accounted for by the fact that the United States imported a lot of its rails from Britain, it may not be the case at all that a nation's railroad-input-producing industries grew in proportion to the growth of its own railroad system. The United States purportedly had the larger and greater railroad system; but if it got most of its rails from the British iron industry, then the expansion of the American railroad system may have had more of an expanding effect upon the British iron industry than its own iron industry.

Consequently, for the sake of comparison, the mileage data of Table 2.1 have been divided by data of national territory (also shown in Table 2.1) to form a measure of railroad mileage per thousand square miles of national territory for Great Britain, the United States, and Germany for every five years from 1830-1914 displayed in the far right section of Table 2.1. This adjustment is designed to gauge a better understanding of the relative importance of the railroads in each nation's economy. Chandler maintained that the American railroad system was larger and more expansive than Britain's, and therefore more important in its economic development. However, it must be remembered that we are dealing with countries of significantly different area sizes. Given the United States' greater area, it is only natural to assume that it would it would require a larger and more expansive railroad system. However, given Britain's smaller area, it is very possible that its albeit smaller and more compact railroad system loomed relatively larger in importance to its economic development than that of the United States. Given Britain's smaller area, it is natural to assume that a smaller and more compact railroad

system would be adequate for its needs. However, on a per square mile basis, Britain may have had the larger and more expansive railroad system. Given the fact that it produced mainly all its rails itself, and exported another hefty portion to abroad, Britain's iron industry may well have been much more railroad-intensive than the United States', thus the derived demand effects of the railroads may have had a far greater impact upon British industry than upon the American. Railroad mileage per square mile of national territory is another potential indicator of a more heavily railroadized economy where railroads were a bigger industry in proportion to the rest of the economy, and therefore more important as a market for the output of iron, coal and other industries.

In examining Table 2.1, the most immediately obvious and striking feature is the ranking of railroad mileage per square mile of national territory in reverse proportion to the degree that each nation was supposed to have received the benefits of railroadization; Britain first, Germany second, the United States third. Table 2.1 reveals that although Britain is the lowest of the three in terms of sheer railway mileage, it surpasses both countries in terms of railroad mileage per thousand square miles of national territory throughout the period in question, which is to be expected given its earlier start in general industrialization, more urbanized nature, and smaller and more compact geographical layout. Britain's earlier start in the building of its railway system too, may have played a role in its achieving a relatively more expansive and ubiquitous railway system.

The United States, although starting out ahead of Germany, loses that lead by the 1840's, and never regains it. Clearly the United States' greater mileage of railways is not enough to offset its wide-open spaces and more dispersed geographical layout, and the British effect of a more concentrated and compact industrial landscape already begins to

operate in Germany's favor by the 1840's, despite its later start and overall smaller railway system in terms of sheer mileage.

This topsy-turvy ranking order calls the premises of the Chandler theory into question. If railroad mileage per square mile of national territory were the yardstick by which we gauge the degree of railroadization of a nation's economy, Britain would come out on top; a result in contradiction to the Chandler hypothesis that lesser (greater) railroadization in Britain (the United States and Germany) was associated with lesser (greater) economies of scale and scope in industry. By the results of this yardstick, with railroad mileage per square mile as an indicator of greater railroadization, it would show greater railroadization linked with lesser economies of scale and scope, if what Chandler believes is true that the United States and Germany received greater economies of scale and scope benefits from the railroads.

While the mere fact that Britain had the greatest railroad mileage per square mile of national territory does completely demolish the premises of the theory--Britain could have easily had great railroad mileage per square mile of national territory without a tremendous stimulating effect of this seemingly widespread railroadization on its railroad-input-producing industries, not to mention little market expansion as a result of these railroads and lesser effects on capital market augmentation from this railroadization--by the same token, there is nothing in these results that *assures* lower derived demand, market expansion, or capital market augmentation effects of the railroads on British industry, and it makes one think. The fact that Britain had a busy iron industry, producing its own iron for its railroads, not to mention the United States and other countries, and even though its own domestic demand for rails was small after 1860

due to most of its own rail network having been laid down, we know that the continued great expansion of the American and Continental systems was yet to come, and even Chandler acknowledges that in 1880 Britain was still the world's largest producer of steel, even though he maintains that this American and Continental expansion had its primary impact upon the American and German steel industries as they faced greater incentives to invest in large integrated steel mills at that time.[29] But this all occurred much later. It could be that Fishlow, Fogel and Chandler were right and Rostow was wrong about one thing—that these derived demand effects were weak in the United States and Germany prior to the latter 19th century, and it was derived demand effects such as these that only had a prominent effect upon the British iron and steel industries. However, if these effects were great in Britain from the start of its railroad system all the way up until the latter part of the 19th century, this is information overlooked by Chandler that weakens his contention that the railroads were far more important for the industrial development of the United States and Germany, and this cannot be used as a compelling explanation for Britain's failure to achieve large scale concentrated industries in the modern industrial sectors by the late 19th century.

But before we get too carried away in interpreting these topsy-turvy results as a refutation of the Chandler hypothesis, we must bear in mind one crucial caveat. That is that the railroad mileage per square mile of national territory of Table 2.1 do not indicate, on a per-square-mile basis, the much greater rapidity of railroad construction relative to Britain achieved by the United States from the 1850's on and by Germany from the 1850's to the 1870's. An examination of rates of increase in this section of the table does not show any one or two particular countries being especially rapid. This is no doubt due

[29] Ibid., pp. 281-82.

to the United States' and Germany's greater area. A relatively small addition to railroad mileage in Britain shows up as a relatively large increase per square mile due to its smaller area. So this section of the table conceals a very important phenomenon, that the 1850's-70's were a period of very rapid growth of the American and German railroad systems with respect to Britain, in which they not only overtook Britain in total mileage, but may have gained crucial scale and scope advantages in industrial structure that were abetted by this rapid and extensive growth of their railroad systems.

V. DERIVED DEMAND CONTINUED: PHYSICAL CAPITAL INPUTS

Another yardstick we may use to gauge the relative importance of the railroads insofar as they stimulated different countries' railroad-input-producing industries besides mere mileage alone is the amount of physical capital inputs that went into the production of their railroad systems. Greater capital inflow to the railroads is another indicator of greater demands on railroad-input producing industries that may have stimulated these derived demand effects. If the railroads were a more important part of the industrial development of the United States and Germany, their construction may have more greatly stimulated railroad-input producing industries, such as iron, steel and coal, thus precipitating more opportunities for exploitation of economies of scale and scope advantages in these American and German industries than in the British, where the railroad system was smaller and more compact, thus less demanding of inputs from these industries. However, the historical assessment of the relative impact of the railroads on the iron and coal industries in such a capacity may however point to greater stimulation of the British iron and coal industries; a point that is bolstered further by the fact that on a

per square mile basis, Britain appeared to be the country poised to reap the greatest impact of the railroads on its economy, especially with regards to derived demand effects. If we want to measure the validity of the theory of the larger and more extensive a nation's railroad system, the greater its need for capital inputs, why not cut to the chase, and look at capital inputs themselves?

In Table 2.2 below, I delineate the total value of reproducible (physical) railway capital formation/expenditure as a flow variable for Great Britain, the United States, and Germany for every year from 1830-1914. That is followed by Table 2.3 that delineates the same but as a stock variable for every five years from 1830 until 1914.

In looking at Tables 2.2 and 2.3, we must bear in mind that since the data are in current rather than constant prices, a precise comparison of the capital stock and flows at different dates cannot be made here. Notwithstanding, in looking at Table 2.2 alone (flow), it appears that Britain experienced a brief, sharp spike in railway investment in the 1840's, followed by a relative lull in the 1850's, a bounce back in the 1860's that tapered off a bit in the 1870's, and then remained relatively constant throughout the remainder of the period surveyed.

The United States appears to have experienced a great initial thrust of railroad investment in the latter half of the 1830's that subsided in the early 1840's, but again picked up momentum in the late 1840's that continued throughout the remainder of the period in question, during which United States achieved a sustained, steady level of great investment with the exception of a brief lull in the mid-1890's. Within this period of sustained growth, there was a particularly great thrust forward in the 1860's and early 1870's; however the 1860's data may not be entirely accurate because they are estimates

made due to a break in the availability of data for those years (see Note 8, Table 2.2 below).

A high level of volatility of German investment can be observed in the figures of the 1850's and 1860's. Some of these irregularities are due to the construction of the series, which involved piecing together data from different sources (see the derivation of the German estimates in Notes 12-13, Table 2.2 below). However, the primary reason for this volatility appears to be a great imbalance between land and non-land railways purchases, with land purchases frequently comprising a large, if not the lion's share, of total capital expenditures. Since the German railways were in their infancy, it is natural to expect to see land purchases comprising a greater share of expenditure than for later years when presumably most of the land had already been acquired, and was busy being filled up with railways. However, for some reason, land purchases are more volatile for Germany than for Britain and the United States for these years, and produce a more highly variegated series for Germany for the 1850's and 1860's in particular.[30]

In order to provide a precise measure of these relative volatilities, a regression of the growth of the data for capital in Table 2.2 with respect to time has been performed for all three countries so that we can compare their residual variances. In looking at the estimates for the variance of the residuals in the regression output in Table 2.4 below, we

[30] In 1857 for instance, the Hoffmann source listed zero new capital investment including land, so when the value of the land purchases from the Fremdling source was subtracted for that year, a negative figure for capital invested was the result. There were other years in which the German railways lost land, either by selling it or perhaps having it expropriated by the government. Regardless, this loss of land translated into a negative capital expenditure, which when subtracted from the stock of total capital invested including land in one year resulted in an addition to the capital stock that sometimes was quite large. For example, the large figure for 1864, 290.09 million marks, was produced by subtracting the negative value of land loss for that year, -160.09 million marks, from the stock of total capital invested including land for that year, 130 million marks. The stock of total capital invested including land figure for 1863, 250 million marks, was actually a lot greater than the 1864 figure, but since there was a large positive land gain expenditure for that year, 214.17 million marks, when that was subtracted from that total capital invested, it produced the low level of total investment for that year, 35.83 million marks.

see that German residual variance is by far the greatest, at 25,644.97. American residual variance is the next largest at 17,271.09, and the least volatile is that of Britain at 32.11. Moreover, stationarity testing results of an Augmented Dickey-Fuller test on these data from Table 2.2 (Table 2.5 below) indicate probability of stationarity of the data in reverse order, which would be what we might expect given the greater volatility of the German data. In the case of Germany, with a probability of .7692, we would not reject the null hypothesis of non-stationarity (has a unit root). For the United States, with probability equal to .0989, it is difficult to say. But in the case of Britain, with a probability of .0005, we would definitely reject the null hypothesis of non-stationarity and assume these data are stationary.

However, this German volatility produced by an imbalance between land and non-land railways purchases appears to have diminished by the 1870's, upon whose arrival land purchases never comprise a sufficiently large proportion of total capital investment to produce such dramatic ebbs and flows of total investment as Germany experienced in the 1850's and 1860's. By the 1870's, although experiencing minor dips in investment from time to time, Germany's railways always seem to have been able to bounce back to an even higher level than before, and appear to have experienced a take-off into sustained growth. This can be shown in Table 2.4 with Germany having the highest coefficient for rapidity of growth of capital with respect to time, 5.574, followed closely by the United States' coefficient of 5.518, and Britain, predictably the least, at .115.

The primary reason for the regression was to compare residual variances and to empirically verify the greater volatility of the German data Table 2.2 appears to contain

from visual inspection. But these coefficients produced are a good secondary justification for the regression owing to their economic significance. It is interesting to notice that they show rapidity of growth of capital with respect to time in reverse chronology of industrial development. While the railroads were first developed and built in Britain, as it evolved they became more important for the industrial development of the United States and Germany. Furthermore, as "catchers-up" in overall industrial development, the United States and Germany may have faced a more urgent task in developing, building and investing in their transportation infrastructure. If so, these data definitely tend to support and verify these hypotheses.

The stationarity test was done as a procedural matter when using time series data. It has been done to check some conditions and characteristics of the data; primarily whether the mean and variance are constant over time. If the data are constantly increasing over time, then the mean and variance are also changing which affects our regression results. But our stationarity test results produced are also telling in their economic significance. Firstly, they bolster and support the residual variances results computed from the regression in that they indicate probability of stationarity of the data in reverse order of their volatility, with the most non-stationary data being that of the United States and Germany, and the most stationary being that of Britain. A more volatile data series is more likely to have a more volatile mean and variance, which this test confirms. Furthermore, our results confirm the greater rapidity of growth of capital with respect to time in the United States and Germany as it appears from visual inspection of the data, and also in the coefficients. Predictably, the more rapidly-increasing German and American capital growth have greater probability of non-

stationarity. In data that are constantly increasing over time, as it appears the American and German data do, it is more likely that the mean and variance are changing, thus the data are non-stationary. Predictably, the American and German data, with their greater rate of capital accumulation, have a more variant mean and variance, as this is displayed not only by their greater coefficients, but by their unit root tests indicating greater probability of non-stationarity than the British data.

In looking at Table 2.3 alone (stock), it appears that Britain's capital stock grew at a relatively constant rate throughout the period surveyed. The United States' railroads accumulated capital at a modest rate until the 1850's, after which they grew by leaps and bounds, not leveling off until the 1870's, and then made one more large jump between 1905 and 1910. Germany seems to have made a great "catching-up" attempt from the start of its railway system, all the way up to the 1870's. After that, it accumulated capital steadily but more modestly, until the early 20th century, during which more rapid capital accumulation appears to have occurred, which continued up until the end of the period in question.

The patterns of growth seen in both the stock and flow capital data support the general contention of more rapid capital growth and accumulation in Germany and the United States with respect to Britain, particularly from the middle of the century until the 1870's; the period coincident with the early industrialization of the United States and Germany until the time at which Chandler believed the effects of the railroad on size and structure began to have their major impact. Sharp spikes in the stock capital data, and high rates of inflow of capital for the United States and Germany as compared with steady but more modest rates for Britain at that time do not induce us to make any new

deductions that input demand effects affected the industrial development of the three countries in any significantly different way than Chandler believed market expansion did, or was revealed in the mileage data contained in Table 2.1. So they do not contradict, and buttress in fact, Chandler's idea that because the railroads were more important during the initial industrializations of the United States and Germany, they had a greater impact upon not only financial intermediation and market enlargement but also derived demand effects upon railroad-input-producing industries.

Since the data of Table 2.3 tend to move in the same direction within the same time phases as railroad mileage for all three countries, it does not appear that input demand affects impacted in a markedly different trajectory than market expansion affects. The data show the same expected ranking of magnitude of these effects by country as mileage do: the United States first, Germany second, and Britain third. Furthermore, since the data show that for all 3 countries, the 1850's-70's are the period in which the greatest amount of investment in railroads occurred, there is nothing here to contradict the notion that the benchmark time period to begin to look for evidence of these derived demand effects was any different than the time at which Chandler believed that economies of scale and scope effects related to market expansion effects were felt, which was by about 1870.

The data also do not contradict the Fogel/Fishlow argument that derived demand effects from the railroads on American industry were weak in the ante-bellum era as opposed to the post-bellum era because they show that for the United States, the greatest amount of physical capital was invested in the railroads in the 1860's and 1870's—not only for the United States, but for Britain and Germany as well. Consequently, it ought

not be at least until then that we begin to look for significant traces of expansionary effects on these industries in association with their role as suppliers of inputs to the railroads.

However, when one considers the sharp spikes in the British flow data in the 1840's and 1860's in combination with what we already know about the strong dependence of its railroad system on coal, and the strong dependence of its own, the American, and Continental railroad systems on its iron industry; not to mention its far greater railroad mileage per square mile of national territory, the railroads may have had a far greater impact on the British industrial development at mid-century than Chandler gave them credit for. The immense capital accumulation of the American and German railroad systems at mid-century may have been greatly assisted by Britain, as Chandler (and Fishlow and Fogel with respect to the United States) maintained that the American and German railroads did not become huge eaters of domestically-produced physical goods until the American post-bellum era. Then again, we must bear in mind that we are dealing with nations of very different areas. In the case of Britain, it was perhaps an easier feat to blanket such a small area with railroads, thus this was not as demanding on its other industrial sectors. So giving Chandler his due, there is perhaps some wisdom to his statement that because of Britain's smaller geographical area, the construction, financing, and management of its railroads created fewer challenges than in the United States or Germany.[31]

Furthermore, there is nothing here that makes us think that input demand effects may have impacted the different countries in a different magnitude than that which the

[31] *Scale and Scope*, p. 252.

mileage data indicated. It can be seen from Table 2.3 that just as in Table 2.1, Britain starts off as the leader in the very early days of the railroads, but by the 1850's is overtaken by the United States, and by the 1870's by Germany. Just as Table 2.1 displayed, Table 2.3 shows Britain as having experienced its last hump of great railroad investment in the 1860's, by which time its railroad system was essentially complete, and railroad investment for it as having leveled off to lower-averaging levels from the 1880's on. From the 1880's on, there is still great investment in railroads going on in the United States, corresponding to the still rapid growth of its railroad network, whereas German investment in railroads slows down to British levels by this time, as Table 2.1 showed via the lessened rapidity of German mileage growth after that date.

There is one small glitch in this in that from the 1850's to the mid-60's, Germany does not have a significant lead over Britain in these regards, and Germany and Britain are actually about tied for last place. But as was discussed and resolved in the Table 2.1 analysis above, this doesn't blow a hole in the theory. It was recognized above that Germany did not overtake Britain in mileage until the 1870's, but this fact does not obviate the possibility of significant strides having been achieved over the course of the 1850's and 1860's that could have led to the more concentrated and integrated industrial structure that Chandler believes had emerged in Germany by last quarter of the century. Greater capital market augmentation as achieved through greater reliance on outside capital for the construction of their system is one such potential pivotal catalyst. Whatever activities the German railroads were engaged in over this time, they had to have been doing something right, because some time around the 2nd half of the 1860's they began to invest a lot more than Britain, and by the mid-70's had overtaken Britain in

mileage completed. The dramatic upsurge over Britain experienced by Germany by the late 1860's (the cusp of the advent of the large industrial corporation), that continued on throughout the 1870's, comes in time to rescue the theory that by the 1870's, forces were operating in the German railroads that could have been propelling wide scale investment and financial intermediation in the business of railroads (thus economies of scale and scope in industry) in ways in which they were less likely to, or had ceased to have operated in Britain; if in fact they ever had. At least the data do not show Germany as having invested less in its railroads over this period, which would be a surprising and discouraging result in terms of explaining its rapid railroadization that occurred over the 1870's, and concomitant industrial growth experienced from that point on.

VI. SUMMARY AND CONCLUSION

To summarize the previous section, and in wrapping up this chapter in general, our comparison of the development and growth of the American, British and German railroad networks yields mixed results in terms of support for Chandler's claim that the British industrialization of the mid-to-late nineteenth century was less heavily impacted by the railroads than that of the American and German, and in terms of the nature and extent of its implicit hypothesis of a correlation between the railroads and economies of scale and scope. Our initial analysis that examined the relationship between timing of effects of the railroads on the industrial development of these countries and data pertaining to the development of the railroads themselves showed no inconsistency between the initial industrializations of the United States and Germany and the rapid development of their railroad systems that Chandler claimed gave them such a great advantage in expanding

the markets necessary for the development of other large scale industry later on. For both the United States and Germany, the mileage data contained in Table 2.1 show a rapid expansion in their railroad networks as having occurred at mid-century, a period can be roughly designated as a take-off period of growth of large-scale industrial enterprise for both nations. While Germany's most rapid growth of its railroad system does not occur until slightly later, the 1870's, it has been here revealed that this railroad growth is not too far off the mark from what can be termed Germany's "early industrialization" period in that it merely buttressed an earlier stage of growth of Germany's railroad system, and is coincident with what one might call a "second stage" of its early industrialization in which the effects of rapid railroadization upon its economy that may have been coincident with, or resultant from that earlier railroadization were realized.

In general, our comparison of mileage phases data for the three countries essentially does correspond to and support Chandler's claims that a greater expansion of the railroad systems of the United States and Germany at mid-century and a resultant vastness thereof with respect to Britain by the 1870's occurred, and could have been be a factor contributing to a more concentrated industrial sector that was intensive in the new science-based technologies of the Second Industrial Revolution, and that these forces were set in motion by the 1870's. While German mileage data indicate that it was a late bloomer compared to the United States in not overtaking Britain in mileage completed until the 1870's, the rapidity of growth of and investment in its railroads in the immediately preceding decades, combined with the unification of the German Empire and its railroad system by 1870 suggest that while the date at which to look for economies of scale and scope effects in association with the railroads in Germany may be

slightly later than for the United States—perhaps the 1880's rather than the 1870's—this is not so far later in history that it calls for a radical forward shifting of the dates to look for empirical evidence of economies of scale and scope in association with the German railroads. 1870 is a reasonable enough benchmark date for which to anticipate these economies of scale and scope effects of the railroads in Germany, as it is in the United States. The mileage phases of growth of these countries' railroad systems also support the idea that this lagged effect of the great German and American expansion at mid-century precipitated a wave of industrial growth centered around the new technologies by the end of the century, in contrast to the experience of Britain, where less rapid growth in railroads at mid-century seemingly was a detriment to the development and growth of the more modern sectors by the end of the 19th century.

In making use of our cross-country data tables for investigation of the relative magnitude of derived demand effects of the railroads on manufacturing industries across the three countries (or existence thereof), it was found that the greater physical expansion of the railroads in the United States and Germany would, on the surface, support the contention that these countries would have a greater proportion of the output of their railroad-input-producing industries actually ending up in the production of the railroads, thus greater demand-side stimulus emanating from the railroads themselves, and this could have been a factor abetting economies of scale and scope in those countries and contributing to their technological leapfrog over Britain in the late 19th century.

However, in looking at the railroad mileage per square mile of national territory data of Table 2.1, the topsy-turvy ranking order of Britain first, Germany second, the United States third raises the possibility that insofar as derived demand effects are

concerned, Britain may have received a significant boost from the railroads in its manufacturing industries earlier on in a way that the United States and Germany did not experience until long after their initial industrializations. This factor that weakens the empirical validity of Chandler's hypothesis, for it points to a later effect of the railroads on American and German industrial development in accounting for their leapfrog over Britain at the end of the century, and points to an earlier effect of the railroads on British industrial development that ought to have had a similar impact upon scale and concentration in British industry that Chandler maintains market expansion and financial augmentation effects from the railroads had on American and German industry. Empirical evidence that the American railroads did not consume a great amount of the outputs of its domestic burgeoning manufacturing industries until the late nineteenth century produced by scholars of the growth of the American railroad system such as Fishlow and Fogel, and further research provided by scholars of the growth of the British railroad system such as Bagwell and Hawke showing that it was Britain that provided the American and Continental railroad systems with much of their iron, and that the British railroads used coal far more extensively than the American railroads, which when viewed in combination with this more concentrated omnipresence of the railroads in Britain, serve to support this contention of stronger derived demand effects of the railroads in British industry at mid-century than in American and German industry. However, the growth of the American and German railroad systems at mid-century was still more rapid than that of Britain.

In comparing and interpreting rates of physical capital accumulation of the three countries, both the flow and stock capital data charts (Tables 2.2 and 2.3, respectively)

show more rapid capital growth and accumulation in the German and American railroad systems than in Britain, particularly from the middle of the century until the 1870's; the period coincident with the early industrialization of the United States and Germany until the time at which Chandler believed the effects of the railroads on size and structure of industry began to have their major impact. However, in light of the sharp spikes in the British capital flow data in the 1840's and 1860's, in combination with what we already know about the strong dependence of its railroad system on coal, the strong dependence of its own, the American, and Continental railroad systems on its iron industry; not to mention its far greater railroad mileage per square mile of national territory, we are still left with an indicator of the possibility that the railroads may have had a far greater impact on the British industrial development at mid-century than Chandler gave them credit for. Also noteworthy is the fact that Britain's rates of capital investment are on par with those of Germany all the way up until the mid-1860's. However, the dramatic upsurge over Britain experienced by Germany by the late 1860's that continued on throughout the 1870's comes in time to rescue the theory that by the 1870's, forces were operating in the German railroads that could have been propelling wide scale investment and financial intermediation in the business of railroads that had a greater stimulus on German industry than the British. Again, we must take heed not to put an exaggerated emphasis on the omnipresence of the railroads in Britain because it was probably an easier feat to blanket Britain's smaller area with railroads, thus this was not as demanding on its other industrial sectors.

In the following chapter, we take a closer look at the impact of the railroads on financial intermediation in the three countries, and the role of financial intermediaries in

the evolution of large-scale industrial enterprise. It will be revealed that the impact of the railroads on the financial super-structure of the three nations is not as different as imagined by Chandler, and that a reassessment of the Chandler hypothesis as it concerns this evolution may well be in order.

VII. TABLES, CHAPTER TWO

Table 2.1—Railway mileage for Great Britain (UK), the United States (US), and Germany (GR), every five years, 1830-1914.

	Total Railway Mileage			Total Area of Territory (Square Miles)			Railway Mileage per Thousand Square Miles of National Territory		
Year	UK	US	GR	UK	US	GR	UK	US	GR
1830	97	23	--	122,313	1,749,462	208,780	0.79	0.01	--
1835	338	1,098	4	122,313	1,749,462	208,780	2.76	0.63	0.02
1840	1,497	2,818	291	122,313	1,749,462	208,780	12.24	1.61	1.39
1845	2,530	4,633	1,332	122,313	1,749,462	208,780	20.68	2.65	6.38
1850	6,084	9,021	3,640	89,715	2,940,042	208,780	67.81	3.07	17.44
1855	7,293	18,374	4,864	89,715	2,940,042	208,780	81.29	6.25	23.30
1860	9,069	30,626	6,892	89,715	2,969,640	208,780	101.09	10.31	33.01
1865	11,451	35,085	8,639	89,715	2,969,640	208,780	127.64	11.81	41.38
1870	13,562	52,922	11,732	89,715	2,969,640	208,780	151.17	17.82	56.19
1875	14,510	74,096	17,383	89,715	2,969,640	208,780	161.73	24.95	83.26
1880	15,563	93,262	21,030	89,715	2,969,640	208,780	173.47	31.41	100.73
1885	16,594	128,320	23,351	89,715	2,969,640	208,780	184.96	43.21	111.85
1890	17,281	156,404	26,643	89,715	2,969,640	208,780	192.62	52.67	127.61
1895	18,001	177,746	28,900	89,715	2,969,640	208,780	200.65	59.85	138.42
1900	18,680	192,556	32,118	89,715	2,969,834	208,780	208.21	64.84	153.84
1905	19,535	216,974	35,264	89,715	2,969,834	208,780	217.75	73.06	168.91
1910	19,986	240,831	38,042	89,715	2,969,565	208,780	222.77	81.10	182.21
1914	20,266	256,547	38,377	89,715	2,969,565	208,780	225.89	86.39	183.82

Source Notes, Table 2.1:

GENERAL

All data pertain to miles of track open at the end of the year, and omit mileage of parallel lines. Data for Railway Mileage per Thousand Square Miles of National Territory have been calculated by dividing the data for Total Railway Mileage by the data for Total Area of Territory divided by 1000 for each country.

GREAT BRITAIN

1. British mileage data pre-1850 are from H. G. Lewin's *Early British Railways* (London, 1925) found in B.R. Mitchell and P. Deane's *Abstract of British Historical Statistics* (Cambridge, 1975), p. 225 and Peter Mathias' *The First Industrial Nation: An Economic History of Britain, 1700-1914* (New York, 1969), p. 257. Figures are rounded. Although it is not stated in the original source, comparison of these figures to other early data sources such as Parliamentary Session Papers, suggests that they include Ireland. Complete data for years preceding 1850 excluding Ireland were not available.
2. British mileage data from 1850 on are from Mitchell and Deane, pp. 225-27, and are also found in Mathias, p. 456.
3. Mileage Data for Britain for 1914 are 1913 data. Data from 1914-18 are not listed. I am assuming that little new railway construction occurred due to the war, because 1919's statistic, 20,309 miles, is little above the 1913 figure above. A further note about the 1914 data is that statistics were collected on a new basis in 1913, in which the properties of the Manchester Ship Canal Company were no longer included.
4. British territory data are from B.R. Mitchell and P. Deane's *Abstract of British Historical Statistics* (Cambridge, 1975), pp. 11-13. Data have been converted from acres. British data pre-1850 are greater because they include Ireland in order to be consistent with the mileage data in Table 2.1. British data from 1850 on include only England, Wales, and Scotland. British calculations have been rounded.

UNITED STATES

5. American mileage data are from U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C., 1975), II, pp. 727-31. The data from 1890 on are from series Q 284-312 in the above volume, which are data compiled from the annual publications of the Interstate Commerce

Commission *Statistics of Railways in the United States*. The data from before 1890, found in series Q 321-28 in the above volume, are from the U.S. Interstate Commerce Commission, *Railway Statistics Before 1890*, Statement No. 32151 (mimeographed), 1932.

6. American territory data are from U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C., 1975), I, pp. 8, 428. Data refer to land area only, excluding water area. Since the data are from United States Census Bureau reports that were done only on a decennial basis, data for the semi-decennial years, as well as for 1914, have been estimated by relying on the census statistic at the start of the decade.

GERMANY

7. German mileage data are from Brian R. Mitchell, *European Historical Statistics, 1750-1970* (New York, 1976), pp. 581-83. All German data relate to mileage contained within the area of national territory within the 1914 boundaries of the German Empire.
8. Since no, or very little, railways were in operation in Germany prior to 1835, there is no mileage listing for 1830.
9. The German mileage data have been converted from kilometers to miles, and rounded.
10. All German territory data relate to the area of national territory within the 1914 boundaries of the German Empire. Data for 1914 are from editor J. Scott Keltie (with the assistance of M. Epstein)'s *The Statesman's Yearbook: A Statistical and Historical Annual of the States of the World, for the Year 1914*, Macmillan and Co. (London, 1914), pp. 888-89, that were based on the census of Dec. 1, 1910.

Table 2.2—Gross reproducible (physical) railway capital formation/expenditure (total capital flow) for Great Britain (UK), the United States (US), and Germany (GR) listed in pounds, dollars, and marks, respectively, 1830-1914.

Year	UK Million Pounds	US Million Dollars	GR Million Deutschmarks
1830	0.34	1.60	--
1831	0.58	3.40	--
1832	0.56	4.90	--
1833	0.63	5.60	--
1834	0.64	7.40	--
1835	1.06	8.80	--
1836	3.05	12.80	--
1837	4.28	15.60	--
1838	6.44	17.40	--
1839	8.64	17.70	--
1840	9.01	14.10	--
1841	7.01	11.50	24.90
1842	5.26	8.60	39.10
1843	3.64	6.50	44.70
1844	3.86	8.20	61.10
1845	7.94	10.0	130.60
1846	19.34	16.60	166.90
1847	30.34	27.30	136.50
1848	24.85	37.40	117.60
1849	17.70	36.70	79.70
1850	10.63	36.10	74.0
1851	8.61	50.90	85.10
1852	8.24	66.40	68.70
1853	9.20	93.40	10.05
1854	11.23	110.70	185.43
1855	10.98	74.20	85.25
1856	9.47	77.0	111.0
1857	10.18	84.20	-12.54
1858	9.55	67.10	273.90
1859	9.90	60.80	58.63
1860	11.64	52.60	232.57
1861	14.37	323.0	103.0
1862	15.49	323.0	139.0
1863	18.26	323.0	35.83
1864	21.13	323.0	290.09
1865	23.37	323.0	112.69
1866	23.58	323.0	299.69

1867	18.88	323.0	47.60
1868	15.27	323.0	255.0
1869	13.61	323.0	238.07
1870	14.31	380.0	401.0
1871	16.82	420.0	230.78
1872	18.42	379.0	705.76
1873	21.42	262.0	531.21
1874	23.67	148.0	525.47
1875	25.37	105.0	491.71
1876	17.73	104.0	610.55
1877	15.80	117.0	367.29
1878	14.18	114.0	98.20
1879	11.70	125.0	533.06
1880	11.54	282.0	163.07
1881	13.84	440.0	68.41
1882	13.72	398.0	235.58
1883	15.24	283.0	186.35
1884	17.38	199.0	109.85
1885	13.93	150.0	67.23
1886	11.42	206.0	53.52
1887	10.45	275.0	84.81
1888	10.39	251.0	181.48
1889	11.22	227.0	267.11
1890	13.15	231.0	241.36
1891	15.55	237.0	189.98
1892	15.23	407.0	105.33
1893	13.61	433.0	120.99
1894	13.62	190.0	85.58
1895	14.45	69.0	192.01
1896	15.46	48.0	190.0
1897	16.95	48.0	298.61
1898	19.03	82.0	304.04
1899	20.72	175.0	304.84
1900	21.14	205.0	418.02
1901	19.93	186.0	255.27
1902	18.07	200.0	261.93
1903	19.34	217.0	353.88
1904	18.89	250.0	307.0
1905	17.33	329.0	396.39
1906	17.20	474.0	541.74
1907	14.77	570.0	621.64
1908	10.88	575.0	464.19
1909	9.45	626.0	563.24
1910	8.77	714.0	469.30
1911	9.29	653.0	455.76

1912	10.63	636.0	685.02
1913	13.61	682.0	692.02
1914	12.98	465.0	836.35

Source Notes, Table 2.2:

GENERAL

Data represent flow statistics of additional gross capital investment made within the given year listed.

GREAT BRITAIN

1. British data are in million pounds. Data from 1830-75 are from A.G. Kenwood, "Railway Investment in Britain, 1825-1875", *Economica*, New Series, Vol. xxxii, No. 127 (Aug., 1965), p. 322. Kenwood's data summarize the total of expenditures on "reproducible" or "real" capital that go to make up the physical plant of a railway. His annual investment figures relate solely to expenditures on the construction of lines (including engineering costs), on railway plant, on rolling stock, and on repairs and renewals of track and equipment. Capital expenditures excluded from his investment figures are legal and parliamentary costs, compensation charges, way-leave rents, the cost of land, and interest payments where these were made out of capital. Also excluded from his estimates are capital spent on projects not strictly speaking railway investment, including expenditures on ancillary industries such as dock construction, and the erection of staiths and coal drops, as well as money spent on steamships and the purchase of canals and tramways.
2. These data are presumed to be in current prices, although this is not stated in the original source. They are also assumed to be for Great Britain, excluding Ireland, although this too is not stated explicitly in the original source.
3. British data from 1876-1914 are from B.R. Mitchell, "The Coming of the Railway and United Kingdom Economic Growth", *Journal of Economic History*, Vol. XXIV, No. 3 (Sep., 1964), pp. 335-36. I have made these data consistent with the earlier data provided by Kenwood by taking Mitchell's figures for Total Gross Capital Formation, which include expenditures on repairs and renewals, found in Col. 5 of the table in the above citation, and subtracting figures for capital expenditures on Ancillary Businesses and Land, found in Cols. 3 and 4 respectively in the same table. Thus a figure for Total Gross Capital Formation, which includes expenditures on repairs and renewals, as well as Permanent Way and Works, and Rolling Stock, found in Cols. 1 and 2 of the table, respectively, that is essentially consistent with the Kenwood estimates, has been constructed. These data are in current prices. They are also assumed to be for Great Britain, excluding Ireland, although this too is not stated explicitly in the original source.

4. The 1914 data are net, not gross because figures of expenditure on repairs and renewals were not available in that year (see Mitchell, footnote, p. 336).

UNITED STATES

5. American data are in millions of current dollars. Data from 1830-60 are from Albert Fishlow, *American Railroads and the Transformation of the Antebellum Economy*, Harvard University Press, (Cambridge, 1965), p. 399. Gross capital formation is defined by Fishlow as all capital expenditure allocated to road construction and equipment, including replacement expenditures of equipment and way (rails and ties); basically all costs involved in railway construction (see p. 383). Although it is not stated explicitly in the text, it is implied that land costs are not included in these estimates, for as Fishlow states, "Although such outlay [land costs] is an expense to the individual road, to the economy as a whole it is only a transfer expenditure since the transaction involves no production," and that counting land, therefore, "fall[s] outside the scope of an investment series." (p. 351).
6. American data from 1870-1914 are from Melville Jack Ulmer, *Capital in Transportation, Communication, and Public Utilities: Its Formation and Financing*, Princeton University Press, (Princeton, 1960), pp. 256-57. The Ulmer series includes all expenditures (except those for land) charged to the capital account by the railroads. It includes all direct expenditures for equipment and road and structures and also "general expenditures"—that is, expenses incurred incidental to actual purchase (p. 220). This latter category, which covers organization costs and such overhead items as taxes and legal expenses, was important only in the early days of the railroads, according to Ulmer, so its inclusion here ought not create a significant upward bias above the Kenwood data that overlap this period, or the Mitchell data if they exclude these data, or the comparative German data for the same period, if they exclude these kind of costs.
7. Although it is not stated explicitly in the description of the above series, it is implied that these data exclude expenditure on ancillary industries of the type described in the Kenwood data above, for in the description of the data on value of the stock of road and equipment for the same period, Ulmer states "Under this heading is embraced all physical property of the railroads used directly or indirectly for transportation. Excluded is a small amount of physical property, such as hotels, not used for transportation" (p. 218)
8. American data for 1861-69 are estimates based upon the difference between the total value of the capital stock of 1860 and 1870 (see derivation of data of total value of capital stock for 1865 in Note 6 of Table 2.3 below). Since these estimates were constructed using data on the total value of capital stock that are based on net, not gross additions to the capital stock, they represent increases in the capital stock that are net of expenditures on repairs and replacement of worn-out capital, unlike the rest of the data in this series.

GERMANY

9. German data from 1841-52 are from Rainer Fremdling, *Eisenbahnen und deutsches Wirtschaftswachstum 1840-1879* (Dortmund: Gesellschaft fur Westfalische Wirtschaftsgeschichte, 1975), p. 32. Data are in millions of current marks, and include purchases on land because land purchase values data for these earlier years were not available.
10. For 1853 and on, German data are from Walther G. Hoffmann, F. Grumbach, and H. Hesse, *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts* (Berlin, Heidelberg, and New York, 1965), Table 42, pp. 259-60, col. 5. These data are in current prices, and in million marks.
11. Data for Germany for 1914 are 1913 data. Data from 1914-24 are not listed.
12. Data from 1853 on have been modified from their original source by subtracting the value of land acquisition as a flow variable for those years derived from data found in Rainer Fremdling, Ruth Federspiel and Andrea Kunz (eds.), *Statistik der Eisenbahnen Deutschlands 1835-1989*, (Quellen und Forschungen zur historischen Statistik von Deutschland, vol. 17), (St. Katharinen: Scripta Mercaturae Verlag 1995), pp. 512-13.
13. Land acquisition flow data were derived from the stock data in the above *Statistik der Eisenbahnen* source by converting the figure of every year to the prices of a single base year (1913) using the German wholesale price indices found in B.R. Mitchell, *International Historical Statistics: Europe, 1750-1993*, 4th ed., Stockton Press (New York, 1998), pp. 856-58. The difference between the figure of every year and the preceding year was then converted back into the prices of the year in question, and subtracted from the above Hoffmann data to arrive at the figures listed above.
14. The stock values of land acquisition for 1878-79, from which the flow values for 1878-80 were estimated, were made using the stock value of land acquisition for 1877 instead. Stock values for 1878-79 were not listed in the original source.

Table 2.3—Total value of reproducible (physical) railway capital formation/expenditure (total capital stock) for Great Britain (UK), the United States (US), and Germany (GR) listed in pounds, dollars, and marks, respectively, for every five years, 1830-1914.

Year	UK Million Pounds	US Million Dollars	GR Million Deutschmarks
1830	1.4	2.6	--
1835	5.0	31.5	--
1840	36.5	103.2	58.8
1845	55.3	135.8	281.5
1850	145.0	244.8	825.4
1855	228.8	625.3	1,766.0
1860	250.2	880.0	2,119.0
1865	315.5	2,495.0	2,731.0
1870	339.9	3,829.0	4,116.0
1875	395.5	4,630.0	7,041.0
1880	371.5	4,494.0	6,918.0
1885	361.5	5,354.0	7,273.0
1890	365.5	5,955.0	9,758.0
1895	329.9	6,104.0	8,863.0
1900	472.1	6,944.0	14,182.0
1905	476.0	7,940.0	14,399.0
1910	518.5	11,265.0	17,648.0
1914	610.3	12,687.0	21,007.0

Source Notes, Table 2.3:

GENERAL

Net, rather than gross capital formation has been used for this series construction (in general, where available) because net, as defined by Ulmer in the source cited above on p. 224, is gross less capital consumed—capital which is "used up" either through depreciation or obsolescence. Since this part of expenditure does not add to the total physical capital stock of the railroads, but merely replaces worn-out capital, it has been excluded from Ulmer's estimates of additions to the total value of road and equipment occurring in each year (see pp. 256-57). To make my calculations of value based on all other data series consistent with Ulmer's data, the same methodology has been applied to all the other data used to construct this series.

GREAT BRITAIN

1. British data are in millions of current pounds. They were compiled from various sources, adjusted to prices of a single year, cumulated over the period, and then re-adjusted to own year prices in order to obtain the series shown here. Data from 1825 (the first year of railroad construction in Britain) to 1875 are from the same Kenwood source cited above. Data from 1876-1912 are from Harold Pollins, *Britain's Railways: An Industrial History*, Rowman and Littlefield, (Totowa, N.J., 1971), pp. 112-13. The Pollins data were used rather than the Mitchell data because they were delineated in both current prices and in prices of a single year, which facilitated easier accumulation. These data are assumed to be for Great Britain, excluding Ireland, although this is not stated explicitly in the original source. Data from 1913-14 are from the B.R. Mitchell article, "The Coming of the Railway and United Kingdom Economic Growth" cited above, p. 336.
2. The series was constructed by taking the Kenwood and Mitchell data cited above and converting them to 1869 pounds using the Rousseaux Price Index for Principal Industrial Products for 1800-1913 found in B.R. Mitchell's *British Historical Statistics* (Cambridge, 1988), pp. 722-24. These data were, in turn, cumulated with the Pollins data, already in 1869 prices, and then re-adjusted back to own year prices using the Rousseaux index again. For convenience, the price deflator for 1913 has been used to convert 1914 data to 1869 data, and vice versa.
3. All the data used to construct the British series are net, except for those of 1913, from the Mitchell series cited above, which include expenditures on repairs and renewals. The 1914 data, while also from the Mitchell series, are still net because figures of expenditure on repairs and renewals were not available in that year (see footnote, p. 336).

UNITED STATES

4. American data are in millions of current dollars. Data from 1830-60 are from the same Fishlow cite as above. They have been computed by adding the figure for net capital formation in 1860 dollars for the first year of railroad construction in the United States, 1828, to the next year's figure, thus obtaining the total capital stock for each year up to 1860 in 1860 dollars, and deflating each of those figures by the composite index provided in column 2 of the table on p. 399 cited above to obtain the total capital stock value for each year in its own year prices.
5. American data from 1870-1914 are from the same Ulmer source cited above. The data listed for each year corresponds to the data of the following year listed in column 1 of Ulmer's table (i.e., 1870 on my table is 1871 data on Ulmer's). That is because Ulmer's table lists the value of road and equipment on January 1st of each year—before the capital additions for that year have occurred. Therefore, in order to obtain the value of capital for, say, 1870, that includes the value of capital additions made through that year, 1871 data must be used.
6. Data for 1865 have been estimated by taking the difference between the capital stock at the end of 1860, $880 million, and at the beginning of 1870, $3,787

million, which equals $2,907 million, dividing that figure by 9, representing the nine annual periods between the beginning of 1861 and the end of 1869, to obtain an average annual net capital stock addition of $323 million. That figure was multiplied by 5, representing the 5 annual investment periods encompassed by 1861-65, obtaining $1,615 million. This figure was added to the total capital stock of 1860, $880 million, to obtain the estimate for total capital stock of 1865 listed above, $2,495 million.

7. The great disparity between the 1860 figure of $880 million and the 1870 figure of $3,829 million, both listed in current prices, probably indicates a great deal of inflation as having occurred over this period due to the American Civil War. However, since the figure for 1865 represents an average of capital increase that occurred between 1860 and 1870 using the current prices of both periods, the effects of the inflation that occurred in that period are probably well taken into account, and this figure may thus be a reasonably good estimate of the value of the capital stock as it existed at that time in current prices.

GERMANY

8. German data are in million marks. For years before 1855, they are from R. H. Tilly, "Capital Formation in Germany in the Nineteenth Century", *Cambridge Economic History of Europe*, VII (1978), p. 417. These data are presumed to be in current prices, although this is not stated explicitly in the original source. They are also assumed to represent cumulative capital formation, due to the steepness in jumps in between each five-year period, although this too, is not stated explicitly in the original source. Due to this factor, and to the unavailability of any earlier data for German railroad capital, these data have been used instead of an aggregation of the Fremdling data. Since the Fremdling data are only flow data, they provide us with no indication of the cumulative capital formation as it existed in 1841 or earlier.
9. For 1855 and on, German data are from Walther G. Hoffmann, F. Grumbach, and H. Hesse, *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts* (Berlin, Heidelberg, and New York, 1965), Table 40, pp. 255-56, col. 5. These data are in current prices. These data were delineated in a separate table from the flow data from this source that were used in Table 2.2.
10. German data from before 1850 include the value of total land acquisition because data for land acquisition for earlier years were not available. Data from 1850 on have been modified from its original source by subtracting the value of land acquisition for those years found in Rainer Fremdling, Ruth Federspiel and Andrea Kunz (eds.), *Statistik der Eisenbahnen Deutschlands 1835-1989*, (Quellen und Forschungen zur historischen Statistik von Deutschland, vol. 17), (St. Katharinen: Scripta Mercaturae Verlag 1995), pp. 512-13. These data are assumed to be in millions of current marks, although this is not stated in the original source. The figure from 1850 was estimated by using the data on land acquisition from 1852 from the above source; data for 1850 were not listed.
11. Data for Germany for 1914 are 1913 data. Data from 1914-24 are not listed.

Table 2.4—Summary Output of Regression Analysis of Gross reproducible (physical) railway capital formation/expenditure (total capital flow) with respect to year for Great Britain (UK), the United States (US), and Germany (GR), 1830-1914.

SUMMARY OUTPUT FOR UK

Regression Statistics	
Multiple R	0.450560917
R Square	0.20300514
Adjusted R Square	0.193402792
Standard Error	5.666940761
Observations	85

ANOVA

	df	*SS*	*MS*
Regression	1	678.9330511	678.9330511
Residual	83	2665.48006	32.11421758
Total	84	3344.413111	

	Coefficients	*Standard Error*	*t Stat*
Intercept	-202.485794	46.90121658	-4.317282339
X Variable 1	0.11518761	0.025051917	4.597955913

SUMMARY OUTPUT FOR US

Regression Statistics	
Multiple R	0.72171258
R Square	0.52086904
Adjusted R Square	0.51509638
Standard Error	131.419517
Observations	85

ANOVA

	df	*SS*	*MS*
Regression	1	1558375.589	1558375.589
Residual	83	1433500.419	17271.08938
Total	84	2991876.008	

	Coefficients	*Standard Error*	*t Stat*
Intercept	-10124.694	1087.66537	-9.308648113
X Variable 1	5.51859293	0.580967927	9.49896314

SUMMARY OUTPUT For GR

Regression Statistics	
Multiple R	0.601933467
R Square	0.362323899
Adjusted R Square	0.353467287
Standard Error	160.1404766
Observations	74

ANOVA

	df	*SS*	*MS*
Regression	1	1049135.471	1049135.471
Residual	72	1846438.001	25644.97223
Total	73	2895573.471	

	Coefficients	*Standard Error*	*t Stat*
Intercept	-10212.41638	1636.409031	-6.240747992
X Variable 1	5.574404591	0.871532964	6.396091511

Table 2.5—Summary Output of Augmented Dickey-Fuller test for stationarity of data for Gross reproducible (physical) railway capital formation/expenditure (total capital flow) for Great Britain (UK), the United States (US), and Germany (GR), 1830-1914.

Null Hypothesis: UK has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.437774	0.0005
Test critical values:	1% level	-3.511262	
	5% level	-2.896779	
	10% level	-2.585626	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: US has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.591154	0.0989
Test critical values:	1% level	-3.511262	
	5% level	-2.896779	
	10% level	-2.585626	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: GR has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.942116	0.7692
Test critical values:	1% level	-3.524233	
	5% level	-2.902358	
	10% level	-2.588587	

*MacKinnon (1996) one-sided p-values.

Chapter Three: EFFECTS OF THE RAILROADS UPON FINANCIAL INTERMEDIATION

Introduction

Continuing our analysis of the nature and extent of the correlation between the railroads and the more concentrated, large-scale mode of industrial organization that had evolved in the United States, Germany, and purportedly to a lesser extent in Britain by the late 19th century, we now begin to take a closer look at the role of financial intermediaries in that evolution, and provide a similar critical assessment of the Chandler hypothesis that the British industrialization of the mid-to-late nineteenth century was less heavily impacted by the railroads due to a lesser impact of its railroads on financial intermediation. In our task of measuring the degree of correlation between the railroads and greater concentration and scale of industry that was achieved through the strengthening of financial intermediation, we conduct a similar analysis that attempts to juxtapose the timing of effects of the railroads on the industrial development of these countries with data concerning the financing of the railroads themselves. This methodology is therefore a continuation of the pattern of the analysis of the railroads' market-expanding properties and input demand effects of the previous chapter that juxtaposed the timing of effects of the railroads on the industrial development of these countries with data concerning mileage and physical capital invested in the railroads. In so doing, we were able to evaluate the degree of the correlation between the railroads and greater concentration and scale of industry achieved through the railroads' market-expanding properties and input demand effects. Here we do the same, but with respect to the organizational impact achieved through the railroads' impact upon financial intermediation; and using financial, not physical capital data. But we will first begin with

a literature overview that critically examines Chandler's not-well-documented assertions regarding the differing means of financing of the British, American and German railroads, to be followed by the theoretical framework of our empirical analysis and a summary of its results.

I. CHANDLER ON THE EFFECTS OF THE RAILROADS ON CAPITAL MARKETS IN BRITAIN, THE UNITED STATES, AND GERMANY: EMPIRICAL VALIDATION?

To briefly recapitulate and expound upon the principles earlier discussed, Chandler maintained that because the American and German initial industrializations occurred in tandem with the building of their railroads, the organizational and structural revolutions associated with the railroads were firmer in the saddle at mid-century than in Britain, where a smaller scale mode of industrial organization based on individual proprietorships, partnerships, and family-owned firms that had sufficed for the earlier production technologies of the First Industrial Revolution continued to prevail on into the latter part of the 19th century. Owing to the fact that Britain had an extensive transport system consisting of canals, coastal shipping, and wagon trails intact prior to the railroad, the railroad as a means of goods transport assumed a lesser degree of importance for Britain than for these later industrializers who, lacking such extensive pre-railroad transport systems, naturally constructed theirs in the most up-to-date manner, and consequently, by the mid-century, possessed much more railroad-intensive goods transport systems than Britain. Due in part to this later industrialization, and also due to their greater geographic size and population, the American and German railroads systems became far more extensive than the British railroad system. The importance of the

railroads to the American case of linking up newly-settled frontier areas in the west with the established commercial centers of the east across wide-open spaces is obvious. In the German case, greater land area combined with lesser sea access (a nearly land-locked country) may have also been a factor contributing to the omnipresence of the railroads there, as opposed to in Britain, where coastal shipping may have remained a viable option concurrently with the railroads.

The tremendous capital needs of the construction of these railroads greatly stimulated financial intermediation in the United States and Germany, as their construction called for funds way beyond the recourse of a lone entrepreneur. While the British railroads also bore these characteristics, due to their smaller and more compact nature, they were able to be financed more internally than their American and German counterparts, according to Chandler. In the United States and Germany, the construction and continued operation of the railroads called for an incorporated joint stock form of enterprise in which significant sums of outside capital had to be obtained in exchange for share ownership. A more modern form of industrial organization, it is said, evolved in the United States and Germany this way, characterized by large firms of these types in which the managers were not the owners. Instead, the owners were shareholders scattered around the country, and funds were raised by large investment banks whose business grew as more of this type of enterprise evolved.

Chandler calls this type of enterprise “managerial” capitalism, and credits the railroad greatly with providing the impetus towards its creation. As a result of the railroads, the business of investment banking grew, and these banks became well versed in the practice of funneling capital out to fledgling other types of large, capital-intensive

industry. These banks grew, branched out, and diversified, and before long, the United States and Germany were poised with all of the requisite tools and apparatus for the building and maintenance of other large-scale, capital intensive industry, including the necessary financial mechanisms, and thus the stage was set for their subsequent rapid industrialization based on the modern production technologies.

In Britain on the other hand, the smaller and more compact railroad system that evolved did not require such huge quantities of outside capital as the German and American railroads, and was therefore capable of being financed by more traditional, local mechanisms. Consequently, the dramatic reorganization of industrial structure that was required for the construction and continued operation of the American and German railroads, and concomitant huge role for investment banking in funneling huge quantities of outside capital for the construction, maintenance, and basic operation of the railroads, did not occur in Britain, or at least not to as great an extent as it did in the United States and Germany. In Britain, the smaller scale mode of industrial organization based on individual proprietorships, partnerships, and family-owned firms that had sufficed for the earlier production technologies of the First Industrial Revolution remained largely intact. Furthermore, the large financial institutions specializing in the channeling of large sums of outside capital that were necessary in order to create enterprise of the mammoth corporate variety also did not evolve to the extent that they did in the United States and Germany. Consequently, later on in the era of the 2nd industrial revolution when the industrial landscape began to be changed by the modern, science-based industries of the "Second Industrial Revolution", in which efficiency and competitiveness called for enterprise of the mammoth corporate variety capable of exploiting their vast potential for

economies of scale and scope, British industrial development was hamstrung. It was hamstrung firstly by an industrial structure consisting of individual proprietorships, partnerships, and family-owned firms that was ill-suited, in fact, incapable of reaching the threshold scale for efficiency in the modern sectors, and secondly by lack of appropriate financial intermediation facilities that would be "up to the task" of providing the capital necessary for such a reorganization of industry even if the will, desire and ability to modify the prevailing mode of industrial organization was present.[1]

Chandler's assertion that because the British railroads were smaller scale, and more internally-financed, their construction did not have as great an impact on investment banking as the American and German railroads needs to be empirically validated. In order to draw these conclusions, Chandler referred to various sources dealing with the financing of the early British, American and German railroads (including his own previous work), and came to separate conclusions for each regarding the degree to which its early railroad companies relied on outside capital, and experienced concomitant financial augmentation. He inferred from these sources that the British railroads were much more locally-financed than their American and German counterparts, and that consequently, Britain did not receive as much financial augmentation in connection with the railroads. He asserted this as fact in *Scale and Scope*, but never produced any concrete empirical evidence, or cited any studies that demonstrated that this is, in fact the case.

An examination of the literature that Chandler cites, as well as other sources dealing with the financing of the British, the American and German railroads, reveals some crucial insight into the difference between the way the British railroads were

[1] *Scale and Scope*, pp. 54-58, 252-55, 397, 411-19.

financed vs. their American and German counterparts. From this literature, it is not at all certain that the British railroads were less externally-financed than their American and German counterparts, and nor is it demonstrated that Britain received significantly less of an augmentation of its financial intermediation facilities in connection with the business of railroad finance. From this literature, it appears that the British railroads were also heavily externally financed. Moreover, Britain also experienced significant financial augmentation in connection with the railroads, but this augmentation was merely of a different character than that experienced by the American, just as that experienced by the American differed from that experienced by the German.

The following literature survey analyses Chandler's key points on the differences between the impact of the railroads on capital markets of the three countries, his sources for these points, and additional key readings on the subject. The literature surveyed below still does not contain any concrete empirical evidence, or cite any studies that can be used to compare the precise degree of outside financing of the railroads of these countries, or the precise degree of financial augmentation experienced by the three countries in connection with the business of railroad finance. This points to the need for further empirical work in this area in order to determine if in fact it is the case that the American and German railroads were more heavily reliant upon outside capital in the construction of their railroad systems, and if this greater reliance on outside capital is associated in any way with greater growth of investment banking industry; some of which has been included in this study. One fact that does emerge as fairly certain is that Britain did not appear to suffer from lack of adequate investment banking facilities at the end of the 19th century. Why Britain failed to make the necessary investments in the

large-scale, science-based industries of the late 19th century, and its industrial sector grew less rapidly than that of the United States and Germany is difficult to pinpoint, but it does not appear to be due to lack of appropriate financial apparatus.

II. BRITAIN AND THE UNITED STATES: CHANDLER VS. THE SCHOLARS

Insofar as the impact of the railroads on American capital markets, a critical examination of Chandler's *Scale and Scope*, and the sources he cites, does appear to indicate a great deal of outside financing of the early American railroads, and a great deal of financial augmentation in the United States in connection with this financing that was centered on New York. However, these sources still do not contain any concrete empirical evidence, or cite any studies indicating the precise degree of outside financing of the American railroads, or the precise degree of financial augmentation experienced by the United States in connection with the business of railroad finance that can be held up to other countries for comparison. Chandler states in *Scale and Scope*,

> Besides being the first business to be administered through extensive hierarchies and the first to compete in a modern oligopolistic manner, the railroads were the first enterprises to be funded by modern financial institutions. The unprecedented capital requirements for constructing the American railroad network led to the centralizing and institutionalizing of the nation's money market in New York City. In volume of transactions, and complexity of operations the New York money market quickly became second to that of London. From the 1850's to the late 1890's the institutions and instruments of finance on Wall Street were used almost exclusively to finance the railroads. In fact, nearly all the instruments and techniques of modern finance in the United States were perfected in order to fund the construction of railroads and to facilitate their growth through merger and acquisition. Before 1900 the great investment banks that were to play an important role in the financing of industrial mergers at the turn of the century and in the subsequent rationalization of facilities and personnel—such houses as J. P. Morgan; Kuhn, Loeb; Lee, Higginson; Kidder, Peabody; and Winslow, Lanier—concentrated on railroad finance.[2]

It is implied in the above passage that because the railroads required such vast sums of outside capital, great investment banking houses came into being as a result of such activity, and these houses later came to play a great role in the later industrial

[2] Ibid., pp. 57-58.

expansion experienced by the United States associated with the great merger movement of the late 19th century in which large scale enterprise in the United States came into full bloom, and the great scale and scope achievements of American industry were realized.

Chandler's only source cited for the above statement is his own previous book, *The Railroads: The Nation's First Big Business* (1965) [3], a collection of original sources and readings (mainly reprints from *The American Railroad Journal*) dealing with the early American railroads which he compiled, edited, and wrote prefaces and introductions to chapters and sections of. The financing of the early railroads is mainly dealt with in Part II, "The Beginnings of Modern Corporate Finance".[4] In his introductory notes to this section, he merely cites some figures detailing the tremendous cost of the early railroads, with no sources cited. He then proceeds to explain that due to the tremendous capital costs of constructing the railroads, local sources of capital (individuals living in a road's termini or along its line who believed they had much to gain from its construction, or banks and stock exchanges situated in a road's termini or along its line) were insufficient for the railroads' construction, thus outside capital from distant sources was required. This resulted in the centralizing and institutionalizing of the nation's money and investment markets on Wall Street, and the rapid expansion of the New York Stock exchange after 1850 as securities of railroad corporations began to be listed and traded on its floor.[5] Again, no sources provided.

Essentially, the "sources" of the above statements, it is implied, are the original articles presented in the following section of the book. Yet none of these sources contain

---

[3] Chandler, Alfred D., Jr., ed. *The Railroads: The Nation's First Big Business* (New York, 1965). Hereafter *Railroads.*
[4] Ibid., pp. 43-94.
[5] Ibid., pp. 43-45.

figures that tell us the exact quantities of total railroad capital that was “outside”, or present any data that tell us the percentage that was outside vs. local. It is merely composed of articles from contemporary observers concerning the different methods and instruments of financing, and describing ways of marketing railroad securities that were used by directors of various investment houses. While the articles are interesting and informative insofar as they detail and recount the growth of a new form of industrial finance and provide a glimpse into the world of investment banking that was forming in New York at the time, and provide us with a portrait of the empire builders; men in the process of building their large powerful and profitable business empires, they are short on providing evidence of the magnitude of the quantity of capital such enterprise contributed to the railroads that we can use to hold up to a comparison to other countries such as Britain. Nor do they provide us with a quantitative measure of the magnitude of growth of the money market that Wall Street experienced that Chandler claims is associated with the “centralizing and institutionalizing of the nation’s money market in New York City”, and the tremendous “volume of transactions, and complexity of operations” the made New York money market second to that of London that were supposedly the consequence of this augmenting force of the new business of railroad securities transactions. If the New York money market did grow to these great lengths, and it was railroad securities transactions that caused it, Chandler does not present the evidence that proves it. None of the old articles contained herein from *The American Railroad Journal* contain it. This book provides a nice chronicling of the flurry of activity on Wall Street in those days wrought by the likes of Morgan and Winslow, Lanier and the rest, but with no numbers to

really back up the claims he is making here that railroad security dealings are what were responsible for making the New York exchange what it became.

Later on in *Scale and Scope*, Chandler makes the contention that the British railroads were constructed using a greater proportion of local capital than the American, and that the activities of railroad finance had a greater augmenting effect on the New York capital market than on British capital markets. Again, an inspection of both the American and British sources Chandler uses to support these contentions provides no data, or any links to sources containing an exact breakdown of how much capital used in the construction of the early American or British railroads was outside vs. local, or the exact percentage growth of the American or British capital markets that occurred as a consequence of railroad finance activity. In comparing the impact of the railroad in Britain to that of the United States, Chandler explains

> Because Britain began to industrialize well before the coming of the railroad, the telegraph, the steamship, and then the cable, these innovations in transportation and communication had much less impact on industrial institutions there than in the United States, or in Germany. Not only had Britain become an industrial urban economy before the building of the railroad network, but its much smaller geographical area had required a smaller, tighter network than did the United States. Thus the construction, financing, and management of railroads created fewer challenges in Britain than they did in the United States. [6]

Later, in comparing the impact of the railroads in Britain to that of the United States, Chandler makes even more audacious claims concerning the difference between the means of finance of the American and British railroads, and the impact on capital markets it supposedly had.

> Nor did the coming of the railroads have so great an impact on capital markets in Britain as they did in the United States. In industrial Britain, railroad promoters were able to rely more on local capital than could their American counterparts in the rural areas of the recently settled South and West. When railwaymen did go to London, the world's largest and most sophisticated money market, they had little difficulty in raising the funds needed. True, the new demand for railroad capital did lead to the development of new financial instruments—preferred stock and debentures. Industrialists would later use the same type of

[6] *Scale and Scope*, p. 252.

> nonvoting securities to meet their capital needs without losing control of their enterprises. British stockbrokers, such as the partners in Foster & Braithwaite, Haseltine Powell, and Henry Cazenove, took their places on the railroad boards. In no sense, however, did they acquire the influence, both formal and informal, that the New York investment bankers enjoyed in the affairs of American railroads at the turn of the century…In America the far greater capital requirements of the railroad network resulted in centralizing and institutionalizing the American capital market in New York, thus creating the second largest money market in the world. In Britain the smaller requirements of a much smaller network only enlarged and refined somewhat the activities of what had long been the world's largest financial center.[7]

Several statements here require empirical validation. Firstly, there is the contention that the British railroads were constructed using a greater proportion of local capital than the American, and secondly that the activities of railroad finance had a greater augmenting affect on the New York capital market than on the London.

Chandler's sources for the above information consist of, for the American railroads, his own book, *The Visible Hand* (1977)[8], and for the British, two books by T.R. Gourvish: *Railways and the British Economy, 1830-1914* (1980)[9] and *Mark Huish and the London and North Western Railway: A Study of Management* (1972).[10]

An inspection of the American sources in which Chandler cites himself provides no data, or any links to sources containing an exact breakdown of how much capital used in the construction of the early American railroads was outside vs. local, or the exact percentage growth of the American capital market that occurred as a consequence of railroad finance activity. In *The Visible Hand*, Chandler states that no other enterprises required as large sums of outside capital as the railroads, but does not provide any cites to justify this claim.[11] In *The Visible Hand*, we find merely a repetition of what Chandler states in *Scale and Scope* concerning the supposed centralizing and institutionalizing of

---

[7] Ibid., pp. 253-54.
[8] Chandler, Alfred D., Jr. *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, Mass., 1977). Hereafter *Visible Hand*.
[9] Gourvish, T.R. *Railways and the British Economy, 1830-1914* (London, 1980). Hereafter Gourvish (1980).
[10] Gourvish, T.R. *Mark Huish and the London and North Western Railway: A Study of Management* (Leicester,1972). Hereafter Gourvish (1972).
[11] *Visible Hand*, p. 187.

the American capital market on Wall Street as a result of railroad finance, and the massive amounts of outside capital the railroads required for their construction. There are no cites for this information provided except for a footnote to one paragraph in which Chandler explains that railroad promoters seeking funds came increasingly to the New York capital market to obtain these funds.[12] His cites for this statement are again works of his own, "Patterns of Railroad Finance, 1830-1850" (*Business History Review*, 1954) and Chapter Four of *Henry Varnum Poor, Business Editor, Analyst and Reformer* (1956).[13]

"Patterns of Railroad Finance" is mainly a summary of the triumph of New York over Philadelphia and Boston in becoming the nation's financial center, and the role of railroad securities dealings in the process. The article essentially chronicles the story of the early American railroads, and explains how, as these railroads spread into the newly- and sparsely-settled lands of the south and west, they were unable to obtain the needed funds locally, and came to increasingly rely on the established financial centers of the Northeast for the necessary financing. It was by acting in this capacity, Chandler explains, that by the 1850's New York became established as the chief artery of the nation's financial system. The article discusses several railroads, where they got their funds, but contains no data summary of the total financial transactions incurred over this period that tells us the total quantity of outside capital employed by the railroads of the United States over this period. The overall picture one receives from reading the article is that outside capital does begin to play a very important role in the funding of the

---

[12] Ibid., pp. 90-91.
[13] Chandler, Alfred D., Jr. "Patterns of Railroad Finance, 1830-1850," *Business History Review*, 28:248-263 (September 1954), and Chandler, Alfred D., Jr. *Henry Varnum Poor, Business Editor, Analyst and Reformer* (Cambridge, Mass., 1956). Hereafter, *Poor*.

railroads, and there does seem to be the beginning of quite a flurry of activity in railroad securities on the Wall Street of the 1830's-50's, but as far as evidence you can hold up to the case of another country like Britain and prove that the American railroads were more heavily reliant on outside capital, the article comes up short.

Chapter Four of *Henry Varnum Poor* contains scarcely better empirical analysis of the capital composition of the early American railroads. It is essentially a biography of Chandler's great-grandfather that focuses on his career in business journalism as editor of the *American Railroad Journal* in the twelve years before the Civil War and the *Manual of the Railroads of the United States* in the postwar years.[14] Chapter Four summarizes the manner in which Poor attempted to act as the railroads' representative to Wall Street, by providing advice to railroad promoters on how to market their securities so as to attract wealthy investors, and also by promoting the railroads as sound investments in order to attract the necessary funds. Little valuable insight as to the precise capital composition of the railroads is provided, other than the fact we know already: that due to the tremendous capital cost of the railroads, and the inadequacy of capital resources in the sparsely-settled southern and western regions of the country the railroads were making their way across, railway promoters had little recourse but to seek funding from the large established capital markets of the northeast, chiefly New York, Philadelphia and Boston. Poor's mission was thus firmly cut out for him; he had to do the best job he could at representing the railroads as sound investments to the Eastern and foreign investors who purchased their securities through the large Northeastern markets, and do the best job he

[14] *Poor*, p. 1.

could in his editorializing to provide sound advice to railroadmen on how to market their securities so as to make them attractive to these large investors.[15]

The chapter does not contain any facts or figures that can be used to determine the data we are seeking in this study, namely the precise composition of capital used in the railroads that could be considered "outside" at various dates that could be used to compare with the British or the German to see how heavily funded by outside capital the American railroads were as compared with the British or German railroads. However, it does provide us some explanation as to why the market for railroad securities in the United States became concentrated in New York, and the New York market became the colossus it became. As will be shown below, the main different contrast between the effect of the railroads on capital markets in Britain vs. that of the American is that in Britain, this growth in capital markets was initially dispersed across a variety of urban centers, with northern areas' financial exchanges such as Liverpool, Manchester, Leeds, Birmingham and Glasgow sharing in the profits and growth from railroad finance along with London. While it is quite understandable that the American railroads would seek their capital from established centers in the East, why was it that Philadelphia and Boston, and perhaps other Eastern cities did not share in the growth that New York experienced? Why was the American capital market growth concentrated in New York, and not also dispersed across pre-existing American industrial urban regions as in the British case?

Chandler summarizes the reasons why the New York market became the center of the railroad finance industry, and grew also to become the principal artery of industrial finance in the United States very succinctly in this chapter. Chandler explains that, with

[15] Ibid., pp. 72-73.

the exception of the early New England roads, the early American railroads were funded more by bonds than by stock, because investors at that time preferred the secured principal and guaranteed interest of bond issues. Further, because middlemen were required to market these bonds to investors scattered overseas and in the few large American coastal cities, and the only men who had the expertise and connections necessary to market securities this way were those who operated in New York, Philadelphia and Boston, these became the principal markets for railroad securities.

Philadelphia in the 1830's was originally the largest market for railroad securities due to a thriving business partnership selling railroad bonds to British mercantile houses that was spearheaded by the most active firm in that market, Thomas Biddle and Company. However, when the depression precipitated by the financial crises of 1837 and 1839 destroyed British confidence, Biddle's bank failed, along with it Philadelphia's primacy in American railroad finance. Boston, however, was able to weather this storm due to the fact that it had been the primary financier of the Northeastern roads, and thus was not dependent on British capital. With a stockpile of savings from the still-profitable textile mill industry of Massachusetts, Boston remained a great railroad finance center until the depression that struck New England in 1847. Boston's railroad capital industry, built on equity finance, was no longer competitive as investors' preference switched to more secure bond issues. Railwaymen then turned to the New York railroad bond market, with greater specialization in the marketing of bonds and lower interest rates. By that time, New York was booming in food export trade, as the Irish and German famines had increased demand for exports, and also a massive import trade consequent of the depression abroad that had forced down import prices. New York was thus able to

provide a reservoir of capital to be tapped that was unavailable in the other cities. By the 1850's, New York was financing most of the United States' railroad construction.[16]

As for a comparison with the British railroad systems, Chandler's citations, the Gourvish books, are equally vague in terms of being able to provide us with any definite figures on outside capital with which to hold up against the American and determine whether the American railroads were in fact more heavily dependent on outside capital or not. Nor do they provide us with any definite yardstick figures with which it may be possible to compare the growth of the London, or other British exchanges in connection with the railroads with that of the American.

The most striking factor of all, however, is that the very sources Chandler cites for his British information that he uses to make this comparative assessment of the lesser impact of the railroads on the growth and evolution of industrial finance there actually paint a very different picture of this process than Chandler presents in *Scale and Scope*. While acknowledging that the railways obtained their initial financial support from local interests, through such means as public meetings and local advertising, Gourvish (1980) points to the growth of two main reservoirs of capital that established themselves as financial centers to meet the needs of not only railroads serving their own areas, but of those distant from them: London and Lancashire, which Gourvish maintains assumed a role of primary importance in the promotion of companies from the 1830's on. In addition to the Liverpool and Manchester exchanges that arose in the 1830's, provincial exchanges arose in Leeds, Glasgow, Edinburgh, and elsewhere to meet the task of helping finance the railroads during a further railroad boom that occurred in 1844-45.

---

[16] Ibid., pp. 74-79.

According to Gourvish, while local capital was prominent in the financing of the early British railroads, as evidenced by the creation of the provincial stock exchanges, this should not be misinterpreted to mean that the railroads were inexpensive to build, or that all capital needs were satisfied by the then-existing facilities. On the contrary, the ballooning of exchanges across the land, in addition to that of London, is testimony to a great extension of the British capital market in connection with the railroads. According to Gourvish, the British railroads were also very costly to build during their formative era; so much so that the London Stock Exchange also experienced dramatic growth from the mid-1830's on that was coincident with a radical restructuring of the British capital market marked by a shift in emphasis towards railroad company securities. According to Gourvish's research, railways made a tremendous impact on financial markets in Britain through the marketing of railway paper, which extended the geographical and occupational base of investment, thereby transforming the Victorian capital market. It was in this extension of the capital market, Gourvish states, and the encouragement to savings that the railways had their most pronounced impact on the economy. A new class of investor, it is claimed by Gourvish here, was introduced into industrial capitalism as a result of this railroad financing activity that resulted in a steady expansion of shareholding on a broad front.[17]

A very different picture, indeed, of Britain from that presented by Chandler in his own work. To read Chandler, one would infer that the provincial facilities that arose to help finance the railroads were of a small-scale and local character, and were inconsequential as to growth and further development of the British capital market. Furthermore, one would infer that London experienced little growth or change as a result

[17] Gourvish (1980), pp. 16-17.

of its railroad financing activities. Such an anomalous description of the impact of the railroads on British industrial finance compels a further investigation of the vast literature surrounding the subject in order to determine the precise impact of railroad finance on the British capital market, and how it differed from the American and German.[18]

*

An enquiry into the literature surrounding the financing of the early British and the American railroads reveals that some of Chandler's conjectures and opinions may be hyperbolic. In examining the work of Albert Fishlow, we find that Chandler's claim of the perennial reliance of the American railroads on outside capital may be exaggerated. Fishlow, while accepting the notion Chandler advances that the business of railroad finance in the Ante-bellum era contributed a lot to augmenting the degree of savings total in the economy, and developing the capital market centered in New York, does not believe this reliance on the capital markets of New York was as great as is stated by Chandler. Fishlow maintains that it was only mainly the Western railroads for whom outside capital was exceedingly important, and the subsequent development of the New York capital market was due, in part, to its role as a conduit by which to access funds

[18] To briefly touch on Gourvish's 1972 book, *Mark Huish and the London and North Western Railway* before we embark on this investigation, it is mainly a study of the managerial innovations Mark Huish contributed to the London & North Western Railway as its manager from 1846-58 (pp. 108, 253-54). The sections cited by Chandler only deal with the managerial organization of the London and North Western Railway, and the new techniques that Huish contributed. As for the means of financing of the railroad, and the railroads in Britain in general, there is little information provided in this book, apart from a brief description of the ways in which Huish procured funding for his company: compiling share lists, issuing circulars announcing further calls on shares, and writing to agents in Liverpool, Dublin, Manchester, and Birmingham in connection with arrears and checking accounts. However, the brief section on the financing of the railroad also reveals the story of a significant railroad in the history of Britain's early system that certainly was not wholly dependent on local capital for its financing. According to Gourvish, the London and North Western Railway enjoyed significant local support, with the Lancashire investment common to most early railroad projects, but also received significant contribution from Scottish financial interests with whom Huish enjoyed a particularly close relationship (pp. 90-91).

from abroad. The Southern railroads, on the other hand, had been able to finance their construction from mainly local sources. Furthermore, Fishlow claims that extensive reliance on imported and outside capital was mainly a feature of the early construction of the American system pre-1850's, when the price of rails was very high. These high costs forced railroadmen to seek additional funds that were not available locally. When the price of rails came down in the 1850's, the American railroads were able to rely upon local sources of finance much more extensively.[19] Moreover, Fishlow notes that much of the funds that the United States used to construct its railroad system were borrowed from abroad; particularly from Britain.[20] So if one were to count as "outside capital" capital raised from outside the country, this "gift" towards the enlargement of a nation's railroad system, if substantial, would certainly show a significant degree of outside capital as being invested in your domestic railroad system, but would have little stimulating effects on a nation's own domestic financial capital industry. On the contrary, it would have a greater stimulating effect on the financial industry of the donor nation; in this case, Britain.

However, far more misleading is Chandler's depiction of the impact of the railroads on the capital markets of Britain. As alluded to above in the survey of the Gourvish literature, it is revealed by the growth of the London and Lancashire exchanges in response to the capital needs of the railroads that the British railroad system was also very expensive to build. Local capital sources were not always sufficient, and a new variety of large-scale finance of industrial enterprise may have come into existence in Britain in connection with the railroads in a manner very similar to that as it occurred in

[19] Fishlow, pp. 117-18, 245, 247, 273.
[20] Ibid., pp. 107-08, 117-18, 302.

the United States. A further investigation of Chandler's sources and the remaining vast literature on the subject leads one to draw vastly different conclusions regarding the degree of outside capital involved in the construction of Britain's railroads and the consequent impact of this means of finance on the British capital market as a whole. As it turns out, the impact of the railroads on the financial structure of Britain during the 19th century was not that different from its impact in the United States, or Germany either for that matter. While there were some minor differences that will be discussed below, it appears that the British railroad system was also heavily financed by outside capital, and the British financial system also received a great deal of augmentation in connection with the railroads.

M. C. Reed (1975) summarizes the chief impact of the railroad construction of the mid-19th century in Britain as follows: "Increasing railroad demands on the capital market were accompanied by the development of market institutions, most clearly seen in the growth of stock exchanges."[21] The dramatic impact of the business of railroad finance on the financial landscape of Britain is also acknowledged by Hawke, who similarly points out the considerable impression the railroads made on British stock exchanges, greatly increasing the volume of trading in non-government debt in London, and stimulating the growth of stock exchanges in provincial towns.[22]

A major point that deserves emphasis here is that the railroads could not have been as cheap to construct as Chandler would have us believe if their construction precipitated this kind of growth of financial exchanges. Regardless of their location, whether concentrated in London, or dispersed across the provinces, if there was in fact,

---

[21] Reed, M.C. *Investment in Railways in Britain, 1820-1844: A Study in the Development of the Capital Market* (London: Oxford University Press, 1975), p. 209. Hereafter Reed (1975).
[22] Hawke, pp. 388-90.

such a dramatic growth in the number of financial institutions in the land, and if there was such a dramatic increase in the volume of trading activity in the London exchange as a result of railroad finance, then Chandler's contentions about the lesser impact of the railroads on capital markets in Britain are called into question.

We are called, firstly, to reexamine Chandler's contention that "In Britain the smaller requirements of a much smaller network only enlarged and refined somewhat the activities of what had long been the world's largest financial center". It is here revealed that this may be an understatement regarding the impact of railroad finance on the London exchange.

Secondly, we must reexamine his contention that "In industrial Britain, railroad promoters were able to rely more on local capital than could their American counterparts in the rural areas of the recently settled South and West." This statement is misleading because it leads one to believe that local capital sources were available to fund the railroads *ex ante,* and the impact of the railroads on these local exchanges was insignificant. On the contrary, as was alluded to above, and will be show below, the phenomenon of railroad finance in the provinces was much more dramatic than described by Chandler, in that it brought about a flurry of industrial financing activity to areas in which there had previously been little.

It is also misleading because it overlooks the fact that many of these local exchanges grew to be financial centers in their own right, and assumed an important role in a market for railroad shares that was national, not local in character. In fact, a few of them, notably those of Lancashire and Yorkshire, grew to become markets for railroad capital of a breadth and stature equivalent to London in the national market. One should

not jump to the conclusion that because Britain's market for railroad capital was more "local"—that is, dispersed around the nation, rather than concentrated in a single center, such as the United States' was in New York—that it was smaller scale, and less significant insofar as the impression it made on the overall development of the financial system.

In terms of a comparison with the American railroad system, it stands to reason that because the American system branched out from the densely-populated and industrialized Northeast, and out into the sparsely-settled, rural south and west, local sources of capital for railroads serving these areas would be inadequate, and substantial sums of outside capital from financial centers such as New York, Philadelphia and Boston would be an imperative. Consequently, any augmentation of the nation's financial intermediation facilities in connection with the construction of the railroads would be seen in a concentrated form in one or more of these cities. In contrast, in a much smaller, densely settled nation such as Britain, already in a stage of ubiquitous industrial development and urbanization, railroads would be constructed in shorter distances between already settled industrial areas. Due to its smaller and more compact geographical layout consisting of densely populated, urban industrial areas, Britain's railroad network did not involve linking urban centers with the frontier, as in the American case, but rather of linking urban areas with other urban areas. Consequently, local sources of financing would be more readily available.

So far, this is an accurate description of a key difference in the patterns of development of railroad finance in the two nations. In Britain, more so than in the United States, markets for railroad capital emerged in most of its great cities, such as Liverpool,

Manchester, Leeds, Birmingham, Bristol, Glasgow, and Edinburgh, and they all played a significant role in the financing of railroads that ran through them, or had them as a terminal point. It is not surprising that a thriving market for railway shares should arise in thriving centers of industry and commerce such as Liverpool and Manchester, where there was already much economic growth and a relatively high level of savings available. Given that these were already active centers of trade and commerce, it was far easier to develop effective banking facilities in these areas than in, say, the frontiers of Nebraska.

However, this overlooks the point that all of these exchanges (Lancashire and Yorkshire in particular), dealt in securities of railroads outside their regions, providing capital to railroads of other regions, and vice versa. One area, Lancashire, was so important to the financing of the railroads of the entire nation, and experienced so much growth related to this activity, that it became like a "northern London"—another financial capital of the nation in the north that was just as important to the financing of the nation's railroad system as its southern sister, London. What developed, then, in Britain as a consequence of the business of railroad finance, was an augmentation of the national capital market that may have been just as great as the corresponding American augmentation, but was dispersed across industrial regions. Rather than concentrated in one financial center, as the American augmentation was in New York, Britain's financial growth was dispersed across the nation; to some degree in the smaller exchanges that developed in cities such as Birmingham, Bristol, Glasgow, and Edinburgh, but concentrated in two main regions: London and the northern center of industrial growth and commerce, the Lancashire/Yorkshire area that contained the great exchanges of Liverpool, and the lesser, but still significant exchanges of Manchester and Leeds.

Therefore, the moniker “local” as applied to the financing of the British railroads is a misleading misnomer. If one were to observe the fact that the railroads that served the New York vicinity were heavily dependent on New York capital, one would not assume on that account that all the railroads of the United States were also similarly locally-financed because New York is a well known as a financial center serving the entire nation, if not the world. Similarly, if one were to observe the fact that railroads that served the London area were heavily dependent on London capital, it would be erroneous and fallacious to assume that all railroads in Britain were similarly locally-financed, because it is well known that London is the financial center of Britain, and one would assume that London was also involved in the financing of railroads in other areas of Britain.

Therefore, one ought not assume that because the railroads that served the Lancashire/Yorkshire region were heavily funded by capital from that region that all the railroads of Britain also had their own local, personal Daddy Warbucks. It just so happens that due to Britain’s small geographic size, and densely-settled urbanized and industrialized layout, a plethora of financial centers were able to arise to meet the demands of its railroad system, and two areas in particular grew to prominence. With two prominent financial centers at either end of such a small country, naturally a great number of British railroads found themselves with an abundant source of local capital available along their lines or at their termini. W. A. Thomas, in his 1973 study of the provincial stock exchanges, concurs that if the British railroads were more “locally funded” than the American railroads, it is no doubt in probability due to the existence of

these large provincial exchanges.[23] However, as will be seen, local capital resources were seldom adequate for all the railroads of Britain; especially for those whose termini and lines did not lie in or along any of the major hubs of London, Lancashire or Yorkshire. In order to make up these capital inadequacies, these railroads borrowed heavily from the London, Lancashire and Yorkshire markets.

It will be revealed below that the capital markets of London, Lancashire and Yorkshire played a great role in the financing of railroads all over Britain. London and Lancashire capital made its way to railroads of Britain that did not touch either of these areas. Moreover, there was cross-fertilization of financing between these two major capital markets, with Lancashire capital making its way down to the south to finance railroads that had access to the London market, and vice versa. It is the consensus of the authors surveyed here that the great capital cost of the British railroads wrought a changeover in the capital market not dissimilar from that experienced by the United States, and that a national market for railroad shares had emerged in Britain by the 1850's just as it had in the United States. Consequently, the funding of the railroads of Britain may not have been as "local" as was asserted by Chandler.

In the context of the Chandlerian hypothesis, the question naturally arises, what was so unique and special about this concentrated American development of the financial sector in New York that proved so beneficial to industry that gave the American such a great advantage later on in the financing of other large scale enterprise? An answer to this question becomes more pressing as it is revealed below that the railroad business of the Provincial exchanges was a temporary phenomenon associated with the great railroad booms of the 1830's-1840's, and that ultimately, the business of railroad finance in

[23] Thomas, W. A. *The Provincial Stock Exchanges* (London: Frank Cass and Co. Ltd., 1973), p. 31.

Britain became concentrated in London as the American had in New York, and this growth pattern only continued as the century wore on. The fact that Britain experienced financial augmentation in connection with its railroads of a seemingly nearly identical nature and magnitude as that experienced by the United States calls the Chandlerian hypothesis of lesser impact of the railroads on capital markets as an explanation for British industrial retardation in the late 19th century into question.

The following section describes the processes of growth experienced by the British capital market in connection with the railroads. Careful emphasis is placed on the tremendous capital cost of the British railroad system and the concomitant need for massive infusions of outside capital that led to the evolution of a national market for railroad capital in Britain, and the centralization and institutionalization of that capital market in the two main centers of London and Lancashire, and ultimately, the primacy of London.

III. RAILROADS AND THE GROWTH OF THE NATIONAL CAPITAL MARKET IN BRITAIN

The two main great financial centers of London and Lancashire began their great trajectory of growth in the 1830's as suppliers of capital to railroads that served their immediate environs. Reed, in his 1968 article "Railways and the Growth of the Capital Market,"[24] notes the great increase in the railway business that hit the London Stock Exchange in 1833, and notes that it is not surprising that this increase was coincident with the authorization of the first railroad companies to serve London, the London &

[24] Reed, M.C. "Railways and the Growth of the Capital Market," in M.C. Reed, (Ed.), *Railways in the Victorian Economy* (New York: Augustus M. Kelley Publishers, 1968), pp. 162-83. Hereafter Reed (1968).

Birmingham, and the London & Greenwich. According to Reed, from 1833 onwards, there was a considerable amount of business in the shares of railway companies, and that the companies mainly dealt in were "local" companies, in the sense that they served the London area.[25]

However, there was another important hub of railways, and railway financing activity going on simultaneously up north; particularly in Lancashire, and to a significant extent in Yorkshire as well. Thomas chronicles the rise of the great financial exchanges of Liverpool and Manchester subsequent to a great railway promotion boom commencing in 1836. Their importance to the funding of the construction of the first great early local railway lines that served this northern area, rich in industry and commerce, is well-documented by Thomas, and other historians. For instance, Thomas notes the naturally large contribution of Liverpool and Manchester interests to the launching of the Liverpool and Manchester line in 1826, noting that of the 2,907 shares allotted that year, 1,979 were held by Liverpool people, 124 were held by Manchester people, as against 844 held by London interests.[26] Reed notes that shares of the Manchester & Leeds railroad were seldom quoted on the London Stock Exchange, and that the lion's share of its securities were sold on the Manchester market.[27] The same can be said for other railroad lines that had as their termini, or served densely populated, urban industrialized areas. Thomas also notes the predominance of subscriptions held by locally interested

[25] Ibid., pp. 169-70.
[26] Thomas, pp. 28-30.
[27] Reed (1968), p. 177-78.

people in Lancashire and Yorkshire in the Manchester and Leeds line, as well as the same predominance of Birmingham people in the Grand Junction Line.[28]

Further testimony to the heavy reliance of the northern lines on these local financing centers can be found in Broadbridge's outline of the early history of financing of the Lancashire & Yorkshire Railway, *Studies in Railway Expansion and the Capital Market in England: 1825-1873* (1970). According to Broadbridge, the overwhelming proportion of the capital that funded the Lancashire & Yorkshire during the period from about 1835-1845 came from what may be termed "locally interested" counties—Lancashire, Yorkshire and Cheshire.[29] Although primarily concerned with the early financing of the Lancashire & Yorkshire, Broadbridge's 1970 book also covers the general affairs of the business of railway finance in the Lancashire/Yorkshire area. In Chapter Four, in which Broadbridge analyses the sources of share capital for a conglomeration of other companies that served the Lancashire/Yorkshire area for selected periods in the 1830's and 1840's, it is revealed that these companies also relied principally on this "local" capital as their means of finance.[30]

Of course, one should not make the erroneous assumption that because the London and Lancashire capital markets arose to become principal financiers of railroads serving their area that the capital needs of these railroads were small, or that all the early British railroads were similarly served by their local providers. Reed, in his 1975 book that surveys the early financing of the British railroad system, explains that the London

---

[28] Thomas, p. 31; see also S.A. Broadbridge, "The Sources of Railway Share Capital" in M.C. Reed, (Ed.), *Railways in the Victorian Economy* (New York: Augustus M. Kelley Publishers, 1968), pp. 184-211. Hereafter Broadbridge (1968). Esp. pp. 185-87, 209-10.

[29] Broadbridge, S. A. *Studies in Railway Expansion and the Capital Market in England: 1825-1873*. (London: Frank Cass and Co. Ltd., 1970), pp. ix, xiv-xv. Hereafter Broadbridge (1970). See also Broadbridge (1968), pp. 185-87, 209-10.

[30] Broadbridge (1970), pp. 112-17; see also Reed (1968), p. 174; Bagwell, pp. 95-96; Reed (1975), pp. 145-46.

Stock Exchange experienced dramatic growth in the early years of the railroads due to the tremendous capital cost of these enterprises. The railroads, Reed explains, as a whole required far more capital than any non-government user of borrowed capital, including the canals. Even the largest canal, the Grand Junction, used less capital than any railroad.[31] According to Reed, it was the inadequacy of local capital resources for railroad construction that led to the foundation of the Provincial Stock Exchanges of the north in the first place, and that this widening out of the capital market from London to the provinces was a direct market response to the capital inadequacies that existed in certain areas with respect to the building of the railroads.[32] Similarly, once the great exchanges of Liverpool and Manchester were founded, these exchanges too, played a role in the provision of capital to less capital-rich regions to aid their railroad construction, and experienced a resultant growth pattern similar to that experienced by London. As put by Broadbridge, "In Chapter 5 it is argued that the traditional view of pre-1840's railways—that they were "locally" financed—is an inaccurate one. The high proportions of initial capital subscribed to our companies by residents of Lancashire, and, to a lesser extent, Yorkshire, are to be regarded not as confirmation of the traditional account of early railway financing, but as confirmation of the paramount influence of Lancashire and its bordering areas in the early railway capital market."[33]

It appears that the misnomer "locally financed" as applied to the early British railroads stems from the observation that large stock exchanges arose in London and Lancashire to construct the railroads, and that these exchanges played a major role in the construction of the railroad lines that lay along, or had these areas as their termini.

---

[31] Reed (1975), p. 212.
[32] Ibid., pp. 220-21.
[33] Broadbridge (1970), pp. xiv-xv.

Naturally, given Britain's small geographic size, these railroads who relied heavily on London or Lancashire capital would comprise a fair proportion of all the railroads in the land. This may lead one to the erroneous conclusion that therefore, the early British railroads were heavily locally financed. There is also the misconception that remoteness from these capital centers forced railroads not conveniently situated along these areas, and/or lacking one of these principal capital markets as a terminal point, to rely heavily on their own local resources.

Reed and Broadbridge sharply refute these contentions as myths, and point to the significant role of outside financing in the construction of the early British railroads, both in those that directly served the London and Lancashire areas, and for those lying outside of these regions. Firstly, while railroads that served the London and Lancashire areas certainly did comprise a fair proportion of the early British railroads, and their abundant local capital resources certainly did play a major role in their financing, "a fair proportion" ought not be misconstrued to mean "all". For there were many railroads not conveniently situated along these areas or lacking one of these principal capital markets as a terminal point. For these railroads, outside capital from at least one of these principal regions played an exceedingly important role in their initial financing. According to the authors surveyed, remoteness from London and Lancashire was not an obstacle for railroads lying outside this region in obtaining capital from these regions, for an active national market for railroad shares had arisen by the 1820's and 1830's.

According to Broadbridge, the idea that until the great railroad mania of the mid-'40's, Britain's railroad finance was primarily local in character is not accurate. As he explains, "Before the wider development of railways in the 1830's, traveling was

difficult, and remoteness from London, Lancashire, and other important industrial areas, may well have led to some of the smaller, local lines being financed by local people. But the history of many of the major lines of that decade shows that this obstacle did not prevent promoters from soliciting help from Lancashire and other places, such as London and Birmingham." Quoting an old *Circular to Bankers* from 1836, Broadbridge reaffirms this assessment: "On the whole, the statement 'No considerable Railway can be completed that depends upon local money for its outlay' seems to be correct."[34]

Broadbridge's conclusion is that remoteness of transport undertakings from the large capital centers as a major cause of local financing is not really justified, as viewed by the extensiveness of Lancashire capital all over Britain, including in those areas in proximity to London itself. Importation of Lancashire capital into the London area for railroad financing is also confirmed by Reed, who notes that for the London & Birmingham railroad over the years 1833-37, Liverpool always held a significant quantity of shares; more, in fact, than London and Birmingham individually just about any year during that period. This importance of Lancashire capital in the railroads of the far south in the immediate proximity of the London capital markets is also evident in its role as a principal financier of the London & Southampton and Grand Junction railroads. It appears that for railroads in the South, midlands, east, what capital that could not be gotten from London was available in abundance from Lancashire.[35]

Furthermore, even the great center of Lancashire did not possess regional hegemony over the financing of railroads in its respective area. The Northern railroads relied heavily on share capital from London, as Broadbridge notes occurred in the case of

---

[34] Broadbridge (1968), p. 210; Broadbridge (1970), p. 164.
[35] Broadbridge (1970), pp. 163-65; see also Broadbridge (1968), pp. 184, 208-10; Reed (1968), pp. 174-78; Reed (1975), pp. 133-37, 210.

the Manchester & Leeds Railway, as Reed notes occurred in the case of the Liverpool & Manchester, and as Bagwell notes in the case of the North British. Not only was there crossover of this sort between the two main financial centers, even railroads situated within the proximity of Lancashire sought capital from farther afield. According to Broadbridge, the Lancashire & Yorkshire received loan capital from banks as distant as Ireland, Scotland, the (more?) northern counties, and other areas that even included the Bank of Australia, as well as tapping London's resources. Broadbridge holds these facts up as testimony to the fact that railroads were drawing their capital from ever-widening sources as early as the early 1840's.[36]

This assessment of the financing of the early British railroads is confirmed by Reed, who notes that due to the active new market for railroad capital that arose in London, and the creation of the great exchanges of Lancashire, railroad shares became readily marketable in the 1820's and 1830's. In fact, for the British railroad system as a whole, Reed found that most railroads over the course of their early development relied heavily on non-local sources of capital, with London predominating in the 1820's, and then Lancashire as well as London beginning to play an important role in the 1830's.[37]

*

Thus, the two principal railroad capital markets of London and Lancashire were both set upon a trajectory of growth based on railroad financing. This included financing of not merely their own local railroads, but railroads all over Britain.

[36] Broadbridge (1970), p. 95; Broadbridge (1968), pp. 188-92; Bagwell, pp. 95-96; Reed (1975), p. 102.
[37] Reed (1975), pp. 193-96.

By serving as a capital market for the railroads that served both its immediate environs, and distant lines to the north, the London Stock exchange entered a new stage of development marked by rapid growth in volume of transactions; a rapid growth in connection with railroad securities dealings not unlike that described by Chandler concerning the growth of the New York securities industry in association with railroad finance. Reed explains that the London stock exchange was originally primarily a market for government securities during the first three decades of the 19th century prior to the great railroad boom, with railroad company securities comprising a very small portion of total assets traded.[38] However, the huge capital needs of the burgeoning railroad industry, that included distant lines remote to the London area, led to a spur of financing activity that acted like an engine of growth for the London exchange.[39] Reed reports that as early as 1842, railroads represented the largest single group of joint-stock companies quoted in London, consuming more capital than comparable older utilities such as canals, gas, and other utilities—not only on an individual basis but more than these other utilities combined.[40] Furthermore, in comparing the volume of railroad share capital issued on the London Stock Exchange in 1843 to that of 1847, Reed found that it more than doubled over that time, going from 43 million pounds to 126 million pounds. In comparing the number of railway companies out of total firms with quotations on the exchange in 1830 to that in 1844, Reed found that it had risen from 4 out of 205 (.0195) to 66 out of 755 (.0874). However, even this figure underestimates the precise quantitative contribution of the railroads to the growth of the exchange, because while the actual raw number of companies on the exchange is not huge, the high value of their paid

[38] Ibid., p. 210.
[39] Reed (1975), p. 212; Reed (1968), pp. 169-70.
[40] Reed (1975), pp. 44-46.

up capital at the later date represented about a third of the total joint-stock company capital quoted on the exchange.[41] The contribution of outside capital dealings to this growth of the London exchange in these years is also acknowledged by Reed, who reports that as early as 1836, railroad companies that did not serve the London area directly made up a significant portion of those traded on the London Stock Exchange.[42]

To summarize, Reed believes that by the 1840's, the business of the Stock Exchange had been revolutionized by the railroad. Railroad shares, much more lucrative than government securities, aroused a great investor passion hitherto unknown in the banking and securities industry, and consequently played a significant part in enlarging the activities of the London Stock Exchange.[43]

This momentum of growth in connection with railroads continued on into the 19th century, according to Cottrell (1979), who notes the rapid growth experienced by the London exchange from the 1850's-80's that was coincident with what he terms its "golden age" of railway construction.[44] According to Cottrell, London by 1870 had grown to become a well-established capital market based primarily on dealings of two types of assets: government bonds and railway securities. The fact that Cottrell lists railroad securities as one of the leading factors contributing to the growth of London as a financial center in these years leads one to believe that London may also have experienced much of the growth similar to that experienced by New York as a result of the railroads.[45]

---

[41] Reed (1968), p. 167.
[42] Ibid., pp. 169-70.
[43] Reed (1975), pp. 211-13.
[44] Cottrell, P. L. *Industrial Finance, 1830-1914: The Finance and Organization of English Manufacturing Industry* (London and New York: Methuen & Co. Ltd., 1979), p. 152; see also railway data tables on capital invested in this chapter.
[45] Ibid., p. 141.

Similarly, the northern provincial exchanges, particularly of Lancashire and Yorkshire, received a significant augmentation as a result of their railroad financing activities that involved railroads of their own region, as well as around all of Great Britain. The description above detailing the importance of Lancashire capital in such northern railroads as the Liverpool and Manchester, the Manchester and Leeds and the Lancashire & Yorkshire lines is well documented. It was also mentioned above that there was cross-fertilization of capital between the two main centers, with Lancashire capital often coming to the aid of railroads serving the London area. But what cannot be stressed enough is the tremendous degree to which Lancashire capital financed the railroads of the entire realm, and the role that this financing activity played in enlarging these northern exchanges.

It is a broad consensus among the authors surveyed here that the investment banks of Lancashire and Yorkshire provided capital not only for railroads that served the north of England, but for the railroads of the entire nation, and even for those abroad.[46] According to Reed, by 1836, railroad companies that did not serve the Lancashire and Yorkshire area comprised a significant portion of the Liverpool, Manchester and Leeds exchanges.[47] Reed notes that shares of the Manchester & Leeds railroad were seldom quoted on the London Stock Exchange, and that the lion's share of its securities were sold on the Manchester market. He reasons that if this is true of the Manchester & Leeds, as well as the other northern and midlands railroads, then the Manchester and Liverpool Stock Exchanges, in addition to their local function, must also have challenged London as the most active market for a fair proportion of all railway securities, and were thus an

[46] Reed (1975), pp. 214-17; Reed (1968), pp. 169-70; Broadbridge (1970), pp. xiv-xv; Bagwell, pp. 95-96.
[47] Reed (1968), pp. 169-70.

important supplier of "outside" capital for railroads in between, or off the line of the northern areas and the London area.[48] According to Thomas, the investors of Lancashire, particularly, were highly active in the financing of lines in other parts of the country, contributing the lion's share of the capital not only to lines such as the Manchester & Leeds, but also more distant lines such as the London & Birmingham, the Great Western Railway that served Bristol (and London?), the Southern Railway, the London-Southampton, the Eastern Counties, and the South Eastern Railway.[49] Lancashire was not only a principal financier of railroads in its own immediate northern region, but also of all the principal railroads of the nation, such as the Leicester & Swannington, the Midland Counties, and North Midland, the Eastern Counties, and the Great Western.[50] According to Reed, the Great Western, North Midland, Leicester & Swannington and London & Southampton all had in common the fact that none of them served Lancashire directly, yet they relied heavily on capital from it. Moreover, this Lancashire importance grew over time. The three latter ones, in particular, found local capital insufficient, and were primarily financed from outside capital, with capital from Lancashire prominent among this capital.[51]

As a consequence of this railroad financing activity that occurred both around their area, and all over the country, the provincial exchanges of Lancashire and Yorkshire experienced growth not unlike that experienced by London in connection with its railroad financing activities. In fact, as a source of capital for the railroads, Lancashire grew to rival, if not exceed London in importance. According to Reed, a shifting of the loci of

[48] Ibid., pp. 177-78.
[49] Thomas, pp. 31-32.
[50] Broadbridge (1968), pp. 208-10; Reed (1975), p. 210.
[51] Reed (1975), pp. 167-68.

banking and financial activity in Britain away from London, and northwards towards Liverpool, Manchester and Birmingham was a chief consequence of the establishment of the provincial exchanges in response to the capital needs of the railroads. Noting the great degree to which Lancashire funded railroad projects outside its area, both Broadbridge and Reed contend that it was Lancashire, not London, that was the principal reservoir of capital for the financing of the early growth of the British railroad system, and it was the pressure of Lancashire capital, and not that of London, that was the more important influence in the early railroad capital market.[52] The relatively greater importance of the provincial exchanges as providers of capital for the early railroads is also noted by Thomas, who, in a table listing stock of trade in railroad shares for the main provincial markets and London from 1835-46 for selected years, shows Liverpool exceeding London for all those years, Manchester rivaling it, and Leeds also quite prominent (though nowhere near as great as London). Citing a contemporary observer, Henry Burgess writing in *Circular to Bankers* of Nov. 6, 1835, Thomas notes that of the railroads in operation at that time in the counties of Northumberland, Cumberland, Durham, Yorkshire and Lancashire, less than one twentieth of their capital was provided by members of the London Stock Exchange.[53] According to Reed, the national importance of Liverpool in the railroad capital market gave that city a sophistication comparable to that of the wider London market, and Manchester also began to assume this characteristic for the same reason.[54] It appears that if there had to be a single main financial center of importance for the early British railroad system, Lancashire would have to have been it.

---

[52] Broadbridge (1968), pp. 210-11; Broadbridge (1970), pp. xiv-xv; Reed (1975), p. 262.
[53] Thomas, pp. 32-33.
[54] Reed (1975), pp. 167-68, 214-17.

The tremendous growth of the Provincial exchanges as financial centers equivalent in stature to London primarily through railroad securities dealings reveals Chandler's claim of the early British railroad system as having been primarily "locally financed" as something of a misnomer. The history of the development of the provincial exchanges in connection with the capital needs of the railroads chronicled above paints a very different picture of the financing of the British railroad system and its impact upon capital markets than that painted by Chandler in *Scale and Scope*. Chandler maintained that because the British railroads capital needs were small, they were capable of being satisfied by local finance. The implication is that there were local capital facilities—local merchants, manufacturers, bankers, and landowners living at the termini or along the rail lines—who specialized in small-scale financing activities that had existed all along, and were sufficient for the capital needs of the railroads. Thus, there was little impact of the business of railroad finance upon those facilities. There were no, or little, new revolutionary features imparted by the business of railroad finance to these financing facilities that arose on an *ad hoc* basis in response to the business of railroad construction.

What a different picture emerges from this literature I have surveyed! In discussing the impact of the railroads upon these provincial exchanges, Reed notes that because of the great need for capital for the railroads in both the immediate Lancashire/Yorkshire area and beyond, including London, local brokers dealing with railroad securities as the greater share of their business began to appear in the provinces in greater and greater number as the 19th century wore on. Formal stock exchanges were established in the provinces principally on account of the fact that railroad securities dealings were a profitable form of new enterprise. Reed notes that apart from Dublin,

where there was an established Stock Exchange dealing with government securities, the Liverpool and Manchester exchanges were the first in Britain to be formed outside London, and it is not too much to say that their formation was the direct result of the railroad boom of the mid-1830's. In fact, according to Reed, it was on account of the railroads, and their tremendous capital needs, that sharebroking began to emerge as a separate profession in the provinces. A new form of finance was thus created in the provinces; one that was associated with a new technology that called for greater quantities of capital than had ever been hitherto required. The fact that these provincial exchanges subsequently grew in size to capital centers of industrial finance rivaling London in importance nearly from scratch (it must be remembered that London had a head start from previously being a great financial center based on government securities dealings), and that this was achieved through extensive financing of distant projects, shows that the term "local finance" as applied to these exchanges is a great misnomer; at least in the sense in which the term is used by Chandler as applied to these exchanges as small-scale banking facilities associated with smaller-scale industrial projects.[55]

Certainly one can say that much of the early British railroad finance was "local". But one must emphasize that this was "local finance" of a much grander scale and newer, unprecedented variety than had ever hitherto existed in the provinces. While it is possible that in Britain there developed less of this apparatus than in the United States, one should not jump to the conclusion that it was insignificant or backwards because of its "local" character. The fact that these financial centers grew to rival London in magnitude, and that there was significant growth of the London exchange on account of the railroads should signal as a word of caution to those who would infer that the United

[55] Reed (1975), pp. 212-14; Reed (1968), pp. 177-78.

States received greater financial sector augmentation as a result of the railroads; after all, even Chandler acknowledges that after the railroads had completed their work in institutionalizing and centralizing the American money markets in New York, the New York money market was still in second place in the world in size to London by the turn of the century.

Furthermore, the fact that they dealt in securities that funded railroads all over the nation serves to bolster the claim I make that "local finance" sources is a term that really cannot be applied to the Provincial Exchanges; certainly not the great ones of Lancashire and Yorkshire. Certainly the railroads of the North were heavily funded by Lancashire and Yorkshire. If one were to observe the fact that London heavily financed the Southern railroads, which it did, one would not automatically conclude that all Britain's railroads were locally financed, because one would reasonably assume that as a large financial center, London was also heavily involved in financing railroads all over Britain. Therefore, since we know that Lancashire and Yorkshire also served the British railroads in a similar capacity, we should not call their financing activity "local" either.

There were some smaller, less important provincial exchanges that did play an important role in the financing of their own regions' railroads that one could call "local financing" in the sense of the word used by Chandler, although it is not clearly demonstrated that their financing activities were confined to their own immediate regions. Both Reed and Thomas report that after the mid-1830's boom, there was another, much larger boom in the mid-1840's in railroad securities that led to the formation of exchanges in other cities, such as Birmingham, Edinburgh, Glasgow, Dublin, Leeds, Bristol and Leicester. We do know from Reed that by 1836, companies

that did not serve the Lancashire and Yorkshire area comprised a significant portion of the Leeds exchange. Furthermore, as detailed above, we know that seldom were the railroads in the areas these exchanges served exclusively reliant upon this local capital for their construction.[56]

Furthermore, the evidence appears to indicate that Britain experienced a significant augmentation of its investment banking facilities as a result of the business of railroad finance. The emergence of a national market for railroad shares, particularly through the growth of the great exchanges of London and Lancashire, provided a channel through which savings from economically advanced regions and individuals could be harnessed to stimulate development elsewhere and contribute significantly to the overall level of capital formation. Consequently, the impact of the financing of the railroads on the capital markets of Britain does not appear to be as different from its effects on the United States as imagined, or misconstrued to be the case, by Chandler.

Firstly, the tremendous role played by outside capital from the great exchanges of London and Lancashire point to the emergence of a national capital market for railroad securities and the advent of large-scale impersonal finance in Britain *circa* the 1840's.[57] According to Reed, "One of the most important by-products of the introduction and extension of the railway system in the second quarter of the nineteenth century was the part played by railway shares and debentures in assisting the development of a national market for company securities."[58] According to Bagwell, the tremendous preponderance of Lancashire capital in particular in the railroads of other regions bears testimony to the

[56] Thomas, p. 28; Reed (1975) pp. 215-18; Reed (1968), pp. 169-70, 179-80.
[57] Reed (1975), pp. 193-94, 214-17.
[58] Reed (1968), pp. 162-63.

national character of the market for railroad capital in Britain that existed by the 1840's.[59] This description of these northern markets is echoed by Reed, who notes that the Manchester and Liverpool markets in the early 1840's provided, in addition to a regional market in a wide range of securities, the most active *national* market in some railway securities.[60]

Secondly, the tremendous growth experienced by the two major centers of railroad capital dealings suggests a centralization and institutionalization of the British capital market in association with the railroads not unlike that which was occurring simultaneously in the American in New York. Reed feels the railways had a profound impact on the capital market, particular the London Stock Exchange. Prior to the coming of the railway, Reed explains, the London Stock Exchange was primarily a market for government stock and the stock of the historic chartered companies. However, by the mid-1840's boom in railroad construction, the rapid increase in railway business had geared the London Stock Exchange to handle a growing range of company securities, and created a network of stockbrokers all over the country to serve the investing public. According to Reed, railroad companies were a model for the increasing number of companies which followed the liberalization of company law, and the characteristics of railroad capital issues—an unprecedented volume of securities, and the initial opportunities for speculative profits—ensured the enlargement of the formal capital market so that it was able to handle other company securities.[61]

Besides this augmentation of the London exchange, the other, more radical change in structure of British capital markets bequeathed by the railroads was the birth of

---

[59] Bagwell, pp. 95-96.
[60] Reed (1968), pp. 177-78.
[61] Ibid., pp. 162-63, 182-83.

the great northern exchanges of Lancashire and Yorkshire. Reed explains that the railroads had a dramatic effect on the capital market in Britain by extending it to the provinces, for in so doing, they enabled it to draw upon the new sources of wealth and income that had come into existence there, thus bypassing imperfections in the capital market that hampered industrial development across the land.[62] Lancashire, in particular, as the area of Britain undergoing the most rapid industrialization, and which supplied the bulk of Britain's exports, was a natural source of large reserves of capital that needed to be mobilized in order to fund industrial development elsewhere.[63] Its large and profitable textile industries, the Liverpudlian slave trade and shipping industries all played an essential role in initiating the process of railway investment in Britain. In so doing, this process provided a specific channel through which the resources of an economically advanced region could stimulate development elsewhere and contribute significantly to the overall level of capital formation.[64]

In summary, as Reed states, the railroads had a dramatic effect on the capital market in Britain in two ways: one, their tremendous capital needs dramatically increased the level of investment. By drawing on new classes of investors, railroads dramatically increased the overall level of savings of the economy, bringing it into productive use in the industrial sector. Secondly, by drawing these classes into the community, one may argue, they provided the necessary army of funds to be mobilized for providing the massive capital needs of enterprise; or they opened up new sources of capital for the financing of other large-scale enterprise.[65]

---

[62] Reed (1975), pp. 263-66.
[63] Broadbridge (1968), p. 209; Bagwell, pp. 95-96.
[64] Reed (1975), pp. 263-66.
[65] Ibid., p. 263.

The fact that the Provincial exchanges of Lancashire and Yorkshire grew to rival London in magnitude, and that there was significant growth of the London exchange itself on account of the railroads, should signal as a word of caution to those who would infer that the United States received greater financial sector augmentation as a result of the railroads; after all, even Chandler acknowledges that even after the railroads had completed their work in institutionalizing and centralizing American money markets in New York, the New York money market was still in second place to London by the turn of the century. It would appear that it is possible that the railroads may have had just as dramatic an impact on capital markets in Britain as they did in the United States, but that this impact was a little more dispersed across various financial centers rather than having been concentrated in London, in contrast to the American money markets that became concentrated in New York.

This leads us to the question of what happened to the Provincial Exchanges after the great railroad boom of the 1830's-'40's? Did they continue to grow after the railroad mania, and contribute to economic development along and in tandem with the great banks of London?

We know, as Reed reminds us, of how the railroad stock trade came into London, and revolutionized the exchange. The magnitude of these effects remains a controversy, but one thing is certain: there was no shrinkage of the London exchange as a result of these railroad dealings, only an increase in the volume of securities traded. And this growth certainly could not have been deleterious to its ability to handle other types of company securities.[66] But what was the contribution of the Provincial Exchanges to the

[66] Ibid., pp. 218-19.

economy's financial intermediation facilities after the great boom of the railroads was over?

According to Reed, the provincial exchanges assumed a role after the great railroad manias as local capital markets and dealers of local government securities. Their importance as part of the larger, national capital market for railroad and other large, industrial capital declined after the great railroad manias because the invention of the telegraph had provided convenient, ready access to the London stock exchange. Also, due to the emergence of the great amalgamated railroad companies, railroad business became increasingly concentrated on the London Stock Exchange, where specialized rail markets emerged in which the specialist division of jobber and broker was able to maintain a liquid market in a wide range of home and foreign railroad shares, and the increasing concentration of banking and discount houses made all the resources of the money market available. With this consolidation of local companies into the national railroad companies, and the concomitant emergence of a more settled market in railroad securities, the wide market in railroad shares that had been a feature of both Liverpool and Manchester in the formative years of local exchanges was largely lost to London, and its dominance of the market for railroad securities was quickly established.[67]

Further indication of a transferal of railroad financing resources from north to south is provided by Cottrell, in his recounting of the story of the investment bank, Glyn, Mills. According to Cottrell, many English country joint-stock banks became absorbed into metropolitan concerns from the 1890's on, which enlarged their capital base. Glyn, Mills, one such bank, had acted as the London correspondent for a large number of country banks. Since the bank's partners had played such an important part of the

[67] Reed (1968), pp. 181-83; Reed (1975), pp. 218-19.

railway-building boom of the 1840's, Glyn Mills became known as the "railway bank." This bank grew, and expanded by other means after the great railroad boom, first handling Canadian loans in the 1850's, then assisting in the formation of a number of overseas banks in the 1860's and 1870's, and then, from the 1880's on, undertaking a number of domestic industrial issues, including British Westinghouse beginning in 1901, with whom the bank enjoyed a long, close relationship.[68]

The fact that the railroad business of the provincial exchanges became absorbed by London, who came to *dominate* railroad finance serves to call into question Chandler's claim that the British railroads were primarily locally-financed. That appellation, if it were to apply to the British railroads at all, would only apply to their very early years during which the Provincial exchanges were in their heyday. Even then, it is very misleading to say that local capital markets were dominant, considering that the provincial exchanges, particularly that of Liverpool, were part of a national market for railroad assets, and dealt with railroad securities all over the land. Moreover, that this absorption of the provincial exchanges railroad dealings into London concerns further abetted growth and concentration of the London capital market, *and* that this augmentation of the London market was significant insofar as the financing of other large-scale industrial enterprise is concerned, serves to put Chandler's assertion that the railroads had a less dramatic impact on capital markets in Britain than in the United States into question.

It is now revealed that not only did Britain experience great financial sector growth in connection with the railroads, this growth was, in the long run, concentrated in a main financial center as the United States' was in New York, and did not remain

[68] Cottrell, pp. 228-29, 232-33.

dispersed across industrial centers, as was the case during the early history of the British railroad system. How much different is the saga of the growth of the provincial exchanges, and their ultimate incorporation into the London exchange, from the enlargement of the New York exchange following the collapse of the railroad business of the Boston and Philadelphia exchanges? It appears that Britain may have experienced much of the same "centralization and institutionalization" of its capital markets in London as a result of railroad financing that the United States did in New York, even though London was already a great financial center before the great railroad boom of the mid-19th century. Furthermore, the growth of financial institutions through railroad finance, and their ultimate branching out to finance other industrial enterprise--the whole phenomenon that Chandler claims differentiates the American and German experience from the British--can also be seen in Britain in the case of the London bank, Glyn, Mills that Cottrell recounts. The fact that one of its clients was British Westinghouse, a typical example of a science-based, large-scale, capital intensive, technologically advanced industry, serves as testimony to the fact that Britain may have also experienced at least a modicum of financial augmentation as a result of the railroads, and that this augmentation may have been significant insofar as the financing of the enterprise of the 2nd Industrial Revolution.

IV. BRITAIN AND GERMANY: CHANDLER VS. THE SCHOLARS

Britain's lesser impact of its railroads on its financial institutions, and consequent financial weakness relative to the United States and Germany is further called into question by the comparison of the effects of the railroads on capital markets in Germany

to that of Britain provided by Richard Tilly (1967, 1986).[69] Chandler's depiction of the impact of railroad finance on Germany's capital market closely parallels his analysis of the corresponding American situation, except that Chandler feels that this causal relationship is even stronger in the German case than in the American, thus providing an even more stark contrast with Chandler's description of the British situation. While Chandler's sources do not identify any data sources that can be used to support his conclusions, they do lead us to further literature on the subject, particularly that of Tilly, that, like the literature on the financing of the British railroads discussed above, lead us to draw very different conclusions regarding the alleged greater impact of the railroads on the capital markets of the United States and Germany. Tilly, while concurring with Chandler as to the dramatic effects of the railroads on financial intermediation in Germany, sharply differs from Chandler in his belief that Britain experienced much of the same impact of the railroads on its capital markets, albeit with some qualitative differences that will be discussed and summarized below.

In *Scale and Scope*, Chandler contends that the German railroads were constructed using a far greater quantity of outside capital than the British, and that consequently, the impact of this financing on Germany's financial institutions was far greater than in the British case. Again, an inspection of the sources Chandler uses to support these contentions provides no data, or any links to sources containing an exact breakdown of how much capital used in the construction of the early German or British

---

[69] Tilly, Richard. "Germany 1815-1870" in Rondo E. Cameron, ed., *Banking in the Early Stages of Industrialization: A Study in Comparative Economic History* (New York, 1967). Hereafter Tilly (1967). ---------. "Financing Industrial Enterprise in Great Britain and Germany in the Nineteenth Century: Testing Grounds for Marxist and Schumpeterian Theories?" in H. J. Wagner and J. W. Drukker, eds., *The Economic Law of Motion of Modern Society: A Marx-Keynes-Schumpeter Centennial* (Cambridge, Eng., 1986), Ch. 9. Hereafter Tilly (1986).

railroads was outside vs. local, or the exact percentage growth of the German or British capital markets that occurred as a consequence of this railroad financing activity.

According to Chandler, the "Great" German banks, or *Grossbanken*, had come into being, as had the great American investment banking houses, primarily to finance the railroads.[70] Chandler explains that in Germany, as in the United States, the rapid rail growth of the late 1840's and 1850's created an unprecedented peacetime demand for capital. Just as in the United States, where this demand led to the centralizing and institutionalizing of the nation's money market in New York, in Germany, it resulted in the creation of a wholly new financial intermediary, the *Kreditbanken*, the largest of which were known as Grossbanken. According to Chandler, the Kreditbanken became central to the later financing of large-scale industrial enterprise, for they were able to provide capital on a both a national and international scale. Since the 1850's, Chandler asserts, the Grossbanken have dominated German finance.[71]

Before this boom of the 1840's-50's, Chandler explains, much of the capital for the German railroads was raised locally, coming from merchants, manufacturers, bankers, and to a lesser extent, landowners living at the termini or along the rail lines. However, as the network expanded, local funds proved inadequate, and external finance of the type provided by the Kreditbanken became a necessity.[72] Quoting Tilly, Chandler writes that until the 1850's, banking and finance in Germany were "personal and interfamilial." Then: "The railroads, and a good deal of heavy industrial enterprise which followed or

---

[70] *Scale and Scope*, p. 499.
[71] Ibid., p. 415.
[72] Ibid., pp. 415-16.

accompanied their construction, involved external finance to a much larger extent than earlier types of business enterprise in Germany did."[73]

Further testimony to the heavy role and importance of external finance to the railroads of Germany, and the impact on capital markets it had, is provided to Chandler by information supplied here from Jacob Riesser in his classic study of the Grossbanken (1911),[74] who noted that of the total capital invested in German joint stock companies between 1851 and 1870, three-fourths of that went into railroad companies, and a major share of those funds were raised by Kreditbanken.[75]

Chandler goes on to explain how a second railroad boom in the 1870's brought still more of these type of financial institutions into existence, and how after the 1880's, when most of the railroad network was being completed and as the railroads were being taken over by the state, the Grossbanken began to concentrate on financing other types of industrial enterprises, particularly in the newer industries. He explains the important role the Grossbanken played in the financing of such enterprises, often serving in an advisory role to the managers of large industrial corporations, thus making a great contribution to the economic growth and rapid industrialization Germany experienced in the late 19th century.[76] Chandler again contrasts the German experience of railroad finance with the British, again ascribing a far greater impact of railroad finance on capital market growth in Germany than in Britain: "…the all-purpose Kreditbanken, particularly the largest, the Grossbanken, were the instruments that made possible the rapid accumulation of capital on a scale vast enough to finance the building of the new Continental transportation and

---

[73] *Scale and Scope*, pp. 415-16; Tilly (1967), pp. 174-75.
[74] Riesser, Jacob. *The Great German Banks and Their Concentration in Connection with the Economic Development of Germany* (Washington, D.C., 1911).
[75] *Scale and Scope*, p. 416.
[76] Ibid., pp. 416-19.

communication infrastructure. In Britain, where such investment was somewhat smaller, and where more local capital was available and the world's largest and most sophisticated money market existed, the provision of funds for railway building had less impact on existing financial institutions…"[77]

Again, Chandler's sources cited contain no empirical validation of the claim that the German railroads were constructed using a greater proportion of external capital than the British, and that the activities of railroad finance had a greater augmenting affect on German capital markets than on the British. Tilly (1967) and Riesser essentially consist of a repetition of what Chandler said above concerning the impact of the railroads on financial intermediation in Germany. While Chandler's analysis and interpretation appear to be on the money, or at least in agreement with the analysis presented in the leading literature on the subject available in English, that literature still does not contain, or point us to any reliable data series that confirm his allegation that the German railroads, through the Kreditbanken or any other sources of industrial finance, were more heavily funded by outside sources than the British railroads. While neither does Tilly's later 1986 article, it does, as will be shown below, present the same strikingly anomalous depiction of the impact of the railroads on British capital markets presented in the above survey of literature in that area. In comparing the impact of the railroads on the capital markets of Britain and Germany, Tilly also found that Britain, like the United States, *and* like Germany, also experienced a great degree of capital market augmentation in connection with the railroads. While he acknowledges that there were *some* differences between the impact of the railroads on financial intermediation in the two countries, and that there was at least somewhat more of a profound impact of the railroads on the capital

[77] Ibid., p. 416.

markets of Germany, he does not believe that outside finance was essentially any more important to the German railroads than the British, and maintains that in Britain, as in Germany, the great capital cost of the railroads led to the development of a national capital market.

Apparently, according to Tilly, Britain received as, or nearly as much augmentation of its financial intermediation facilities from the construction of its railroad network as Germany in the late 19th century. What distinguishes the impact of the railroads on capital markets in the German instance from the British is the fact that in Germany, the business of railroad finance led to the evolution of large investment banks that formed much closer relations between themselves and large industrial corporations than in Britain, and this might explain part of the German great industrial leap forward. According to Tilly, the primary reason for the British slowdown in industrial growth and decline from its position of leadership in industrial innovation is not any kind of relative financial weakness, but rather a pronounced predilection for foreign over domestic investments, and other factors unrelated to the size and structure of its banking industry. It was errors or weaknesses that occurred much later on in the 19th century that were Britain's setback in that period, not a weakness stemming from less vigorous railroad investment earlier on *circa* the 1840's as implied by Chandler. Both countries seemingly experienced great financial augmentation as a result of railroad finance; however, one exploited that augmentation more effectively, while the other one floundered for reasons unrelated to lack of adequate financial intermediation facilities. The great linkage and strong positive correlation between a nation's financial intermediation facilities and its capabilities for industrial growth that is implied in Chandler's analysis is absent from

Tilly's. It is indeed ironic that in one of the very sources that Chandler cites as his source of information on the history of the development of the German railroads and their impact on German capital markets there should be information and opinions that so dramatically contradict his own assessment of the impact of the railroads on British capital markets.

In Tilly (1967), evidence confirming Chandler's belief in the great impetus towards development of financial intermediation facilities presented by the German railroad boom of the 1840's is presented. The basic picture presented by Chandler above of a railroad system that was first dependent on local capital sources, but then finding these local sources insufficient is confirmed by Tilly here. Tilly describes the formation of local joint-stock banks in response to the earliest railroads in Germany in the late 1830's and early 1840's in Rhineland, Saxony, Silesia, Berlin, and elsewhere as the first significant examples of investment banking in Germany. Due to their tremendous capital needs in excess of the financial resources of the individual entrepreneur, the railroads in Germany came to be dominated by the joint-stock company organization. Tilly notes the great increase in joint stock companies founded in Prussia and Saxony in the 1850's, coincident with, or consequent to the great railroad boom commencing in the 1840's. Tilly goes on to describe the evolution of a national capital market in connection with the capital needs of the railroads in the section of the article from which Chandler extracted the quote above that deals specifically with industrial finance and the role of the banks. Tilly states that due to the tremendous capital needs of the railroads after 1840, they involved a much greater reliance on external financing than most other types of industrial enterprise hitherto undertaken in Germany. As railroad securities began to be actively

traded on stock exchanges in Germany by mid-century, the banking system developed the powerful institutional mechanisms by which to attract, draw, and pool savings capital sources from far and wide into industrial employment.[78]

Though insightful, this source still does not contain any data that can be used to determine the exact proportion or percentage of capital that financed the railroads that can be considered to be external; that raised on the type of exchanges mentioned above that are implied to be external capital sources. Of course, it is not clear at which point the local joint-stock banks that funded the railroads at the beginning grew to become the behemoth Kreditbanken Chandler speaks of that funded projects far and wide. Joint-stock capital can be local capital, as the experience of the British financing of the railroads via the Provincial Exchanges illustrates. More recent work on the subject (Fohlin, 2007; Edwards & Ogilvie, 1996)[79] is more skeptical concerning the contribution of railroad finance to the creation of the great German universal banking system, noting that while banks played a significant role in early railroad financing in parts of Prussia and Saxony, state governments financed the vast majority of such investment in other areas.

The Riesser book does not help us determine what proportion of the capital employed by the German railroads at any time was external finance either. There is only a brief mention of railroads in the context of a discussion of the large bank groups that originated from 1870-1911 as a result of the changed relations of the banks to industry (meaning closer alliances), the principal cause of which being the enormous demand for

---

[78] Tilly (1967), pp. 152, 174, 179-80.
[79] See Fohlin, Caroline. *Finance Capitalism and Germany's Rise to Industrial Power*. Cambridge: New York, NY. Cambridge University Press, 2007, pp. 38-40; Edwards, Jeremy and Sheilagh Ogilvie. "Universal Banks and German Industrialization: A Reappraisal." *The Economic History Review*, New Series, Vol. 49, No. 3 (Aug., 1996), 427-446, pp. 434-35.

capital by industry in general. He merely lists a few of the leading bank groups heavily involved in railroad finance that were formed in this period.[80] The book does contain tables that list figures on the value of all railroad securities issued by the great banks at the Berlin Stock Exchange from 1882 to 1908, and at all German Stock Exchanges from 1897 to 1908. However, not all railroad securities traded on exchanges, even by great banks, may necessarily be outside capital, and there could be more external financing of the railroads that occurred over this period that occurred outside of these stock exchanges, by banks that may not fall into the category of "great" ones, so these tables may not be a precise indication of the quantity of outside capital employed by the German railroads over these periods.[81]

Tilly's later 1986 article discusses both the German and British early railroadization, and the impact it had on the capital markets of both countries. Tilly argues that the financing of the construction of the railroads that both nations experienced in the 1840's had a very similar, significant expansionary effect on financial intermediation facilities in both countries.

Tilly concurs with Reed, Broadbridge, and the other experts on the financing of the British railroad system that the large sums of capital raised through the sale of shares and bonds for railroads from the 1830's on through the 1840's was of such a great magnitude that they greatly contributed to the development of a national capital market in Britain by the mid-century. According to Tilly, the railroads established the first major links between business enterprise and a national capital market in both Britain and Germany, and in the 2nd half of the 19th century, those connections widened and

[80] Riesser, pp. 415-17.
[81] Ibid., pp. 921-81.

intensified in both countries.[82] As the century wore on, Britain was in no weaker a position than Germany with respect to its financial system. Tilly presents evidence here showing that the financial systems of both countries developed powerfully between 1870 and 1914, although he does not prove that railroad financing was responsible for this growth, and if so, to what extent. According to R. Goldsmith, the value of assets of financial institutions issued in Britain and Germany between 1861 and 1913 grew about $11 billion and $20 billion respectively, while the value of all securities held by wealthholders in 1912 was $29 billion and $21 billion—about 2 to 3 times the size of estimated national incomes in the two countries. By the beginning of the 20th century (1901-13), British wealthholders were acquiring publicly issued securities at a rate of about 6 or 7 per cent of national product per year, while German savers acquired at a rate of about 4 per cent. For assets of financial institutions, the positions of the two countries were reversed, with Britain's accumulation in the 1901-13 period approximating 3 per cent of the national product and Germany's between 8 and 9 per cent.[83] While it is possible that railroad finance played a greater role in this German growth, one certainly cannot say that the British financial system suffered from less thereof.

A purely quantitative comparison of the financial position of both countries in the late 19th century, however, does not tell the full story. While Britain may have received as much quantitative growth of its financial intermediation as a result of railroad finance, Germany may have experienced financial intermediation growth of a different variety that may have been more conducive to subsequent industrial growth than that which occurred in Britain. To Tilly, the industrial development of Germany in the first half of

[82] Tilly (1986), pp. 127-35.
[83] Ibid., p. 132.

the nineteenth century is very similar to that of Britain, in that the railroad building of the 1840's initiated the development of a national market for enterprise capital. However, the railroad-building experience of Germany differs insofar as its impact on capital markets from the British experience in two ways. Firstly, Tilly explains, railroads were relatively more important in the German economy, as evidenced by the greater share comprised by railroad investment relative to other industrial and commercial investment. Secondly, railroad financing in Germany paved the way for a unique form of industrial finance peculiar to Germany; a unique German innovation in industrial finance that became known as German "mixed" banking. This form of banking, also described by Chandler, entailed greater involvement of financiers in the affairs of business enterprise, as seen by bankers taking a role in the initial organizing committees of forming railroad companies, and taking a leading role in marketing the securities necessary for the initial raising of funds for their construction. This strong relationship between the railroads and their banks continued as the railroads matured, with bankers often occupying key positions on the boards of directors of the railroad companies, as additional safeguard care-keepers for their considerable investments, including organizational contributions.[84]

As Chandler explained, the banks' relationship with railroad companies established a pattern of industrial finance in Germany that continued when the banks began to finance other large-scale enterprise, and served in the same advisory capacity in which they had assisted the railroads. In summary, we find in Tilly the essentially same story of the great contribution of the railroads to industrial finance in Germany as described by Chandler; the evolution of the Kreditbanken, and their great contribution to

[84] Ibid., pp. 128-30.

industrial growth through not only massive outside capital access, but through the supervisory and advisory capacity in which they assisted their industrial clients.

Besides the stronger bonds between banks and industrial corporations that existed in Germany, Tilly points out that there was another crucial advantage that Germany enjoyed that was not shared by Britain: these banks were busy financing domestic enterprise, while British banks were investing abroad. While Britain rivaled Germany in terms of sheer number of securities issued on the London exchange vs. the Berlin exchange, Tilly presents evidence here showing that from 1882-1913, foreign issues dominated the British market, whereas it was quite the opposite in Berlin.[85]

It appears that Britain in general, and London in particular, did experience an augmentation of its financial intermediation facilities as a result of the railroads in one form or another that was commensurate with that experienced by the United States or Germany. It may have been dispersed across the land in the provincial exchanges, or it may have been concentrated in London; regardless, there does not seem to have been a shortage of capital in Britain in the later decades of the 19th century that could have been used to finance industry. There is an extensive literature on the subject of why there was little domestic investment in Britain at this time, and capital tended to gravitate overseas. According to many scholars, this occurred because these investments may have been more profitable, and this may have been detrimental to economic growth and industrial development at home. Cottrell remarks, citing assistance from Edelstein, that in the London market, investors generally placed their savings in large issues, which meant apart from railroad securities, foreign issues (which included foreign railroad assets, as pointed out by Fishlow). Railroad securities appear to have been the great domestic

[85] Ibid., pp. 130-35.

mainstay of the British securities industry. It seems absurd to say that because Britain got little railroad investment in the railroads' formative years that this was its Achilles heel in its later years, when in fact railroad investment was practically its only remaining strength as far as domestic investments were concerned. It points to the notion that perhaps British financial weakness in financing domestic large scale industry in the latter decades of the 19th century may have been something that occurred in spite of, not because of the quantity of railroad investment finance that occurred throughout the century.[86]

Further, Cottrell notes, this lull in domestic investment ended with the financial boom of 1895 that saw a tremendous increase in domestic issues until 1900 that included both railroad and non-railroad investments that both the London and provincial exchanges cashed in on.[87] While this domestic boom may have occurred in "too little, too late" a manner in which to enable British industry to catch up with the American and German enterprises, who had already acquired the necessary first mover advantages in the crucial hi-tech growth industries of the late 19th century, it does seriously call into question the notion that financial sector weakness was a major stumbling block for Britain insofar as keeping up with the Joneses in the area of financing the large scale industry of the 2nd Industrial Revolution.

The more recent literature concerning the comparative development of the British and German financial systems does not support Chandler or Tilly. Besides Fohlin, Edwards and Oglivie's work cited above that called into question the degree to which railroad finance contributed to the growth of universal banking in Germany, these

[86] Cottrell, p. 151.
[87] Ibid., p. 173.

scholars also dispute the alleged dissimilarity of the banking systems of the two countries in finding little differences in the degree of equity participation in industrial companies on the part of banks in the two countries. Fohlin also dispels as myth the idea that the German banks had closer, longer, cradle-to-grave relationships with their industrial clients in finding that actually, compared to the British banks, German banks actually maintained significantly higher cash deposit ratios than the British banks did, and covered a greater share of short-term liabilities with short term or liquid assets. Fohlin notes that the German universal banks may have expanded their available capital at a faster rate, since they invested or lent a greater share of their total liabilities than did the British banks, and implies that this may have played a role in relatively stronger performance of German industry since the end of the 19th century. But she determines that this phenomenon does appear to be related to any real differences in banking structure.[88]

*

To summarize and draw some basic conclusions from our literature survey before we proceed to our empirical analysis, it appears that Chandler may have been only partially correct about the impact of the railroads on Britain's capital markets, and its ramifications for industrial development in the latter decades of the 19th century. It appears that Britain's railroads may have also been heavily financed by outside capital, and that this

[88] Edwards & Ogilvie, pp. 434-35; Fohlin, Caroline. "Bank Securities Holdings and Industrial Finance before World War I: Britain and Germany Compared." *Business and Economic History*, Vol. 26, No. 2, Winter 1997, 463-75; --------. "Banking Systems and Economic Growth: Lessons from Britain and Germany in the Pre-World War I Era." *Review (00149187)*, Vol. 80, No. 3, May/Jun. 1998, 37 (11 pp.). Retrieved from Academic Search Premier database; --------. "The Balancing Act of German Universal Banks and English Deposit Banks, 1880-1913." *Business History*, Vol. 43, No. 1, Jan. 2001, Vol. 43, 1-24.

financing did have a dramatic impact on its capital markets, as evidenced by the development of a national market for railroad shares. The tremendous discrepancy between Chandler's and other authors' descriptions of the impact of the railroads on capital markets in the three nations, particularly the relative degree of outside capital in the railroad networks of the three countries, demonstrates the need for further empirical work in this area in order to determine if in fact it is the case that the American and German railroads were more heavily reliant upon outside capital in the construction of their railroad systems, and if this greater reliance on outside capital is associated in any way with greater growth of investment banking industry. Why Britain failed to make the necessary investments in the large-scale, science-based industries of the late 19th century, and its industrial sector grew less rapidly than that of the United States and Germany is difficult to pigeonhole, but it does not appear to be due to lack of adequate investment banking facilities. A reading of Tilly suggests that Britain invested too much capital overseas to the detriment of home investment, and that closer bonds between the banking community and the industry it served was a crucial ingredient for success for Germany. Yet the United States invested a great deal in the large-scale, science-based industries of the late 19th century, and experienced a rapid industrial growth similar to that achieved by Germany that was mostly unaided by the German "mixed banking" model of industrial finance. The Tilly readings also do not indicate any dramatic centralization and institutionalization of Germany's capital markets in Berlin or any one location, as Chandler maintains occurred in New York, and implies was a crucial ingredient for the subsequent American industrial expansion. The fact that German industrialization in the late 19th century appears unhampered by this lack of a single concentrated financial

center blows a further hole in the Chandlerian hypothesis that lack thereof was an impediment to British industrialization.

V. FINANCIAL INTERMEDIATION EFFECTS: THEORETICAL FRAMEWORK FOR EMPIRICAL ANALYSIS

We now develop the theoretical framework for our empirical analysis of the role of financial intermediaries in the said correlation between the railroads and the more concentrated, large-scale mode of industrial organization that had evolved in the United States, Germany, and, ostensibly, to a lesser extent, in Britain by the late 19th century. This component of the study attempts to quantify the impact of the railroads on capital markets that Chandler claims gave such tremendous impetus to economies of scale and scope in American and German industry via financial intermediation. Here we provide a critical assessment of the Chandler hypothesis that the tremendous capital needs of an expanding railroad network in the United States called for such enormous quantities of outside capital that the result was the centralizing and institutionalizing of the nation's money market in New York, which Chandler believed was of critical importance to the subsequent financing of large scale industry, and provided a significant impetus to the growth of economies of scale and scope in American industry in the late nineteenth century. We also provide a critical assessment of the Chandler hypothesis that the British industrialization of the mid-to-late nineteenth century was less heavily impacted by the railroads due to a lesser impact of its railroads on financial intermediation. In our task of measuring the degree of correlation between the railroad and greater concentration and scale of industry that was achieved through the strengthening of financial intermediation, we conduct an analysis that attempts to juxtapose the timing of effects of the railroads on

the industrial development of these countries with data concerning the financing of the railroads themselves, in a similar manner as these effects were presented alongside data concerning mileage and physical capital invested in the railroads in the previous chapter in evaluating the degree of the correlation between the railroads and greater concentration and scale of industry achieved through the railroads' market-expanding properties and input demand effects. We also, using what data is available, attempt to conduct a similar analysis with respect to the impact of the railroads on German financial intermediaries to provide a further test of the magnitude of these financial augmentation effects wrought by the railroads that Chandler thought to be so important to Germany's industrial development in the late 19th century.

The empirical evidence presented thus far shows mixed support for Chandler's theory. In the previous chapter, Table 2.1 showed that the United States and Germany indeed possessed larger, more extensive railroad systems than Britain. Ostensibly, they therefore ought to have had greater need for capital, which in turn ought to have greatly stimulated the business of selling and buying railroad securities, which ought to have had a commensurate augmenting impact on the financial institutions of those countries, which, in turn, through the task of financial intermediation, ought to have contributed to the growth of non-financial industries, abetting economies of scale and scope in those countries and contributing to their technological leapfrog over Britain in the late 19th century.

However, our literature survey on the financing of the British, American and German railroad systems reveals that Chandler may have greatly exaggerated the role of American financial institutions in providing outside capital to the railroads, and may have

greatly under-estimated the role such institutions played in the construction of the British railroad system, and the respective impact these activities had on these financial institutions of the two countries. Our empirical analysis of railroad mileage per square mile of national territory in Chapter Two buttresses these revelations of our literature survey, because it shows Britain as the most heavily railroadized nation of the three, with far greater railroad track per mile of national territory than either the United States or Germany throughout the period in question. Because Britain had such an extensive railroad system for its size (meaning geographic area *and* overall size of its economy), the industry of railroad construction may have loomed larger relative to other industry there, and therefore may have been relatively *more* reliant on outside capital for the construction of its railroads. This may have precipitated more financial sector growth as a result of its railroad business than in the United States and Germany. The literature survey on derived demand effects also supports this contention of the relatively greater importance of the railroads in Britain in the tremendous impetus to its iron and coal industries Bagwell and other historians have attributed to it. This points to the need for an empirical methodology for assessing financial intermediation effects that takes the relative sizes of these economies into account.

In order to construct our empirical methodology for testing Chandler's theory concerning the effects of the railroads on financial intermediation, a brief recapitulation of that theory is necessary. Chandler maintained that the capital needs of the larger and more extensive American and German railroad systems were beyond the recourse of the lone entrepreneur or local sources of capital, and were such that required massive infusions of outside capital provided through selling securities in large exchanges that

arose to meet that need. These exchanges grew and prospered in association with their railroad business, and before long, a vast financial infrastructure expert in the task of raising funds for large enterprise, and in general capable of supplying large amounts of outside capital to the railroads and other industries came into existence. With this infrastructure, nations were equipped with the means to effectively fund, build and operate other large-scale capital intensive enterprise both during, and particularly after the majority of their railroad systems were constructed. Due to the tremendous capital input needs of the railroads, a dramatically new mode of industrial organization that was larger-scale and more concentrated than that that had hitherto existed was ushered into the developed economies of the United States and Europe, and it was Chandler's contention that the greater preponderance of the railroads in the United States and Germany naturally resulted in a greater preponderance of this form of industrial organization than in Britain where the railroad system was smaller and capable of being financed by smaller-scale, more local, traditional mechanisms.[89]

In order to test this hypothesis, our empirical methodology must provide a fair measure of the degree of financial augmentation each nation experienced that was a direct result of this business of providing these massive infusions of outside capital to the railroads by selling securities in large exchanges. If by a direct result of supplying huge amounts of outside capital to the railroads there was a dramatic growth in the financial capital industry which was of critical importance in raising the investment capacity of the economy in terms of providing capital to other non-financial and non-railroad industries, one possible indicator of that growth would be a large and growing portion of outside railroad capital assets in the portfolios of these financial institutions. However, we must

[89] *Scale and Scope*, pp. 54-58, 252-55, 397, 411-19.

heed the Chandler hypothesis that it was because of the greater capital needs of the larger and more extensive American and German railroad systems that this financial augmentation occurred. For instance, it is possible for a nation with a small railroad network, say Britain, that did not require massive amounts of outside capital to build, to have greatly stimulated the smaller scale banking industry it already had as a result of its railroads due to the relative greatness of this otherwise small sum of outside capital in the portfolio of that existing financial sector—a sum that, although small, contributed a lot to that nation's development of a modern financial sector. Such a scenario would be indicative of a very low correlation between a large and growing railroad system and the growth of the modern financial sector.

To provide a more rigorous and appropriate test of the Chandler hypothesis, we need to examine the enlargement of a nation's financial sector in association with the business of railroad finance in relation to the rest of its economy. That small sum of railroad outside capital in the portfolios of British investment banks that made a great percentage-wise contribution to the growth of a modern financial sector could still have resulted in a small and ineffectual modern financial sector. It all depends upon the size of the economy. If the British modern financial sector was small because railroads stocks, for instance, were its primary asset, and there was little else in their portfolios, and/or this small total chunk of capital in question was a negligible portion of total investment in the economy, then one can rightly attribute the small capital needs of Britain's railroad system as a factor contributing to a weak modern financial sector in Britain. But suppose that given the size of the overall British economy, this creation of a modern financial sector looms large on its economic horizon; despite its small size as compared with the

capital raised for the railroads in the United States for example, this capital stock represented a huge rise in investment as a percentage of total output in the economy. For an economy the size of Britain, viewed in this relative context of growth of the financial sector vis-à-vis the rest of the economy, it may have been a very robust and significant ballooning of the financial sector. A chunk of capital that would be small for the United States might be very large for Britain. As a result of the stimulation of the railroads, Britain's modern financial sector may have swelled to a size that was more than adequate as a means for propelling economic growth given the size and population of Britain. Given the size of Britain's economy, this "small" stock of capital may have constituted a huge package of harnessable economic development potential.

Thus a more appropriate indicator of financial augmentation effects in association with the business of railroad finance would be an enlargement of a nation's financial sector in relation to the rest of its economy from selling railroad securities. The percentage of G.N.P. that railroad outside capital comprised automatically subsumes this enlargement because it would be impossible for railroad outside capital to be a large fraction of G.N.P., yet a low fraction of total investment. That would require investment to be such a large per cent of G.N.P. that it practically wipes out, or makes negative, the other portions of spending that comprise the national income identity; a nearly impossible scenario.

Conversely, if railroad outside capital were a small percent of G.N.P., it would be an indicator of the insignificance of railroad outside capital in a nation's financial intermediation facilities. Even if that quantity of railroad outside capital were a large percent of total investment, it would mean that investment itself is such a small share of

national output that things that induce changes in its size are irrelevant, or at least, of little consequence insofar as they stimulate the financial intermediation capabilities of the nation. And naturally, if railroad outside capital is both a small share of G.N.P. and a small share of investment, changes in railroad outside capital affect neither the overall level of the investment capacity of the nation nor the size of the financial sector itself by very much. Consequently, if railroad outside capital is a small share of G.N.P., it unambiguously points to both insignificance of this quantity of capital in terms of strengthening the overall investment capacity of the economy, and non-strengthening of financial intermediation occurring in relation to supplying capital for railroads.

Consequently, the percentage of railroad outside capital in a nation's G.N.P. serves as an effective empirical variable for measurement of the growth of the financial capital industry that in turn, can be attributed to the railroads. If it is large, it is an indicator of a large stock of capital in relation to the rest of the economy that was directly attributable to the existence of the railroads that also contributed a lot to the strengthening of financial intermediation in the economy. If it is small, it is indicative of a small stock of capital in relation to the rest of the economy that was insignificant insofar as bolstering the financial intermediation facilities of the economy. A small and compact (large and expansive) railroad system could have had a great (small) impact on a nation's financial intermediation facilities; if so, debunking the Chandler hypothesis.

The efficacy of the percentage of railroad outside capital in a nation's G.N.P. in a given period as an appropriate index of the degree of the impact of railroad assets on the augmentation of financial intermediation facilities in an economy over time is given further confirmation by Obstfeld and Taylor (2004), who explain that a measure of the

stock of a given form of investment must be appropriately scaled and consistent over time if we are to gain some sense of the evolution of a given market for a particular kind of asset. The data must be normalized from its measurement at a point in time in current dollars, because the growth of the economy might be associated with an increase in such a nominal quantity, as would any long-run inflation. These trends would have nothing to do with augmentation of the financial sector from railroad assets *per se*. To overcome this problem, railroad capital must be normalized at each point in time by some measure of the size of the economy in question, dividing through by a denominator in the form of a nominal size index.

While the total stock of financial capital might seem to be an ideal denominator for gauging the impact of railroad capital upon financial intermediation, Obstfeld and Taylor point out that the problem with this method is that financial capital measures multiply over the long run as the number of balance sheets in the economy expands through financial development as seen in the rise of numerous financial intermediaries. This trend, in principle, could happen at any point in time without any underlying change in the extent of railroad asset holdings. According to Obstfeld and Taylor, the level of output as measured by G.D.P. in current prices functions better as a normalizing agent. Consequently, the ratio of railroad assets to output should be adequate as a proxy measure of the penetration of railroad capital in any economy over time.[90]

Since we are interested in testing the chronological impact growing railroad systems eventually had on financial intermediaries in these countries in this study, Obstfeld and Taylor's methodology dovetails completely with our own. In Table 3.3

[90] Obstfeld, Maurice and Alan M. Taylor. *Global Capital Markets: Integration, Crisis, and Growth*. Cambridge, UK; New York: Cambridge University Press, 2004, pp. 49-50. Chandler uses the terms "outside" and "external" capital interchangeably; a usage that may be erroneous.

below in which this series is constructed, we can view it in relation to Table 2.1 and see how closely this financial augmentation parallels the construction of the railroad network as a test of Chandler's theory. We can also compare it to Table 2.1 that measured railroad mileage per square mile of national territory to obtain an indicator of the magnitude of the effect of these growing railroad systems on capital markets. Britain's more highly concentrated railroad system may have had a greater impact on its capital markets.

Before we proceed to the empirical analysis, one further issue that must be cleared up is what to use as our measure of "outside capital". Here, we use that provided by Raymond Goldsmith in his1958 NBER study of long-term trends in capital formation and financing in the United States. In this larger work, Goldsmith provides analyses of trends in the principal capital-using sectors of the economy to provide us with more appropriate categories of capital. In categorizing the sources of funds for railroads in the mid-20th century, Goldsmith counted as "internal" sources only retained profits and consumption allowances. All other sources of funds, including bank loans, mortgages, capital stock, bonds, and all other liabilities were considered external sources.[91]

We use Goldsmith's definition of outside capital in order to clear up possible confusion about the meaning of the term caused by our diverse literature sources. In describing the inadequacy of local capital sources for the construction of the American railroads, Chandler describes these as individuals living in a road's termini or along its line who believed they had much to gain from its construction, or banks and stock

[91] Goldsmith, Raymond William. *Financial Intermediaries in the American Economy Since 1900*. Princeton, Princeton University Press for the NBER, 1958, p. 229.

exchanges situated in a road's termini or along its line,[92] implying that outside capital is that originating from any other source; an opinion echoed by Bagwell.[93] However, this definition may be a little too cut-and-dry, as it pertains to local vs. long distance capital sources. As Reed points out, the great provincial stock exchanges of Britain grew to immense capacity by funding railroads both inside and outside their areas.[94] Does one count the funding from such institutions that funded railroads in their own locale as local or outside capital?

Goldsmith's definition of external capital also corresponds very closely to the data for railway financial capital that are available to us. These are data for total stock of railway financial capital for the United States for every five years for 1850-1914 from the Census Bureau's *Historical Statistics* that I have tabulated in Table 3.1 below along with the same for Great Britain for 1830-1914 and their respective decadal growth rates. These American data consist of total capital stock, bonded debt, mortgage bonds, obligations, etc. as described in series Q-347 of the Rail Transportation data series in *Historical Statistics* (the source of my pre-1890 data), and total common stock, preferred stock, and funded debt unmatured as described in Series Q-358 of the same Rail Transportation series (the source of my data from 1890 on). These data ought to be adequate as a measure of the quantity of external capital in the U.S. railroad system.[95]

The British sources encompass a similar array of financial instruments. The 1830-45 data found in Hawke and Reed (1969) represent the sum of all share capital and

---

[92] *Railroads,* pp. 43-45.
[93] Bagwell, pp. 95-96.
[94] Reed (1975), pp. 212-13.
[95] U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C., 1975), II, pp. 734-35.

loans and debentures and the 1850-1914 Mitchell and Deane (1975) data represent all paid-up capital and loans. German data were not available.

Following Table 3.1 is Table 3.2 that delineates Gross National Product for Great Britain, the United States, and Germany for 1830-1914. Next is Table 3.3 that delineates the total stock of railway financial capital as a percentage of Gross National Product for Great Britain and the United States for every five years for 1830-1914.

VI. EMPIRICAL RESULTS AND ANALYSIS

In looking at Table 3.1 that contains the unnormalized data for total stock of railway financial capital for the United States for every five years for 1850-1914 along with the same for Great Britain for 1830-1914 and their respective decadal growth rates, we must bear in mind that since the data are in current rather than constant prices, a precise comparison of the stock of capital at different dates cannot be made here. Notwithstanding, it appears that British railway finance made a relatively modest start in absolute terms in the 1830's and 1840's, although in percentage terms, its rate of capital accumulation was very rapid. After its large leap in absolute quantity of capital achieved by the 1850's that confirms Reed's statements about the mid-century railroad finance boom, Britain continued to accumulate financial capital at a steady, albeit diminishing rate all the way up to 1914. The United States seems to have made its great leap in absolute quantities of capital during the 1870's and early 1880's, making leaps in the two billion dollar range. After this period, investment increased at a more modest, but still healthy rate. One more gigantic burst of financing activity appeared in the early 20th

century as seen by the nearly five billion dollar jump occurring between 1905 and 1910, and the 60 per cent increase over its 1900 level of capital achieved by 1910.

In general, Table 3.1 displays a generally more rapid accumulation of capital as occurring in the American railroad system as compared with Britain throughout the period in question which supports Chandler's contentions regarding the relative strength of the effects of the railroads on financial intermediation during the early industrialization of the United States vs. what was going on in Britain at the same time. I would particularly direct your attention to the period from the 1850's to the 1870's, during which doubling or near-doubling of the capital stock over five-year periods is frequently observed. Such rapid capital accumulation corresponds to the period during which the United States overtook Britain in railroad mileage, and in doing so, purportedly, amassed the huge quantities of capital necessary for constructing the railroads that Chandler believed ultimately led to the centralizing and institutionalizing of the nation's money market in New York and established the essential mechanisms for the financing of other large-scale industrial corporations.

The data are also in sync with Chandler's timing predictions in terms of the effects of this capital accumulation on financial intermediation and wide-scale industry finance. If Britain were to have experienced any consequences of railroadization that abetted the economies of scale and scope of industry through amplification of its financial sector, these spillover effects onto other large-scale industry ought to have occurred at around 1870; the same time in which all the other economies of scale and scope British industry received in association with the opportunities presented by the railroads occurred. Since Chandler believed Britain experienced little of these effects due

to its smaller and more compact railroad system, he does not give us any indication of when these effects, if there were any, would be manifest. However, barring any further exploration of the economic history of the impact of the railroads on British banking, it would stand to reason that if we want to measure and quantify whatever effects the railroads had on the British financial sector, and any concomitant expansionary effects on other industry associated with this augmentation of the financial sector, the peak of finance observed at mid-century would certainly be, as it is in the case of the United States, our starting point. With the lagged effects similar to that that purportedly occurred in the United States, the economies of scale and scope British industry received in association with the opportunities presented by the railroads has been identified above as having begun at about a benchmark date of 1870.

Chandler's timing predictions in terms of the effects of this capital accumulation on financial intermediation and wide-scale industry finance in the United States require far less guesswork. Chandler has definite opinions as to when the dramatic effects of the railroads began to be felt on American financial intermediation where he mentions how the huge capital requirements for constructing the American railroads led to the centralizing and institutionalizing of the nation's money market in New York. Chandler credits the growth of the New York money market from the 1850's to the 1890's, during which time it grew to be second in size only to that of London, as having occurred almost exclusively as a result of railroad financing activities. He notes that the great investment banks that were to play such an important role in the financing of industrial mergers at the turn of the century all owed their birth to the specialty of railroad finance.[96] This acceleration in the rate of capital accumulation during that time is evident in Table 3.1

[96] *Scale and Scope*, pp. 57-58.

below. Certainly a reasonable starting point one can point to the mechanisms for such large-scale financing activity as having established themselves, if not at least their having been set in motion, would be about 1870, about the beginning of the development of the large, (non-railroad) industrial corporation in the United States.

Following Table 3.1 is Table 3.2 that demarcates Gross National Product for Great Britain, the United States, and Germany for 1830-1914. Inspection of these nominal G.N.P. figures shows all three countries as having experienced very constant, steady growth in national output over the period in question, although a real G.N.P. comparison might show peaks and troughs a little more accurately.

Table 3.2 is followed by Table 3.3 that delineates the total stock of railway financial capital as a percentage of Gross National Product for Great Britain and the United States for 1830-1914. As it can be seen in Table 3.3, Britain's head start in railroad construction puts it in a strong first place over the United States all the way until 1875, after which time the American percentage exceeds that of Britain for every year except 1905 and 1910, and these are only very narrow leads of Britain. Yet we cannot attribute Britain's head start in railroad construction to this phenomenon because the United States had overtaken Britain in railroad mileage by 1835. Yet Britain maintained a strong lead in capital as a percent of its G.N.P. all the way until the 1870's, which suggests that railroad finance played a stronger role in the British economy at least until the 1870's, and points to a stronger impact of the railroads on financial intermediation facilities in Britain than in the United States all the way until the 1870's.

This is strongly at odds with the Chandler hypothesis that a much more powerful impact of railroad finance activities in the United States by the 1850's was responsible

for the centralizing and institutionalizing of the nation's money market in New York, which from the 1850's to the 1890's was instrumental in the financing of industrial mergers at the turn of the century, and providing the impetus for rapid economic growth based on large scale production technologies rich in economies of scale and scope. If these railroad financing activities were the catalyst to such growth, then it appears that it is Britain who ought to have experienced this type of growth in its financial institutions, not the United States. These results confirm the contentions of Tilly and the other experts on the financing of the railroads in Britain that Britain did experience a great deal of financial augmentation as a result of its railroads, but this did not translate into great industrial growth at home for other reasons; a strong propensity to export capital perhaps being one of them. If anything, these data overstate the American and understate the British financial augmentations from the railroads, because, as Fishlow pointed out, much of the financial capital that the United States used to construct its railroads was borrowed from Britain. These data also support the contentions of Reed and the other scholars of the financing of the British railroads that there was a massive boom in railroad financing activities in the early-to-mid-19th century that brought the Provincial Exchanges into existence and resulted in the creation of a national market for railroad shares in Britain by the mid-19th century, not unlike the centralizing and institutionalizing of the nation's money market in New York by the 1850's that Chandler claimed was the result of railroad finance activities in the United States.

If a greater impact of railroad financing activities on the American banking system than the British was what was responsible for its leapfrog over Britain regarding large-scale production technologies, then this could not have begun until at least the

beginning of the 1870's—not the 1850's as Chandler claimed. But by that time, the leapfrog had already begun. The United States was already in the lead as a first mover in these large scale production technologies. Thus it is very hard to make the claim that it was a greater impact of railroad finance activities on its banking system that was a catalyst to this rapid growth the United States experienced starting in the 1870's. Railroad financing activities ought not to have begun to have their 20-year or so lagged impact that put them at an advantage with respect to Britain until the 1890's. But Chandler claims that the United States was at an advantage over Britain in these regards long before that time. These data also mirror and bolster the topsy-turvy ranking order found in Table 2.1 that showed that in railroad mileage per square mile of national territory, Britain was the most heavily railroadized nation of the three throughout the period in question, and the historical documentation pointing to a perhaps greater impact of the construction of the railroad network on the British iron and coal industries. Relative to its size—meaning both area and economic output—the British railroad system may have been so large as to have put relatively greater demands upon both its railroad financial and physical capital input industries that the growth impact on these industries from the railroads was greater than the American. Why this did not translate into prowess in the science-based industries of the late 19th century or a more concentrated industrial structure overall is another question. But it calls the premises of the Chandler theory that Britain's stumbling block in these areas was a lesser impact of the railroads on its industrial development into question.

VII. ALTERNATIVE METHODOLOGY: PHYSICAL CAPITAL AS A PERCENTAGE OF NATIONAL OUTPUT

Since we lack data on railroad financial capital for Germany for these years, an alternative methodology for comparing its financial augmentation from the railroads to that of the United States and Britain is presented below. Table 3.4 displays the data for gross reproducible (physical) railway capital formation/expenditure (total capital flow) already presented in Table 2.2 below as a percentage of Gross National Product for Great Britain, the United States and Germany for 1830-1914. Below, in Chart 3.1, are these data presented in a graph for comparison with physical capital as a percentage of G.N.P. on the vertical axis plotted against time on the horizontal axis.

These data function as an alternative measure of financial augmentation from the railroads indirectly, because greater investment in physical plant, way, and equipment as a percentage of national output would likely and logically also mean greater borrowing in capital markets as a percentage of national output. If it were true, as Chandler asserted, that the smaller railroad network of Britain created less financial challenges for its economy than that of the United States and Germany, then the capital required for its construction ought to have been less as a percentage of G.N.P. It stands to reason that if the capital used in the construction of Britain's railroad system was a smaller fraction of G.N.P. than in the United States and Germany, then the capital raised in financial markets to finance that construction also would be smaller fraction of G.N.P. than in the case of the American and German railroad systems. We now have a means by which to compare the capital needs of the British railroad system in relation to its own and the German economy and assess the relative importance of the railroads in these two countries over this time span.

In more general terms, these data provide us with a measure of the raw physical size and extent of a nation's railroad system in relation to the size of its national output, and offset the distortions involved in comparing the railroad systems of nations of vastly different areas. Chandler's idea that that the larger and more extensive a nation's railroad system, the greater the augmenting effect its construction would have on its financial sector is really a fallacious argument because of the vastly different geographic areas and G.N.P.'s of the countries we are comparing. There is no solid theoretical reason why a larger, more extensive railroad system ought to have produced a relatively larger sector of the economy involved in supplying outside capital to industry, other than the fact that these features of the development of the American railroad system were so strong relative to the British that they *did* result in a financial capital industry of greater size in relation to the entire economy. As Tables 2.1 and 3.3 have shown, on a per-square mile basis or as a percentage of national output, the American railroad system was not so large relative to Britain's as to have automatically subsumed a commensurately greater augmentation of its financial sector involved in railroad financing relative to national output. Britain had a far more extensive railroad system in terms of mileage per square mile of national territory and in terms of the value of its financial assets as a percentage of national output. This normalized measure of physical capital investment dovetails more nicely with the theory that a nation for whom investment in its railroads was a more important part of its economic development would have received greater financial market augmentation as a result of this.

It also functions as a normalized measure of the relative impact of railroad inputs demand on industrial growth of the three nations. While the patterns of growth in the

unnormalized stock and flow capital data of Tables 2.2 and 2.3 support the general contention of more rapid capital growth and accumulation in Germany and the United States with respect to Britain, our historical assessment of the relative impact of the railroads on the iron and coal industries in such a capacity indicated greater stimulation of the British iron and coal industries; a point that was bolstered further by Britain's greater railroad mileage per square mile of national territory, and its greater normalized financial capital investment. It would be interesting to see if, when normalized, taking the relative sizes of these nations and their economies into account, these results reproduce themselves or not. Britain's seemingly sluggish patterns of capital accumulation as compared with the United States and Germany may have been tremendous as a per cent of its G.N.P., and also, therefore, by logical implication, a large per cent of its iron, coal and other railroad capital producing industries, pointing to still further derived demand effects from the railroads on British industry.

Also, track mileage only tells half the story, because it omits all the other kinds of plant and equipment that comprise a railroad system, and contribute to making a nation more heavily "railroadized." The data of Table 3.4 get us over these difficulties because they give us a monetary measurement of the augmentation of a nation's railroad system that can be compared to its G.N.P., and they include such other expenditures besides track mileage that go to make up a nation's railroad system.

Referring to Table 3.4 and Chart 3.1, and to the commentary and analysis for the unnormalized Table 2.2 above, it can be seen that the spike in investment Britain experienced in the 1840's remains present even when measured up against G.N.P., while its later spike of the 1860's appears more modest when compared to G.N.P. Regardless,

prior to the late 1870's, British investment is relatively large as a percentage of G.N.P., appearing to average somewhere between 1 per cent and 2 per cent of G.N.P. This bolsters Reed's belief in the mid-19th century as being a boom period for investment in railroads in Britain. For the remainder of the period surveyed, from the 1880's on, Britain's investment remains very constant as a percentage of G.N.P., albeit at a slightly diminished level, hovering closely around the 1 per cent mark.

American investment when compared to G.N.P. shows the great spike of the late 1830's and great thrust of the late 1840's, but what stands out even more prominently is the great spike of the 1860's, as seen by the jump from 1860 to 1861 of 1.28 per cent to 7.23 per cent, respectively. The sustained growth that occurred thereafter can still be seen in Chart 3.1, with an average appearing well above Britain's 1 per cent of G.N.P., albeit with significantly greater volatility.

The German volatility of the 1850's and 1860's appears to continue on throughout the 1870's when compared against G.N.P., and only smoothes out by the 1880's. But as can be seen from examining German G.N.P. of the 1870's in Table 3.2 (G.N.P. table), this volatility seems to come more from G.N.P. than from railroad investment, as there was a sharp spike in German G.N.P. in 1874, followed by a sustained dip that continued throughout the 1870's, not rising again until the 1880's. Thereafter, German investment smoothes out to British absolute levels and constancy. Ironically, Germany's volatile period appears to be its highest averaging period, with an average close to Britain's from the mid-1850's to mid-1860's, between 1 per cent and 2 per cent, then rising to higher levels approaching the American, averaging close to 2 per cent from the mid-1860's to the start of the 1880's.

Comparing all three countries, the United States seems to be the only one for whom very large percentages (2 per cent or above) seem to be a normal, regular phenomenon, and is clearly the highest averaging country in these regards. Next is Germany who seems to average well above 1 per cent for a long stretch from the mid-1840's to the early 1880's. In third place, but not far behind Germany, appears to be Britain, whose golden age of railway investment above 1 per cent of G.N.P. is also from the mid-1840's to the early 1880's, but who does not seem to possess spikes above 2 per cent during that period, as Germany does throughout the 1870's.

One pattern that can be seen that all three countries have in common is a great take-off in the 1840's that is more or less sustained until a leveling off period in the 1880's. Even the United States, which still seems to average above 1 per cent from the 1880's onwards, never regains the massive spikes it achieved in the 1860's and early 1870's. In fact, for all 3 countries, it appears that the 1860's and 1870's were a golden age of railroad investment that was never achieved again.

The essential ranking order of the United States first, Germany second, and Britain third in physical capital formation as a percentage of G.N.P. shown in Table 3.4 is in more or less close correspondence with the degree to which Chandler believes the railroads impacted the industrial development of the 3 nations, and correlates with the specific patterns of railroad mileage growth we observed in Table 2.1. In Table 3.4, we find support for Chandler's contention that the greater capital needs of the larger and more extensive American and German railroad systems would have had a greater augmenting effect on their financial sectors. It can be seen from Table 3.4 that just as in Table 2.1, Britain starts off as the leader in the very early days of the railroads, but by the

1850's is overtaken by the United States, and by the 1870's by Germany. Just as Table 2.1 displayed, Table 3.4 shows Britain as having experienced its last hump of great railroad investment in the 1860's, by which time its railroad system was essentially complete, and railroad investment for it as having leveled off to lower-averaging levels from the 1880's on. From the 1880's on, there is still great investment in railroads relative to G.N.P. going on in the United States, corresponding to the still rapid growth of its railroad network, whereas German investment in railroads slows down to British levels by this time, as Table 2.1 showed via the lessened rapidity of German mileage growth after that date.

This ranking order and phases of growth shown in Table 3.4 are also in sync with Chandler's beliefs concerning the stimulation of financial intermediation during the critical period in which the United States and Germany gained their lead, and support his contention of the 1870's as having been the benchmark period in which the economies of scale and scope effects of this financial augmentation were felt. Examining Table 3.4 over this investment peak of the 1850's to the 1870's, the ranking of railroad investment in G.N.P. was the United States first, Germany second, and Britain third, corresponding to the degree to which railroad investment was purported to have impacted each nation's financial intermediation.

It is likewise in the case of input demand effects, in support of Fishlow's belief that the railroads did not becomes huge "eaters" of the output of railroad-input-producing industries in the United States until the post-Bellum era, for it shows that the period in which the greatest amount of physical capital was invested in the railroads relative to G.N.P. was the 1860's and 1870's—not only for the United States, but for Britain and

Germany as well. These data also support the idea of 1870 as a benchmark period in which to look for significant traces of expansionary effects on these industries in association with their role as suppliers of inputs to the railroads.

Focusing in on Britain, the data show the 1860's as having been its greatest period of railroad investment. If there were any significant effects upon financial intermediation in Britain's economy in association with the railroads, the 1870's would be the time to look for their appearance. But then Britain quickly dropped off and began a descent in the 1870's while Germany pulled ahead of it. Since our data show that Britain invested the least amount of capital as a per cent of G.N.P. of all three nations during this period and the time leading up to the crucial benchmark date of 1870, we determine from these data that whatever effects upon financial intermediation in its economy in association with the railroads were to be found here, they would likely be less than in the United States and Germany, in confirmation of the Chandler hypothesis that lesser demand for capital for the railroads during this period meant that Britain did not receive the tremendous augmentation of its financial sector that the United States and Germany did at this time.

Focusing on the United States, the steep acceleration in railroad capital investment as a per cent of G.N.P. that begins in the late 1840's, and does not begin to level off until the 1880' s is in tandem with Chandler's theories as to when the dramatic effects of the railroads began to be felt on American financial intermediation. Chandler dates the centralizing and institutionalizing of the nation's money market in New York that occurred as a result of financing the huge capital requirements for the United States' railroads as having occurred from the 1850's to the 1890's, during which time it grew to

be second in size only to that of London.[97] Consequently, the results of our analysis of railroad physical capital investment as a percent of G.N.P. for the United States also point to as reasonable starting point of the establishment of the mechanisms for such large-scale financing activity as being about 1870, about the beginning of the development of the large, (non-railroad) industrial corporation in the United States. Furthermore, since the United States is the leader in these regards, our data here show a greater impact of railroad financing activities on the American banking system than for either Germany or Britain.

Focusing on Germany, the steep acceleration in railroad capital investment as a per cent of G.N.P. that begins in the 1850's, and does not begin to level off until the 1880's is also in tandem with Chandler's theories as to when the dramatic effects of the railroads began to be felt on German financial intermediation. According to Chandler, the Kreditbanken and larger Grossbanken arose to meet the tremendous capital needs of Germany's earliest railroad booms of the 1840's-50's. This relationship grew and prospered during Germany's second great railroad boom of the 1870's, and these large banks began funding other types of large enterprise. Chandler credits these large banks with having been the instruments that made possible the rapid accumulation of capital on a vast enough scale to finance the large investments necessary to exploit the cost advantages of scale and scope and acquire first mover advantages in the newer, capital intensive industries. Although it was not until the 1880's that Chandler says that the Grossbanken began to play a great role in the financing of the new industrial enterprises, it is owing to their long history in the making in response to the long history of the development of the railroads that 1870 seems like a reasonable enough benchmark time

[97] Ibid.

period in which to begin to look for traces of influence of the railroads on industrial expansion via their indirect contribution to the growth of financial intermediation.[98] While Germany's lead over Britain in capital invested as a per cent of G.N.P. over this crucial period covering the 1840's-80's is not enormous, the evidence from the data presented here is at least compatible with Chandler's theory that a greater impact of the railroads on German investment banking may be responsible for some of its advantages in amassing the funds for the large investments necessary to exploit the cost advantages of scale and scope and acquire first mover advantages in the newer, capital intensive industries that emerged in the final decades of the 19th century.

Further, these data do not contradict, and buttress in fact, the Chandlerian hypothesis that because the railroads were more important during the initial industrializations of the United States and Germany, they had a greater impact upon not only financial intermediation, but also on market enlargement and (unstated) derived demand effects upon railroad-input-producing industries, and were a factor in propelling them above Britain in economies of scale and scope exploitation opportunities in the latter 1/3 of the 19th century. The rapid growth of railroad investment experienced by the United States from the 1850's through the 1870's can certainly be said to have overlapped part of the United States' early industrialization. Although Germany does not experience rapid growth approaching American levels until the end of the 1860's, recalling the discussion of this issue above in the Table 2.1 analysis, this does not blow a hole in the theory because the period which we may refer to as the "early German industrialization" extends slightly past that of the United States due to uniquely advantageous circumstances gained in association with political unification and territorial

[98] Ibid., pp. 415-19.

acquisition after 1870 that not only abetted the growth of Germany's railroad system, but were conducive to business enterprise in general, and contributed greatly to the German industrial triumph achieved by the end of the 19th century. The further fact that from the 1850's to the mid-60's Germany does not have a significant lead over Britain in railroad investment relative to G.N.P., and Germany and Britain are actually about tied for last place, does not weaken the Chandlerian hypothesis either. As was discussed and resolved in the Table 2.1 analysis above, Germany experienced a dramatic upsurge in railroad investment just in time to rescue the theory that by the 1870's, forces were operating in the German railroads that could have been propelling financial intermediation in ways in which they were less likely to, or had ceased to have done in Britain, contributing to its leapfrog in economies of scale and scope in industry experienced from that point onward.

VIII. SUMMARY AND CONCLUSION

In examining the role of financial intermediaries in this said correlation between the railroads and economies of scale and scope, we find evidence that makes one very skeptical about Chandler's claims that the American and German railroad systems were constructed using more extensive recourse to outside sources of finance than the British, and its ramifications for industrial development in the latter decades of the 19th century. Our literature survey indicates that Britain's railroads may have also been heavily financed by outside capital, and that this financing did have a dramatic impact on its capital markets, as evidenced by the development of a national market for railroad shares. Our empirical analysis of comparative financial intermediation effects from the railroads

consisting of the stock of financial capital data for the United States and Britain for 1830-1914 showed that while the unnormalized financial capital data of Table 3.1 displayed a generally more rapid accumulation of capital as occurring in the American railroad system as compared with Britain throughout the period in question, which supports Chandler's contentions regarding the relative strength of the effects of the railroads on financial intermediation during the early industrialization of the United States vs. what was going on in Britain at the same time, when these data were normalized by being measured relative to G.N.P. in Table 3.3, Britain possessed a strong lead in capital as a percent of its G.N.P. all the way until the 1870's, which suggests that railroad finance played a stronger role in the British economy at least until the 1870's, and points to a stronger impact of the railroads on financial intermediation facilities in Britain than in the United States all the way until the 1870's.

This phenomenon mirrors the findings of our literature survey, and contradicts the Chandler hypothesis that a much more powerful impact of railroad finance activities in the United States by the 1850's was responsible for the centralizing and institutionalizing of the nation's money market in New York, and from the 1850's to the 1890's was instrumental in the financing of rapid economic growth based on large scale production technologies rich in economies of scale and scope, because it shows that these forces ought to have been operating more in Britain's favor. In this component of our empirical analysis, we find greater support for the contentions of Tilly and other experts on the financing of the railroads in Britain surveyed that Britain did experience a great deal of financial augmentation as a result of its railroads, but this did not translate into great industrial growth at home for other reasons such as a strong propensity to export capital.

We find more support for the contentions of Reed and the other scholars of the financing of the British railroads that there was a massive boom in railroad financing activities in the early-to-mid-19th century that brought the Provincial Exchanges into existence and resulted in the creation of a national market for railroad shares in Britain by the mid-19th century that resembles the centralizing and institutionalizing of the nation's money market in New York by the 1850's as described by Chandler, who claimed this was the result of railroad financing activities in the United States.

Our additional empirical analysis of comparative financial intermediation effects from the railroads consisting of gross physical railway capital flow as a percentage of Gross National Product for Great Britain, the United States, and Germany for 1830-1914 in Table 3.4 showed an essential ranking order of the United States first, Germany second, and Britain third in physical capital formation as a percentage of G.N.P. in more or less close correspondence with the degree to which Chandler believes the railroads impacted the industrial development of the 3 nations, and in particular supports Chandler's contention that the greater capital needs of the larger and more extensive American and German railroad systems would have had a greater augmenting effect on their financial sectors. These data also correlate with the patterns of railroad mileage growth we observed in Table 2.1 that showed Britain as the leader in the very early days of the railroads, but by the 1850's being overtaken by the United States, and by the 1870's by Germany, and having experienced its last hump of great railroad investment in the 1860's, by which time its railroad system was essentially complete, and railroad investment for it as having leveled off to lower-averaging levels from the 1880's on while there was still great investment in railroads relative to G.N.P. going on in the United

States, corresponding to the still rapid growth of its railroad network. These data also show the 1850's-70's as being the period of greatest investment in railroads relative to G.N.P. for all three countries, with the ranking of the United States first, Germany second, and Britain third, corresponding to the degree to which railroad investment was purported by Chandler to have impacted each nation's financial intermediation, and as a result, by the 1870's to have helped create efficient, modern investment banking facilities capable of financing other large-scale industry that greatly abetted economies of scale and scope in other industry.

In further analysis and interpretation of the empirical results, one factor that cannot be ignored is the way in which the normalization of the financial capital stock in Table 3.3 showed a vastly different result than the unnormalized financial data of Table 3.1 in that it showed Britain as the leader in financial augmentation effects of the railroads. We cannot dismiss this phenomenon as a mere result of demographic differences in area or output because when the physical capital flow data were normalized by G.N.P. in Table 3.4, there were no anomalous results that refute the Chandler hypothesis. However, that fact that this anomalous result occurred in normalized stock data, not flow data, suggests that Britain's position as the early leader in railroad construction and finance may be partially responsible for this greater relative degree of capital accumulation. It remains to be seen what results a normalized comparison of physical railroad capital stocks might produce.

Another factor to bear in mind is that these investment data only pertain to capital invested in the railroads, and do not discriminate with respect to point of origin of that capital. As it was revealed in the analysis of physical capital accumulation, the early

construction of the American and Continental railroad systems were heavily dependent on imported British capital inputs, such as rails. We must therefore be skeptical in our interpretation of the seemingly greater rates of physical capital investment and accumulation observed in the United States and Germany in the early years of the construction of their railroad systems in assessing the impact these could have had on their domestic railroad-input-producing industries. Similarly, the financial capital data do not segregate foreign from domestic assets. So we must also exercise caution in interpreting the unnormalized financial data of Table 3.1, for it has also been revealed that Britain invested abroad a great deal in these years, including in foreign railroad assets, and in American railroad assets in particular. Our results may therefore contain an upward bias as indicators of the effects of railroad investment on American banking and manufacturing industries, and underestimate the total impact that railroad finance and construction, both foreign and domestic, may have had on the British economy in the 19th century.

IX. TABLES AND ILLUSTRATIONS, CHAPTER THREE

Table 3.1—Total stock of Railway Financial Capital for Great Britain (UK) and the United States (US), including Decadal Growth Rates, listed in pounds, dollars, and marks, respectively, for every five years, 1830-1914.

Year	UK Million Pounds	UK Decadal Growth Rate (Per Cent)	US Million Dollars	US Decadal Growth Rate (Per Cent)
1830	1.8		--	
1835	7.5		--	
1840	48.2	2,577.78	--	
1845	87.7		--	
1850	234.9	387.34	318.0	
1855	282.4		763.0	
1860	327.5	39.42	1,149.0	261.32
1865	429.8		1,149.0	
1870	502.7	53.50	2,476.0	115.49
1875	600.0		4,658.0	
1880	694.6	38.17	5,402.0	118.17
1885	780.3		7,842.0	
1890	860.2	23.84	8,984.0	66.31
1895	961.8		10,347.0	
1900	1,136.2	32.09	11,491.0	27.91
1905	1,228.8		13,805.0	
1910	1,273.2	12.06	18,417.0	60.27
1914	1,282.0		20,247.0	

Source Notes, Table 3.1:

GENERAL

British and American data are presumed to be in current prices, although this is not stated in the original sources.

GREAT BRITAIN

1. British data are in million pounds, and for each year listed measure total paid-up capital and loans as of Dec. 31 of each given year.
2. British data from 1830-45 are from G.R. Hawke and M.C. Reed's "Railway Capital in the United Kingdom in the Nineteenth Century", *The Economic History Review*, New Series, Vol. 22, No. 2 (Aug. 1969), pp. 270-72. They include data for Ireland, in order to be consistent with the Mitchell and Deane data for those years referred to above.
3. British data from 1850 on are from B.R. Mitchell and P. Deane's *Abstract of British Historical Statistics* (Cambridge, 1975), p. 225-26, and apply to Great Britain excluding Ireland.
4. Data for Britain for 1914 are 1913 data. Data from 1914-18 are not listed. A further note about the 1914 data is that statistics were collected on a new basis in 1913 in which the properties of the Manchester Ship Canal Company were no longer included. Thus, the figure listed for 1914 above is lower than that of the next most recent year, 1912, which was 1,289.6 million pounds.

UNITED STATES

5. American data are in million dollars, and for each year listed measure total stock, mortgage bonds, funded debt unmatured, equipment, obligations, etc. All figures are based on reports of individual railroads for fiscal years ending in the calendar year indicated.
6. American data are from U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C., 1975), II, pp. 734-35. The data from 1890 on are from series Q 356-366 in the above volume, which are data compiled from the annual publications of the Interstate Commerce Commission, *Statistics of Railways in the United States*. The data from before 1890, found in series Q 346-355 in the above volume, are from the U.S. Interstate Commerce Commission, *Railway Statistics Before 1890*, Statement No. 32151 (mimeographed), 1932.
7. American data for 1865 are identical to those of 1860 due to a break in the availability of data from 1861-67, presumably on account of the American Civil War that occurred during that time, during which new railroad investment may have been curtailed.

Table 3.2—Gross National Product for Great Britain (UK), the United States (US), and Germany (GR) listed in pounds, dollars, and marks, respectively, 1830-1914.

Year	UK Million Pounds	US Million Dollars	GR Million Deutschmarks
1830	505.0	919.7	5,099.3
1831	502.0	995.0	5,439.4
1832	480.0	1,073.4	5,383.5
1833	475.0	1,229.5	5,187.2
1834	505.0	1,271.0	5,260.1
1835	535.0	1,220.6	5,403.1
1836	571.0	1,378.9	5,548.1
1837	548.0	1,515.3	5,334.5
1838	581.0	1,519.7	5,697.7
1839	612.0	1,692.4	5,994.5
1840	573.0	1,573.7	5,998.0
1841	545.0	1,527.9	5,922.1
1842	524.0	1,491.7	5,996.9
1843	523.0	1,859.5	6,032.7
1844	571.0	1,907.0	5,988.9
1845	606.0	2,009.7	6,540.3
1846	647.0	2,308.7	7,103.2
1847	673.0	2,485.9	7,922.7
1848	646.0	2,348.0	6,280.4
1849	656.0	2,263.9	5,851.7
1850	602.0	2,313.7	6,070.0
1851	633.0	2,491.7	6,431.0
1852	640.0	2,805.4	7,296.0
1853	715.0	3,406.9	7,189.0
1854	758.0	3,597.7	8,203.0
1855	779.0	3,568.6	7,882.0
1856	812.0	3,915.0	9,139.0
1857	821.0	4,030.3	8,581.0
1858	785.0	4,150.1	8,334.0
1859	847.0	4,124.5	8,134.0
1860	847.0	4,099.9	9,630.0
1861	905.0	4,466.0	9,379.0
1862	914.0	4,832.1	10,050.0
1863	970.0	5,198.3	10,372.0
1864	1,024.0	5,564.4	10,207.0
1865	1,064.0	5,930.5	10,279.0
1866	1,111.0	6,296.6	10,714.0
1867	1,106.0	6,662.7	11,558.0

1868	1,110.0	7,028.9	11,558.0
1869	1,121.0	7,395.0	11,750.0
1870	1,188.0	7,141.0	12,876.0
1871	1,247.0	7,135.0	14,013.0
1872	1,316.0	8,163.0	16,627.0
1873	1,394.0	8,333.0	16,627.0
1874	1,449.0	8,073.0	19,544.0
1875	1,375.0	7,964.0	18,242.0
1876	1,341.0	8,065.0	17,966.0
1877	1,296.0	8,279.0	17,414.0
1878	1,366.0	8,244.0	17,874.0
1879	1,216.0	8,701.0	16,678.0
1880	1,437.0	10,962.0	16,902.0
1881	1,366.0	11,208.0	17,330.0
1882	1,394.0	12,050.0	17,489.0
1883	1,466.0	11,884.0	18,014.0
1884	1,442.0	11,547.0	18,540.0
1885	1,385.0	10,883.0	18,731.0
1886	1,389.0	11,258.0	18,935.0
1887	1,429.0	11,739.0	19,280.0
1888	1,446.0	11,740.0	20,716.0
1889	1,512.0	12,500.0	22,749.0
1890	1,562.0	13,100.0	23,676.0
1891	1,589.0	13,500.0	22,624.0
1892	1,584.0	14,300.0	24,061.0
1893	1,550.0	13,800.0	24,357.0
1894	1,629.0	12,600.0	24,361.0
1895	1,640.0	13,900.0	25,254.0
1896	1,727.0	13,300.0	26,979.0
1897	1,716.0	14,600.0	28,714.0
1898	1,832.0	15,400.0	28,714.0
1899	1,974.0	17,400.0	31,761.0
1900	2,026.0	18,700.0	32,448.0
1901	2,155.0	20,700.0	31,617.0
1902	2,109.0	21,600.0	31,928.0
1903	2,100.0	22,900.0	34,402.0
1904	2,140.0	22,900.0	36,284.0
1905	2,211.0	25,100.0	38,878.0
1906	2,244.0	28,700.0	40,643.0
1907	2,296.0	30,400.0	42,976.0
1908	2,278.0	27,700.0	42,441.0
1909	2,320.0	33,400.0	44,358.0
1910	2,386.0	35,300.0	45,785.0
1911	2,507.0	35,800.0	48,106.0
1912	2,565.0	39,400.0	51,563.0

1913	2,729.0	39,600.0	52,440.0
1914	2,744.0	38,600.0	52,440.0

Source Notes, Table 3.2:

GREAT BRITAIN

1. British data are from B.R. Mitchell's *British Historical Statistics* (Cambridge, 1988), pp. 831-33. They are in million pounds, and at current market prices. Entire series includes Ireland.

UNITED STATES

2. American data from 1830 are from Paul A. David, "The Growth of Real Product in the United States Before 1840: New Evidence, Controlled Conjectures", *Journal of Economic History*, Vol. 27, No. 2 (Jun., 1967), p. 184. This figure was calculated based upon Variant II of David's estimates for Gross Domestic (not National) Product which include value added in home manufacturing and the value of improvements made on farm land, activities that did not normally pass through market channels (see p. 169). This figure, given in per capita terms in 1840 prices in the original source, was converted into nominal G.D.P. in 1830 prices by multiplying it by the figure for U.S. population for 1830 given on p. 165 of the above source, and converting it to 1830 prices using the price deflator found in Fishlow, *American Railroads*, p. 399.
3. American data from 1834-60 are from Paul W. Rhode, "Gallman's Annual Output Series for the United States, 1834-1909", National Bureau of Economic Research, Working Paper 8860, April 2002, p. 28. The data from 1835-59 have been converted from 1860 prices to own year prices using the price deflator found in Fishlow, *American Railroads*, p. 399. 1860's figure, not listed in the original source, is the figure for G.N.P. for 1859 from the above source expressed in 1860 prices. Thus, the entire series for that period are in millions of current dollars. These data were not constructed for analysis as an annual series.
4. American data from 1831-33 have been estimated by taking the estimate for 1830 G.D.P. above, converting it to 1834 prices using the price deflator found in Fishlow, *American Railroads*, p. 399, thus obtaining $1,003.9 million. Then Rhode's figure for 1834 G.D.P. was converted from 1860 prices to 1834 prices using the same index, obtaining $1,271.03 million. The difference between these two figures, $267.13 million, was divided by 4, corresponding to the 4 annual periods occurring between the beginning of 1831 and the end of 1834, and added consecutively to the figure for 1830 G.D.P. in 1834 prices above, $1,003.9 million, obtaining estimates for G.D.P. for 1831-34 in 1834 prices. These estimates were then converted into their own year prices using

the same index found in Fishlow to obtain the estimates for G.D.P. for those years shown above.

5. American data from 1869-88 are from the same Rhode source as above, p. 31. They are in millions of current dollars. These data were also not constructed for analysis as an annual series.
6. American data for 1861-68, not listed in the Rhode source, have been estimated by taking the difference between the estimate for G.N.P. at the end of 1860, $4,099.9 million, and at the end of 1869, $7,395 million, which equals $3,295.1 million, dividing that figure by 9, representing the nine annual periods between the end of 1861 and the end of 1869 over which that increase occurred, to obtain an average annual increase in G.N.P. of $366.12 million. That figure was consecutively added to 1860's G.N.P., $4,099.9 million, to obtain the estimates for G.N.P. for those years shown above.
7. The great disparity between the 1860 figure of $4,099.9 million and the 1869 figure of $7,395 million, both listed in current prices, probably indicates a great deal of inflation as having occurred over this period due to the American Civil War. However, since these data represent an average of G.N.P. increase that occurred between 1860 and 1870 using the current prices of both periods, the effects of the inflation that occurred in that period are probably well taken into account, and this figure may thus be a reasonable good estimate of the value of G.N.P. as it existed at that time in current prices. Moreover, comparing this disparity to other decadal jumps in the series, such as the jump from 1850-60 (a near $2,000 million jump *and* a near doubling of nominal G.N.P.), or the jumps from 1870-80 and 1880-90 (both close to $3,000 million), or the jump from 1890 to 1900 (in the $5,000 millions), or the jump from 1900-10 (nearly $17,000 million) suggests that this decadal jump in G.N.P. that occurred over the 1860's is not an unrealistic disparity.
8. American data from 1889-1914 are from U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C., 1975), I, p. 224. They are in millions of current dollars.

GERMANY

9. All German data relate to Germany within the 1914 boundaries of the German Empire.
10. German data from 1830-49 are from Angus Maddison, *The World Economy: Historical Statistics* (Development Centre of the Organisation for Economic Co-operation and Development, Paris, 2003), p. 46. They are G.D.P. in millions of current marks. This series was constructed by taking the difference between the figure for 1830 and 1850 (the only two for that period listed, the latter Maddison's, not below Mitchell's figure), dividing by 20, and consecutively adding 1/20 of that difference to the 1830 figure to obtain figures for 1831-49. These figures were converted from 1990 international Geary-Khamis dollars to 1990 marks using the conversion data found in Angus Maddison, *Monitoring the World Economy, 1820-1992* (Development

Centre of the Organisation for Economic Co-operation and Development, Paris; OECD Publications and Information Center [distributor], Washington D.C., 1995), p. 172. These figures, in turn, were converted from 1990 marks to current marks using the German wholesale price indices found in B.R. Mitchell, *International Historical Statistics: Europe, 1750-1993*, 4th ed., Stockton Press (New York, 1998), pp. 856-61.

11. German data from 1850-1914 are from B.R. Mitchell, *International Historical Statistics: Europe, 1750-1993*, 4th ed., Stockton Press (New York, 1998), pp. 906, 910. They are in million marks at current market prices. They are in Net, not Gross National Product. Data for 1914 are 1913 data repeated, and data for 1873 are 1872 repeated. Data for N.N.P. for 1914 and 1873 are not listed.

Table 3.3—Total stock of Railway Financial Capital as a percentage of Gross National Product for Great Britain (UK) and the United States (US) for every five years, 1830-1914.

Year	UK Per cent of G.N.P.	US Per cent of G.N.P.
1830	0.36	---
1835	1.40	---
1840	8.41	---
1845	14.47	---
1850	39.02	13.74
1855	36.25	21.38
1860	38.67	28.03
1865	40.39	19.37
1870	42.31	34.67
1875	43.64	58.49
1880	48.34	49.28
1885	56.34	72.06
1890	55.07	68.58
1895	58.65	74.44
1900	56.08	61.45
1905	55.58	55.00
1910	53.36	52.17
1914	46.72	52.45

Source Notes, Table 3.3:

Source is Table 3.1 divided by Table 3.2.

Table 3.4— Gross reproducible (physical) railway capital formation/expenditure (total capital flow) as a percentage of Gross National Product for Great Britain (UK), the United States (US), and Germany (GR), 1830-1914.

Year	UK Per cent of G.N.P.	US Per cent of G.N.P.	GR Per cent of G.N.P.
1830	0.07	0.17	0
1831	0.12	0.34	0
1832	0.12	0.46	0
1833	0.13	0.46	0
1834	0.13	0.58	0
1835	0.20	0.72	0
1836	0.53	0.93	0
1837	0.78	1.03	0
1838	1.11	1.14	0
1839	1.41	1.05	0
1840	1.57	0.90	0
1841	1.29	0.75	0.42
1842	1.00	0.58	0.65
1843	0.70	0.35	0.74
1844	0.68	0.43	1.02
1845	1.31	0.50	2.0
1846	2.99	0.72	2.35
1847	4.51	1.10	1.72
1848	3.85	1.59	1.87
1849	2.70	1.62	1.36
1850	1.77	1.56	1.22
1851	1.36	2.04	1.32
1852	1.29	2.37	0.94
1853	1.29	2.74	0.14
1854	1.48	3.08	2.26
1855	1.41	2.08	1.08
1856	1.17	1.97	1.21
1857	1.24	2.09	-0.15
1858	1.22	1.62	3.29
1859	1.17	1.47	0.72
1860	1.37	1.28	2.42
1861	1.59	7.23	1.10
1862	1.69	6.68	1.38
1863	1.88	6.21	0.35
1864	2.06	5.80	2.84
1865	2.20	5.45	1.10
1866	2.12	5.13	2.80

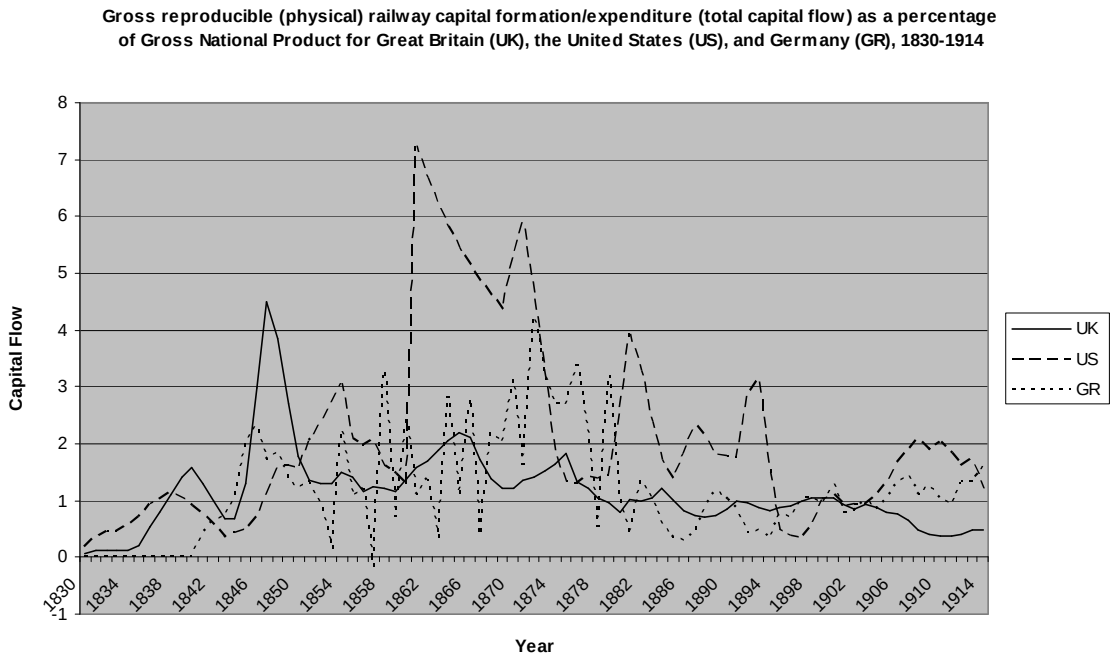
1867	1.71	4.85	0.41
1868	1.38	4.60	2.21
1869	1.21	4.37	2.03
1870	1.20	5.32	3.11
1871	1.35	5.89	1.65
1872	1.40	4.64	4.24
1873	1.54	3.14	3.19
1874	1.63	1.83	2.69
1875	1.85	1.32	2.70
1876	1.32	1.29	3.40
1877	1.22	1.41	2.11
1878	1.04	1.38	0.55
1879	0.96	1.44	3.20
1880	0.80	2.57	0.96
1881	1.01	3.93	0.39
1882	0.98	3.30	1.35
1883	1.04	2.38	1.03
1884	1.21	1.72	0.59
1885	1.01	1.38	0.36
1886	0.82	1.83	0.28
1887	0.73	2.34	0.44
1888	0.72	2.14	0.88
1889	0.74	1.82	1.17
1890	0.84	1.76	1.02
1891	0.98	1.76	0.84
1892	0.96	2.85	0.44
1893	0.88	3.14	0.50
1894	0.84	1.51	0.35
1895	0.88	0.50	0.76
1896	0.90	0.36	0.70
1897	0.99	0.33	1.04
1898	1.04	0.53	1.06
1899	1.05	1.01	0.96
1900	1.04	1.10	1.29
1901	0.92	0.90	0.81
1902	0.86	0.93	0.82
1903	0.92	0.95	1.03
1904	0.88	1.09	0.85
1905	0.78	1.31	1.02
1906	0.77	1.65	1.33
1907	0.64	1.88	1.45
1908	0.48	2.08	1.09
1909	0.41	1.87	1.27
1910	0.37	2.02	1.03
1911	0.37	1.82	0.95

1912	0.41	1.61	1.33
1913	0.50	1.72	1.32
1914	0.47	1.20	1.59

Source Notes, Table 3.4:

Source is Table 2.2 divided by Table 3.2.

Chart 3.1



Source Notes, Chart 3.1:

See Table 3.4 above.

Chapter Four: ECONOMIES OF SCALE ESTIMATION

Introduction--Minimum Efficient Scale—Quantification of Economies of Scale

In this chapter, we develop more fully the discussion of economies of scale contained in the previous chapters by introducing the measure of economies of scale achieved by various industries at any given time that is termed "Minimum Efficient Scale", and is expressed by the acronym *MES*, where

MES = the minimum plant size (in valued added) within the minimum size class range that increased its total percentage of industry value added over a designated time period.

By computing *MES* over successive time periods spanning the late nineteenth century, we obtain a quantifiable measure of the degree of economies of scale achieved in various American manufacturing industries because if the minimum size that a firm needed to be in order to be competitive in its respective industry rose over time, that serves as an indicator that increasing size is something associated with a plant's ability to survive and compete in this industry, thus presence of economies of scale. An increasing *MES* over time in a given industry thereby serves as an indicator of increasing economies of scale as having been achieved over time in that industry. Our data used in the analysis, and the empirical results of this said *MES* computation will be reviewed and discussed. An attempt is made to determine whether our empirical results confirm or contradict the beliefs of Chandler as to which industries experienced these rising scale advantages that were said to have occurred over this period, and when they occurred.

I. INTRODUCTION TO LITERATURE OF METHODOLOGY: THE "SURVIVOR TECHNIQUE' EXPLAINED

A variety of techniques have been employed in the past to measure and quantify economies of scale. However, Jeremy Atack's 1985 article "Industrial Structure and the Emergence of the Modern Industrial Corporation"[1], as the first systematic attempt to address the core of Chandler's thesis with quantitative evidence, provides a good starting point for outlining the empirical method of measurement of economies of scale for this study.

Atack tests Chandler's key argument, that the modern business corporation evolved by taking advantage of continuous production technologies and the opportunities afforded by the railroad and declining transport costs to market a high volume of production nationwide, by measuring the extent to which the average plant at the end of the 19th century (when most of the developments discussed by Chandler had taken place) differed in size from plants that survived the Civil War decade, that is, prior to such changes. The methodology is predicated upon the idea that competition, whether pure or tainted by elements of monopoly, tends to drive less efficient producers out of business. Consequently, the given industrial structure that exists at any given time contains strong indications of the long-run competitive equilibrium outcome of forces set in motion prior to that period. If one observes a more highly concentrated industrial structure in a given industry, marked by larger plant size, as having evolved over that time period, it serves as testimony to support the theory that efficiency is something associated with greater size, thus evidence of economies of scale in that industry. [2]

---

[1] Atack, Jeremy. "Industrial Structure and the Emergence of the Modern Industrial Corporation" *Explorations in Economic History* 22, 29-52 (1985); hereafter "Atack, 1985 (A)".
[2] Ibid., pp. 29-30.

Atack, in discussing his choice of technique for measuring economies of scale in United States manufacturing industries from 1870-1900, explains that scale economies are usually estimated by the ordinary least-squares fit of a homogeneous production function. This approach, however, is flawed within the context of the Chandlerian hypothesis because since it implies a linear cost function, and scale economies that are independent of plant size, it disguises the rapid exhaustion of scale economies in the 19th century manufacturing data. Chandler's emphasis on forces internal to the firm (the technology of continuous production) and external (falling transport costs and the widening market) compel a methodology that incorporates factors internal to the firm and its production technology and externalities that is capable of dealing with dynamic adjustments. Under these conditions, production function estimates are unreliable and biased as they assume technological homogeneity between observations. [3]

Instead, Atack used the "survivor technique" for measuring economies of scale. The survivor technique, as pioneered in its application to measurement of scale economies by George Stigler, William Shepherd and Leonard Weiss among others, [4] seeks to identify the those size classes of firms or plants that not only survived the rigors of market competition, but also succeeded in increasing their share of total industry value-added. An increasing share of industry value-added held over time by the larger size class or classes of firms or plants in the industry is empirical evidence in support of the idea that larger firms or plants gained a competitive advantage over their smaller counterparts, and hence came to acquire greater market share. This acquisition of greater

---

[3] Ibid., pp. 36-37.

[4] Stigler, G. J. "Economics of Scale" *Journal of Law and Economics*, 1:5-71 (1958); Shepherd, William G. "What Does the Survivor Technique Show about Economies of Scale?" *Southern Economic Journal*, Vol. 34, No. 1 (Jul., 1967), 113-122; Leonard W. Weiss. "The Survival Technique and the Extent of Suboptimal Capacity" *The Journal of Political Economy*, Vol. 72, No. 3 (Jun., 1964), 246-261.

market share by the larger size classes of firms or plants indicates greater competitiveness associated with this greater size, thus economies of scale. [5]

According to Leonard Weiss, the survival technique seems more likely to yield optimal scales usable for evaluative purposes when applied to plants rather than firms. Regardless of the source of its over-all size, a large, multi-plant firm would build plants of optimal scale whenever markets were sufficient to support such plants, as would a smaller single-plant firm. Thus, if the survivor method is used as a measure of efficiency, it would be much easier to identify optimal plant scales with this method than firm scales.[6]

One important fact that one must bear in mind about applying the survivor technique is that it is not always the very largest sized class of plants that gain market share. Usually, the surviving class size that gains market share is somewhere in the middle. In the tests of the theory I have surveyed, just as there is usually a size class below the optimum that loses market share over a given period, there is also usually a size class *above* the optimum that *also* loses market share over any period. So one must be careful when applying the survivor technique and using it as an indicator of economies of scale. An industrial structure that identifies a minimum efficient scale (MES) below which plants have lost market share, and above which plants have gained market share clearly shows a scale advantage as having been achieved by the plants in the upper gaining share size class. But an industrial structure that also identifies a maximum efficient scale above which plants have lost market share clearly shows the limits to potential economies of scale in the industry. If one were to use the share of industry

[5] Atack, 1985 (A), pp. 36-38.
[6] Weiss, p. 247.

value-added belonging to the group of plants who increased their share of total industry value-added over a given period as an estimate of the degree of economies of scale in the industry, one would probably want to exclude the share of industry value-added held by the very largest size class or classes of plants in the industry who lost market share from this estimate in order to avoid an exaggerated conception of the degree of competitive advantage from greater scale that existed in this industry (although Weiss does not follow this practice).

This study requires a measure of the *degree* of economies of scale that can be discerned as having occurred in connection with market expansion and financial sector growth from railroads. Unfortunately, as Shepherd and Atack point out, survivor estimates themselves lack such an indicator, as they only indicate the presence of economies of scale, and the borders of a range in which it can be observed. [7] However, for lack of any other suitable or satisfactory methods, a measure of the degree of economies of scale can be derived from survivor estimates by measuring the growth of the MES of plant size itself over time. A rising minimum point of the range in which economies of scale are observed may tell us much about rising scale in an industry, and the degree to which this rising scale is associated with efficiency.

What follows is an essential summary of the tools and techniques that provide a menu of possible means of measuring the degree of economies of scale in various industries, and a justification of the chosen method through compare and contrast. Due to the tremendous similarity in method and technique in applying the survivor method

[7] Shepherd, p. 115; Atack, Jeremy, *Estimation of Economies of Scale in Nineteenth Century United States Manufacturing*, New York & London: Garland Publishing, Inc. (1985), p. 39.

among all the literature in this area, only two authors' works are described, Atack and Weiss's.

II. LITERATURE REVIEW AND ANALYIS OF APPLIED METHODOLOGY

In his 1985 *Explorations in Economic History* article, Atack determined the entire range of size class (size measured in terms of value-added per plant) that increased its share of industry value-added from 1850-70 for 24 industries. Then he computed the total share of industry value-added held by plants in that size class, and expressed it as a percentage of total industry value-added. [8]

Then he took the lower and upper bounds of those size classes that were determined to be optimal in 1870, and divided total industry value-added in both 1870 and 1900 out by those individual value-added sizes. That gives the number of "potentially" optimal plants that industry value-added could sustain, using this 1870 survivorship size class as the standard of optimality. [9]

Then he compared this number of potentially optimal plants to the actual number of plants in each industry at each date. The higher the ratio of potentially optimal plants to the actual number of plants, the greater the indication that many establishments had achieved an efficient scale, and the more economies of scale there was in that industry. If there were more potentially optimal plants than actually existed in an industry, that would

---

[8] Atack, 1985 (A), pp. 39-42

[9] Presumably Atack did not compute a new survivorship class as it emerged from 1870 to 1900 with which to divide out 1900's industry value-added by because the data set he used for this study, the Bateman-Weiss and Atack-Bateman Samples from the Manuscript Censuses of Manufactures, 1850-1880, do not contain individual plant-level data for 1900 that would be necessary to determine a new survivorship class for 1900. For more information, see Atack, Jeremy and Fred Bateman. "Nineteenth-Century U.S. Industrial Development through the Eyes of the Census of Manufactures: A New Resource for Historical Research." *Historical Methods*, Fall 1999, Vol. 32, No. 4: 177-88, pp. 177, 179. This article is also available on line and downloadable at http://www.vanderbilt.edu/Econ/faculty/Atack/atackj.htm.

mean that a handful of plants are producing a large portion of industry output, and they are well above the MES. Whereas, if there were far fewer potentially optimal plants than actually existed in an industry, that would mean that industry output is divided out amongst many, many plants, few of which are operating at this efficient scale. A rising ratio of potentially optimal plants to actual number of plants can be construed to indicate increasing size of enterprise that is consistent with a widening of market opportunities permitted by cheaper transportation and the existence of economies of scale that could be both internal and external. [10]

Then he used these results to test the Chandler hypothesis that it was in the industries that experienced the greatest impact of transportation improvements and the most rapid technological progress over 1870-1900 that the most economies of scale were found in. He categorized various industries by these criteria, and found that those that had the most impact of transportation improvements and the most rapid technological progress also had the highest ratios of potentially optimal plants to total plants as computed in the previous section. These industries were meat packing, flour milling, malt liquor, leather tanning, and pig iron.

While this test does not provide us with a quantitative measure of the degree of economies of scale, it is noteworthy in terms of what its results tell us about industrial growth from 1870-1900, and the degree to which Atack's results confirm the Chandlerian hypothesis. It was Chandler's thesis that the modern business enterprise, as exemplified by American Tobacco, Carnegie Steel, and Armour and Company emerged as a response to the combined forces of continuous production process technology and the

[10] Atack, 1985 (A), pp. 42-47.

transportation revolution of declining railroad freight rates. The effects of this revolution in transportation and production technology on the scale of enterprise, according to Chandler, were seen most visibly in the production of tobacco and grain products and in the furnace and foundry and distilling and refining industries. Atack's results here must be regarded as an empirical validation of the Chandlerian thesis. [11]

Weiss identified MES in 5 industries—automobiles, steel, petroleum refining, flour and cement in the United States from 1924 to 1961. He measured optimal size in terms of plant output per year, or day; actual plant capacity in units of goods, not value-added.[12] Then he divided this whole time expanse into sections; 1924-29, 1929-34, etc. and identified the MES for each period; *the minimum plant size that increased its total percentage of industry capacity over each of these periods*. He found that MES increased over time. In other words, the minimum size that a firm needed to be in order to be competitive in its respective industry rose over time. This seems to be a good indication of much unexploited economies of scale in each industry, and increasing exploitation of it over time. If average plant size is not only rising over time, *and* the minimum size a plant needs to achieve in order to be competitive and survive in the industry is also rising, it certainly shows that increasing size is something associated with a plant's ability to survive and compete in this industry. [13]

Weiss continued his study with a method similar to that used by Atack in his 1985 article [14] to determine optimal ranges that plant sizes fell into, and to express the total

---

[11] Ibid., pp. 47-49.
[12] Weiss does not say how he selected these size classes, except that he did it so that at least several plants would ordinarily fall within each class (see p. 248). He seems to have derived his methodology from J. S. Bain, *Barriers to New Competition* (Cambridge, Mass.: Harvard University Press, 1956), where perhaps these size classes are delineated. See Weiss, footnotes, pp. 247, 249.
[13] Weiss, pp. 247-50, Table 1.
[14] Atack, 1985 (A), pp. 39-42.

share of industry value-added held by plants in that size class as a percentage of total industry value-added. However, Weiss was able to perform successive calculations of that percentage to compare to earlier dates; a practice that Atack could not do due to data limitations.[15] Weiss determined a size class- or range-based MES--the minimum plant size class that increased its total percentage of industry capacity over each of these periods—and computed the percent of total industry capacity accounted for by plants *in that size class or greater* at the end of each period (unlike Atack who only counted the percent of total industry capacity accounted for by plants in the optimal size class), and called that percentage "*P*".

Weiss found that *P* did not increase that much consistently. Although MES rose over the years, the percentage of industrial capacity actually in it did not follow suit. He actually regressed *P* on MES and got negative parameter estimates. Then he determined the predicted change in *P* if you were to assume no changes in MES over time periods. His regression equation predicted that you would get moderate rises in *P* over time which would seem to indicate a positive tendency for firms to move into the optimal range over time periods, but overlooks the fact that the optimal range to be in is itself increasing, so a lot of the economies of scale that exist in this industry are being overlooked. [16]

It is essentially for that reason that I have chosen to measure and quantify the degree of economies of scale achieved in my model with Weiss's MES method, rather than his *P* method, which is essentially conceptually the same as all of Atack's methods. A choice between the two is necessary because the negative parameter estimates that Weiss obtained from his regression of *P* on MES for United States manufacturing

[15] See footnote 9 above.
[16] Weiss, pp. 250-52, Table 2.

industries from 1924 to 1961 put us in a quandary in terms of methodology choice; clearly they cannot both be correct as a measure of economies of scale in industry. High, rising levels of *P* can coexist with low, or even diminishing levels of MES, and vice versa. In order to determine which method is a more accurate and appropriate measure of economies of scale, I will examine the two hypothetical situations; firstly the case in which a high *P* and low MES is observed, secondly the case in which a low *P* and high MES is observed. It will be revealed that *P* is a misleading indicator of economies of scale in an industry, because a high *P* may conceal a low MES, thus exaggerating the degree of economies of scale in an industry, and as Weiss's research on United States manufacturing industries from 1924 to 1961 indicates, a low *P* may conceal a very high MES, thus underestimating the degree of economies of scale in an industry.

The fact that high levels of *P* can be observed simultaneously with low levels of MES implies that use of *P* as an indicator of the degree of economies of scale yields an exaggerated picture of the degree of economies of scale in a given industry. A large percentage of industry value-added in the optimal range at any give time may not indicate great economies of scale in these industries because MES may have been easy to reach at low output. It could be indicative of a situation in which once a plant has reached MES, increased scale could only either lead to constant or decreasing returns to scale. The increasing concentration of output in the optimal range could consist of either the enlargement of existing optimal plants' output or entry of new plants into the industry that are smaller, but just as efficient as the larger ones, with no efficiency gains associated with greater scale, and average plant size increasing, remaining the same, or even diminishing within this optimal range of plant sizes. A rising MES observed over

consecutive periods, however, indicates an industry of growing plant size in which there are great economies of scale that have not yet been realized at the beginning of the period, and are increasingly being obtained and exploited over the course of a given period, and over successive periods surveyed.

Atack acknowledges in his study of plant survivorship from 1850-70 that while a clear MES was established for each industry surveyed, and very large increases in the value-added of the optimally-sized plants were often observed over this period, both of which suggest decreasing costs for larger firms, there were also observed a wide range of surviving plant sizes in almost every industry, which suggests that a considerable portion of the long-run average cost curve may have been flat, or almost so. He also found that in many industries, MES was quite small. In flour milling, for example, firms producing as little as $100 (1860 dollars) value-added in 1870 could still be efficient. This was a bottom range of an efficient scale that extended up to $16,000 value-added (1860 dollars again).[17] This again indicates that for many industries, MES may have been easy to reach at relatively low output. So a large percentage of optimal value-added out of the industry total itself, even excluding the upper portion of plants in the super-optimal range, may yield an exaggerated picture of the degree of economies of scale in the industry.

Furthermore, if one were to precisely apply Weiss's *P* method to the data Atack used (which is in fact, the same data used in this study), still further exaggeration of the degree of economies of scale in these industries is possible because Weiss included the upper super-optimal range of class sizes in the numerator of the expression. Consequently, Weiss's method would include the output or value-added of plants that

[17] Atack, 1985 (A), pp. 39-42.

were really not optimal, thus giving an even more exaggerated picture of the efficiency of larger firms.

Weiss is aware of this problem, but trivializes its importance. Overall, he found in these industries in this period that most or all plant size classes declined in relative importance below the MES, and increased for a very substantial range above it. In accounting for the largest size class of plants whose share of industry output declined, he is skeptical about net decreasing returns to scale as an explanation for this phenomenon. Due to the presence of modern administrative techniques, it is difficult to distinguish a size class that is too large for technological or administrative reasons from one which is declining in relative importance because large firms are at some strategic or political disadvantage, or simply because large firms may be more mobile than small ones and thus may more readily abandon unpromising industries.[18]

However, the same standards may not apply to 19th century industry. Atack excluded this super-optimal portion of industrial value-added from his survivorship estimates from 1850-70, and found that a strong case can be made for decreasing returns to scale in the very largest plants arising from the traditional source, managerial inefficiency. He found that of the 24 industries covered in this study, all but 2 possessed an upper bound of size range beyond which a decreasing share of industry valued added was observed over that period. [19] Since these data are the same data used in this study, it is best to rule out the *P* technique; at least in the manner as applied by Weiss.

Conversely, the fact that low levels of *P* can be observed simultaneously with high levels of MES implies that use of *P* as an indicator of the degree of economies of

[18] Weiss, pp. 247-48.
[19] Atack, 1985 (A), pp. 39-42.

scale poses the potential to greatly underestimate the degree of economies of scale in a given industry. Weiss's results showing negative correlation between *P* and MES for United States manufacturing industries from 1924 to 1961 show static or slightly diminishing levels of *P* associated with increasing MES over these periods. Although the MES is coming up over the years, the percentage of industrial capacity actually in it doesn't seem to follow suit.

Weiss used his regression equation to determine the predicted change in *P* if you were to assume no changes in MES over time periods. His regression equation predicts that you would get moderate rises in *P* over time which would seem to indicate a positive tendency for firms to move into the optimal range over time periods. However, these results are not very robust because the equation predicts that with MES fixed, most of the potential economies of scale in any industry would be exhausted in maybe one or two decades. The implication, Weiss feels, seems to be that further gains in economies of scale from plant size growth must depend primarily on technical changes that may create *new* economies of scale, resulting in larger and larger efficient firm sizes over time, as exhibited by a rising MES being observed over time. [20] The fact that *P* fails to account for these scale increases associated with productivity-enhancing technical changes means that it is a less-than adequate indicator of the degree of scale economies in an industry. Merely focusing on the degree to which firms move into the optimal range, but overlooking the fact that the optimal range to be in may *itself* be increasing yields an understated and incomplete picture of scale economies achieved in the industry.

Weiss acknowledges that the rising MES observed in these industries over this period empirically validates the conventional wisdom concerning the histories of these

[20] Weiss, p. 251.

industries over this period; that technological improvements in steel and flour production and petroleum refining made it more efficient to produce in large volume, and that Fordism in the automobile industry resulted in increasing plant size and concomitant cost-cutting there. [21] The non-increasing *P* estimates are a counter-intuitive result considering what is known about structural and technological change in these industries. Weiss seems to imply here that a rising MES is something definitely associated with economies of scale, and the new technique associated with large-batch continuous production methods.

This seems to correspond closely to the history of the Chandler industries, and their pattern of growth as he describes it in his works, both *Scale and Scope* and his earlier work, *The Visible Hand*, the primary inspiration for the Atack study referred to above. [22] According to Chandler, Britain's trading channels were too restrictive to maintain a level of throughput necessary to achieve the scale economies inherent in, or presented by the new technologies that emerged in the late nineteenth century. [23] In contrast, in the United States, the railroads greatly expanded markets, affording them far greater opportunity to exploit the scale economies offered by the new technologies. As Weiss implies, a rising MES is evidence of this pattern of growth as it occurred in the highly mechanized 20th century United States industries that were still experiencing growth associated with efficiency gains from new technique. I see no reason why it could not also be used as an indicator of the degree of this pattern of growth as it

---

[21] Ibid., p. 250.
[22] Chandler, Alfred D., Jr. *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge: Harvard University Press, 1994 and *The Visible Hand: The Managerial Revolution in American Business*. Cambridge, Mass.: Harvard University Press, 1977. *Scale and Scope* had not yet been written at the time Atack wrote his 1985 article.
[23] *Scale and Scope*, pp. 250-51.

occurred in the American industrial expansion of the late nineteenth century Chandler industries; or say, to compare to the corresponding degree of economies of scale in the same, or another group of British or German industries.

III. DESCRIPTION OF PRECISE METHOD AND DATA

We may now proceed to an empirical study of American industry as described above using the same data set Atack used.

Regarding industry selection, Atack categorized industries by the degree of impact of transportation improvements and pace of technological improvements in a table in his 1985 article that I have reproduced in this text as Table 4.1. [24] In the left hand column of Table 4.1 are listed the industries that Chandler said were the great industries that experienced these great impacts of the decline in transport costs and technological advance that led to these large-scale production methods. They are also, by Atack's study, the group of industries that had the highest ratios of potentially optimal plants to total plants as computed in the previous section of that article, which was an indicator of great scale economies as having been achieved over 1870-1900.

[24] Atack, 1985 (A), Table 4, p. 48.

Table 4.1
Technological Change, Transportation, and the Adjustment
To 1870 Optimal Plant Sizes, 1900

	Pace of Technological Progress	
Impact of Transportation	High	Low
High	Meat packing Flour milling Malt liquor Leather tanning Pig iron	Sawmills and planing mills Millwork Wood furniture Bricks Gray iron foundaries Sheet metal
Low	Distilled liquor Tobacco manufacture Clothing Boots and shoes	Bread and baked goods Cotton textiles Wool textiles Millinery Printing and publishing Saddlery and harness Farm machinery Wagons and carriages

Within that left hand column, there are some industries that, according to Nelson's study on the great merger movement at the end of the century [25] experienced a great impact of transportation improvements, and those that did not. It is an interesting fact that those that did not have a great transportation impact, those in the lower left cell in Table 4.1, had a slightly smaller ratio of potentially optimal plants to total plants.

It would be interesting to see if all of these industries also have a rising MES over 1850-80 (the period the availability of the appropriate data confines our study to). It could be that these industries in the lower cell may have also gained great economies of scale in association with the declining transport costs and scale opportunities afforded by the railroads.

[25] Nelson, R. *Merger Movements in American Industry 1895-1956.* Princeton, N.J.: Princeton Univ. Press for the NBER, 1959, pp. 158, 159, Table C-3.

There is a second column of industries Atack surveyed in the right hand column that do not coincide with those purported by Chandler to have experienced great growth due to continuous production technology and the transportation revolution. Atack's results show that for these industries, the margin of the lower difference in ratio of potentially optimal plants to total plants for these industries as compared with those in the left hand column is substantial, which is a basic confirmation of the Chandler theory that whatever the great impact of technology or declining transport costs on this group of industries was, it was not significant. It is for that reason that I am also going to test these industries and compare the results to the left hand column industries to see if my results confirm the Chandler theory. This test comprises a major portion of the topic of Chapter Five, which takes a closer look at these results, their data, and the grouping of industries together in the data. For now however, it is worthy of noting that the upper right cell that contains industries that had a low pace of technological progress but a high impact of transportation has a greater average ratio of potentially optimal plants to total plants than the cell that contains industries that had both a low pace of technological progress *and* a low impact of transportation. That does support the Chandler hypothesis that the transport improvements had an impact of sort, even if the industries did not experience a great amount of technological change.

Thus the industries covered by the study of this chapter shall be organized into 2 groups corresponding to the left hand column in Table 4.1. These are the following, each followed by its respective 3 digit code per U.S. Office of Management and Budget,

Standard Industrial Classification Manual, 1987. [26] These are the codes by which the industries are categorized in the data set used in this study (see discussion below).

<u>High pace of technological progress/High impact of transportation</u>

Meat Packing-- **Industry Group 201: Meat Products**
Flour Milling-- **Industry Group 204: Grain Mill Products**
Malt Liquor-- **Industry Group 208: Beverages**
--2082 Malt Beverages (ex. Beer)
Leather Tanning-- **Industry Group 311: Leather Tanning And Finishing**
Pig iron-- **Industry Group 331: Steel Works, Blast Furnaces, And Rolling And**

<u>High pace of technological progress/Low impact of transportation</u>

Distilled liquor-- **Industry Group 208: Beverages**
--2085 Distilled and Blended Liquors (ex. Whiskey)
Tobacco manufacture--**Major Group 21: Tobacco Products**
--Industry Group 212: Cigars
--Industry Group 213: Chewing And Smoking Tobacco And Snuff
--Industry Group 214: Tobacco Stemming And Redrying
Clothing--**Industry Group 225: Knitting Mills**
-- Industry Group 231: Men's And Boys' Suits, Coats, And Overcoats
--**Industry Group 232: Men's And Boys' Furnishings, Work Clothing, And**
--Industry Group 233: Women's, Misses', And Juniors' Outerwear
--Industry Group 235: Hats, Caps, And Millinery
--Industry Group 237: Fur Goods
--Industry Group 238: Miscellaneous Apparel And Accessories
Boots and shoes--**Industry Group 314: Footwear, Except Rubber**

All these categories will be analyzed separately except for Distilled Liquor and Malt Liquor because they share the same Standard Industrial Classification (SIC) code, 208, and because for 1880, a period that Atack did not take into account in his study, there are no fields in the data set corresponding to individual final product codes, quantities or value. Therefore no basis exists upon which to disaggregate these plants into primarily malt liquor- or distilled liquor-producing plants, as these finer 4 digit sub-categories

[26] U.S. Office of Management and Budget, *Standard Industrial Classification Manual*, (GPO, 1987), Dun & Bradstreet Information Resources, 1989.

indicate. Thus a separate analysis for that year is impossible. Thus they have been combined into one industrial class called simply "Beverages." Also, since at least a segment of this Beverages category was determined by Atack to be in the High pace of technological progress/High impact of transportation category (Malt Liquor), the entire combined **Beverages** category will be thusly grouped, even thought it includes Distilled liquor, which is not among those industries thought by Atack to have experienced a great impact of transportation changes.

There are also two industries, Tobacco and Clothing, that embraced more than one 3 digit SIC code. Thus all plants that appeared in the data set with codes that fell under the rubric of one of these industry categories were analyzed together with their respective main industry category. [27]

A regrouping of these industrial categories was necessary because the SIC codes used in Atack's 1985 article were obviously that of some earlier unspecified period prior to 1987. The codes used in this study are those of 1987 because these are the codes that are used in the new machine-readable version of the census samples on United States manufacturing during the second half of the nineteenth century that Atack based his 1985 study upon. [28]

---

[27] For further information about these industrial classification codes, see the site http://www.osha.gov/pls/imis/sicsearch.html
This the exact page of the site of the U.S. Department of Labor Occupational Safety & Health Administration that allows the user to search the 1987 version SIC manual referred to in text by keyword.

[28] These data, which are entitled the Bateman-Weiss and Atack-Bateman Samples from the Manuscript Censuses of Manufactures, 1850-1880, are presented in a common format with uniform integrated coding to facilitate their use, and are available through the Inter-university Consortium for Political and Social Research (ICPSR) at the University of Michigan (http://www.icpsr.umich.edu/index.html) and at http://www.vanderbilt.edu/Econ/faculty/Atack/atackj.htm.

IV. RESULTS AND ANALYSIS

Since the data set contains only data from 1850-80, the first period for which a MES can be ascertained is the group of plants that increased their share of industry value added over 1850-60. That is followed in the table below by MES as it emerged from 1860-70, and finally, from 1870-80; 3 periods in total.

The following Table 4.2 shows MES in value added in constant 1860 dollars, rounded. [29] Following Atack's practice, all plants in each industrial category in each year were grouped by size of value added according to the following schema: $0-249; $250-499; $500-999; $1000-1999; $2000-3999; $4000-7999; $8000-15,999; $16,000-31,999; $32,000-63,999; $64,000-127,999; $128,000-255,999; $256,000 and over. The MES range was determined by identifying the smallest size class of plant that increased its share of total industry value added over each period delineated in the columns, and the MES of plant delineated in those columns below the year headings was the smallest size of plant value-added within that class that increased its share of total industry value-added over the period. [30]

When MES occurred in the $0-249 size class (as it did frequently in 1870—see discussion below), and the smallest sized plant within that class was a plant with value-added *equal* to zero, the next smallest plant with a value-added *greater* than zero was designated as the MES instead. This occurred in four out of eight industries in 1870: Clothing, Tobacco, Shoes, and Flour. It also occurred in Meat in 1880.

---

[29] Value-added were adjusted by the rise or fall in the wholesale price indices for the United States in Mitchell, Brian R. *International Historical Statistics: the Americas, 1750-2000*, 5th ed. Palgrave Macmillan, New York, 2003, p. 702.

[30] Atack, 1985 (A), pp. 41-42.

Industries that had both high pace of technological progress and high impact of transportation are highlighted.

TABLE 4.2
Minimum Efficient Scale (MES) for Selected Industries, 1860-1880
in Constant 1860 Dollars

Industry	MES, 1850-60	MES, 1860-70	MES, 1870-80
Meat	450	89,060	11
Flour	2000	28	502
Beverages	8000	265	1163
Leather	8200	86	19,298
Iron	560	276	326
Tobacco	2000	69	256
Clothing	50	96	130,200
Shoes	67,000	7	33,792

The main results do not lend much credence to the Chandler hypothesis. In fact, the trend is decreasing. There is only one industry, Clothing, whose MES increased steadily over the period of 1860-80. Only three out of the eight industries, Beverages, Leather and Clothing, achieve a higher MES in 1880 than they started out with in 1860. These results tend to refute the Chandler hypothesis, because we know that railroad mileage was a steadily increasing variable over all the years that could remotely be construed as correlated with these scale changes, namely 1830-80, which implies an inverse relationship between the railroads and economies of scale in these industries. Even if for the earlier periods there was very little increase in the size of the railroad network, and very little growth in these industries that could be attributable to the railroads, these results show economies of scale still going in the wrong direction.

The other striking feature of the table is the phenomenon of a nearly ubiquitous dip in MES *circa* 1870. Each industry surveyed barring two, Meat and Clothing, drops

down to a lower MES in 1870 than it started out with in 1860, and then rebounds to a higher MES in 1880.

Taking another perspective, if one were to analyze with 1870 as the starting point, the results would overwhelmingly support the Chandler hypothesis. In all but one industry, Meat, there is a rise in MES, and for all those seven industries whose MES rose but one, Iron, the rise may be considered precipitous. Looked at thusly, the results really are a validation of the Chandler hypothesis, because Chandler did not make any claims as to a significant impact of transportation improvements upon scale economies and technological progress as having occurred prior to 1870. To reiterate what was stated in Chapters Two and Three, a minimally efficient plant size *circa* 1870 constitutes a reasonable benchmark period in which to begin to analyze effects of transportation improvements upon scale economies in American industry. Lack of appropriate data preclude a similar study for 1890 and 1900 that would provide further evidence of a rising MES over those periods, thus further validation of the Chandler thesis that the modern business corporation evolved by taking advantage of continuous production technologies and the opportunities afforded by the railroad and declining transport costs to market a high volume of production nationwide, and that this resulted in larger plant size at the end of the 19th century (when most of the developments discussed by Chandler had taken place) than had existed immediately following the Civil War decade (that is, prior to such changes), and that larger firms began to replace smaller ones because they were more efficient.

The only thing about these results that strikes one as odd when analyzed from 1870 on is that the industries that had both high pace of technological progress and high

impact of transportation do not appear to have achieved greater rises in MES than the industries that had high pace of technological progress and low impact of transportation. In fact, the only industry that experienced a significant drop in MES from 1870-80, Meat, was in the high pace of technological progress/high impact of transportation category. These results suggest that the impact of transportation improvements on greater industrial scale, if Nelson's study reveals anything value-worthy about these effects, may be illusory. Either that or the impact of the railroads on those industries in the high pace of technological progress/low impact of transportation category may be greater than Nelson estimated.

Still, the nearly ubiquitous dip from 1860-70 attracts one's attention. If the impact of the railroads that Chandler claims was responsible for the great scale gains of the late nineteenth century was not felt until the post-bellum era, what was responsible for the relatively greater MES that existed prior to the impact of the iron horse? This hearkens back to Fogel and Fishlow's work, who dispute Rostow's claims that the railroads' demand for capital was the primary impetus in the United States' great "take-off" into the era of modern economic growth, and precipitated its great structural transformation from a primarily agricultural to industrial economy, and instead argue that the effects of the railroad were relatively small in comparison to all the other factors that contributed to the growth of these modern industrial sectors, which is perhaps part of the reason that Chandler really is relatively mute on the whole issue of derived demand effects, and it doesn't form part of his argument about why the railroads were such an important factor in revolutionizing the scale and structure of modern industry. Ironically, Fogel and Fishlow's work that trivializes the importance of the railroad in the earlier

industrial "take-off" period saves the Chandler thesis that lionizes it for the latter industrial expansion period because it offers an explanation for the rapid industrial growth experienced by these industries in the ante-bellum era that would otherwise, in the context of the Chandler thesis, lead one to the conclusion that increases in the railroadization of the nation led to *declines* in MES, thereby refuting his thesis.

Still, the nearly ubiquitous dip in MES observed *circa* 1870 raises questions. Granted, the relatively large MES's achieved from 1850-60 could have been achieved due to factors unrelated to the railroads. Even though the railroads had been increasing prior to this period, the scale-expanding properties may not have achieved their main impact until much later. But why would a decrease in MES, of all things, be observed during the time in which the effects of the railroads upon market expansion and financial intermediation ought to have been in full swing? Weiss noted in his study of manufacturing industries in the United States from 1924 to 1961 that while an overall trend of rising MES was observed throughout the period, this was not so during the World War II period, in which MES in all industries surveyed but petroleum declined. According to Weiss, this change may reflect the relatively small additions to capacity, the ability of practically all firms to survive in war-time demand conditions, and possibly the superiority of small plants in the black and grey markets of that shortage period. [31] It is not unreasonable to suppose that similar effects of war on the American economy in the period immediately following the Civil War could not also have been in play. A dip at the immediate post-war period, and a subsequent gain in MES as the effects of the railroads on market expansion and financial intermediation began to be felt, dovetails

[31] Weiss, p. 248.

with Weiss's results for American manufacturing industries from 1924 to 1961 as with Atack's results for the same for 1870-1900.

A further examination of the economic shocks caused by the Civil War leads one to believe that Weiss's hypothesis concerning the dips in MES experienced during the World War II period may also apply to American industry during the Civil War period. The up, down, up-again pattern observed in the MES table above conforms to the general historical knowledge concerning the cyclical macroeconomic fluctuations of those periods. Robert Gallman's estimates of value added in manufacturing [32] show an average growth rate of 7.8 per cent from 1840-60, a slowdown to 2.3 per cent from 1860-70 (the lowest rate for any decade during the century), and a pick-up of 6.0 per cent from 1870-1900. Further, total commodity output rose at an annual rate of 4.6 per cent from 1840-60, slowed to 2.0 per cent from 1860-70 (also the lowest rate during any decade in the nineteenth century), and picked up again to an annual rate of 4.4 per cent from 1870-1900. [33] This pattern conforms exactly to the high peak MES starts out with in 1860, the dip at 1870, and the moderate gains achieved by 1880.

It is impossible to separate the economic impact of the war from the dip in MES, value added, and overall capital formation that economic statistics display *circa* 1870. With the withdrawal of the services of perhaps one fifth of the labor force, the disruption of normal channels of supply, and the weakening of foreign exchange earnings by the loss of raw cotton exports, it would, in fact, have been very surprising if the war had not disrupted industrial growth. The decline in the availability of raw cotton, caused by the

---

[32] Gallman, Robert. "Commodity Output 1839-1899." In National Bureau of Economic Research, *Trends in the American Economy in the 19th Century*, Studies in Income and Wealth, vol. 24. Princeton: Princeton University Press, 1960: 13-67.

[33] Engerman, Stanley. "The Economic Impact of the Civil War." *Explorations in Economic History* 3 (1966): 176-99., pp. 178-79.

embargo of the Union military, probably has something to do with the 30 per cent decline in cotton textiles production during the war. While the MES movements do not show a dip in Clothing at 1870, a movement from $50 to $96 is hardly a significant increase. It must be remembered that the category Clothing includes clothing made of all materials, such as wool textiles, whose output increased significantly during the war as cotton shortages prompted a shift to substitute materials. If the Clothing category had only included clothes made from cotton, there probably would be a precipitous dip at 1870. It is an established fact that the war disrupted the most iron-intensive industry of all, railroad construction, as is seen by the 1870 dip there. And Stanley Engerman notes that Massachusetts boot and shoe production (one half of the nation's) slipped from forty-five million pairs in 1855 to thirty-two million in 1865. The precipitous dip in this industry of $67,000 in 1860, down to $7 in 1870, and back up to $33,792 in 1880 displays this wartime disruption of growth in this industry prominently. [34]

Crowding out also explains much of the economic slump associated with the immediate post-war years. The government paid for the war largely through the sale of massive amounts of interest-bearing bonds. Jeffrey Williamson believes that by exchanging federal government bonds for the financial resources investors would have otherwise have made available for purchases of capital stock, federal government debt crowded out private investment expenditures, leading to lower rates of capital formation. Relying on Gallman's data, Williamson reports that as a share in the 1859 non-South GNP, annual increases in the federal long term debt amount to more than 15 per cent. This figure is almost equal to the non-South gross domestic capital formation (GDCF) as a percentage of GNP of 19.4 per cent achieved in the 1850s. When one considers that the

[34] Ibid., pp. 185-86.

federal deficit in 1865 was some 30 per cent of northern GNP, one can only wonder, if Gallman had computed it, what the GDCF/GNP ratio would have been! The figure calculated for 1869-78, 27.4, is pretty darn close to that 1865 deficit figure. It is completely plausible that for at least some years during and immediately after the war, the federal deficit could have exceeded GDCF as a percentage of GNP. [35]

The greater levels of capital formation occurring after 1870 reported by Gallman may have resulted in additions to capacity, as evidenced by higher MES achieved by 1880. According to John James, there was a post-war recovery "crowding in" effect associated with the government's decision to retire its debt rather than lower taxes. Taxes were collected from the poor, who had low saving rates, to pay interest on the war debt held by the rich, who saved higher proportions of their income. As a result, the national savings rate increased, leading to a rise in investment in the post-war years. This reduction in debt also drove down interest rates, further stimulating investment and economic growth. James estimated the real stock of capital that would have occurred if the government had continued to hold its debt that existed in 1865 until 1890, and then compared it to the amount that would have occurred had the government decided to retire all of it over the same period, and found that capital formation would have been 5 per cent lower than it actually was in the former case, and just 2.16 per cent higher than it actually was in the latter case. This leads one to believe that debt retirement had a lot to do with the acceleration in the rate of capital formation that occurred after the war, and also with the increases in competitive scale observed in my own empirical results. [36]

---

[35] Williamson, Jeffrey. "Watersheds and Turning Points: Conjectures on the Long Term Impact of Civil War Financing." *Journal of Economic History* 34 (1974): 631-61., pp. 639, 643, 645, 647-48.
[36] James, John A. "Public Debt Management Policy and Nineteenth-Century American Economic Growth." *Explorations in Economic History* 21 (1984): 192-217., pp. 194-95, 207-09.

Post-war capital formation was also stimulated by a decline in the relative price of capital goods that Williamson believes was caused by Civil War tariff policy, which provided relatively more protection for consumer goods than for capital goods. This led to a rise in the relative price of final goods that increased the expected profitability of returns on post-war investments. [37]

What factors, then, may account for the ability of so many smaller firms to survive in such a depressed economic climate? While some lowering of the MES might be expected in such a climate that interrupted new capital formation, one would think that such conditions would have fostered an even more competitive environment in which only the strong survive, thereby resulting in MES still in the upper ranges.

There is a misleadingly rosy picture of the impact of the Civil War on American, particularly Northern, industrialization that has been painted in the past by historians Charles and Mary Beard and later, by Louis Hacker, who argued that by destroying slavery, the war shifted the balance of power to northern industrialists and spurred northern industrialization.[38] The Beards believed that the Civil War may have spurred industrialization; however the data reported above concerning the depression experienced in the iron, cotton textiles, and boot and shoe industries at this era evidences the folly of this notion. The overall impact of the war, the evidence indicates, is that it had an overall retarding effect upon the level of capital formation.

The demands of war may, however, have created a short-run situation that contributed to the ability of all firms to survive, no matter how small and inefficient they

---

[37] Williamson, pp. 653-58.

[38] See Beard, Charles, and Mary Beard. *The Rise of American Civilization.* New Edition, Two Volumes in One, Revised and Enlarged. New York: Macmillan, 1934 and Hacker, Louis. *The Triumph of American Capitalism.* New York: Columbia University Press, 1940.

were; a hypothesis that Weiss would nod his head in agreement with as to its plausibility in explaining the low MES's observed at 1870. For instance, as reported above, while there was a slump in the iron industry due to the suspension of railroad construction, small blacksmith shops and iron foundries may have received a new breath of life due to the overwhelming demand for small arms, horseshoes, and other such implements.

Another, more compelling explanation for why industrial activity supposedly boomed during the war, that may partially explain the ability of smaller plants to gain market share, is that the inflation resulting from the government's decision to finance a significant part of the costs of the war through money creation caused prices of commodities to leapfrog over wages, whose prices were renegotiated only infrequently. This decline in real wages increased the expected profitability of investments in much the same manner as the rise of prices of final goods over capital goods caused by the government's tariff policy discussed above did, and may have facilitated the entry of many smaller, marginally efficient enterprises during this era, creating a situation that may have appeared to be a boom, but was in reality a period of very low addition to total capacity. This explanation of the alleged post-war boom figures prominently in the Beard-Hacker explanation of how industrialists managed to gain from the war. While it doesn't provide a compelling or convincing argument that the war was good for the economy, it may illuminate our understanding of the phenomenon of low MES observed in many industries in 1870. [39]

The "decision" to increase the money supply to pay for the war was really the outcome of a revenue crisis that left the government with very little else in the way of options. Reuben Kessel and Armen Alchian recount the saga of the shaky position of the

[39] See Beard, Vol. II, pp. 69-72 and Hacker, pp. 372-73, 401-02.

government on the eve of the Civil War. When the Union blockaded the southern cotton trade, an important source of export revenue was lost. Further, New England textile mills were forced to import expensive foreign cotton, resulting in a huge balance of payments deficit. Given the shaky position of the Union government, further credit from abroad was a dead issue.

To remedy this problem, the government abandoned the gold standard, and allowed the dollar to fluctuate in accordance with market forces. This abandonment of the gold standard allowed the government to print all the money it needed to finance the war, because this new money, called "greenbacks", while not exchangeable for gold coins of the same face value, was declared legal tender for all debts public and private (though not for import duties and interest on the national debt).[40]

The result of this policy, however, was much inflation, and the deterioration in the exchange rate of the dollar vis-à-vis other currencies. While output prices soared, nominal wage rigidity meant that all wage earners experienced a significant drop in their real wages, thus creating windfall profit opportunities for capitalists. And anyone—wage earner, capitalist or farmer—who consumed goods made abroad received a reduction in their dollar purchasing power. [41]

Many other factors besides the inflation of the money supply contributed to a decline in real wages in this period, that may have abetted business creation and explain the entry of many new smaller firms into the market. There was further deterioration in

---

[40] Kessel, Reuben, and Armen Alchian. "Real Wages in the North during the Civil War: Mitchell's Data Reinterpreted." *Journal of Law and Economics 2* (1959): 95-113. Reprinted in *The Reinterpretation of American Economic History*, ed. Robert W. Fogel and Stanley L. Engerman. New York: Harper & Row, 1971: 459-69., pp. 461-63.

[41] Mitchell, Wesley. "The Greenbacks and the Cost of the Civil War." Reprinted in Ralph Andreano, ed. *The Economic Impact of the Civil War*. Cambridge, Mass.: Shenkman, 1962: 66-78., pp. 68-72; see also Kessel & Alchian, pp. 463-64.

real wages due to the government's tax policy during this era. While most of the expenditures for the war were financed through bond sales and money creation, taxes were also raised. Wage earners were made relatively worse off than other groups because, as Williamson explained above, many of the new taxes that were initiated were tariffs that allowed domestic manufacturers to raise their prices. But for consumers of these goods, there was a loss in purchasing power of wages. Just as the tariffs raised the price of final goods relative to capital goods, they also increased the price of final goods relative to wages. The decline in wages relative to output prices, particularly in the import-competing industries, must have created still further windfall profit opportunities for would-be entrepreneurs. Further excise taxes on goods such as tobacco and liquor were raised during the war, raising the price of these goods for consumers. [42] Stanley Engerman also believes that a deterioration in the quality of the labor force may have driven down real wages, as wartime demands brought marginal workers into the labor force. Shifts in age and sex composition of the labor force towards younger and more female, and the continued influx of lower-skilled immigrant labor all may have contributed to a decline in labor productivity.[43]

There is ample statistical evidence in support of the notion that real wages declined during the Civil War. Jeffrey Williamson calculated real wages in manufacturing from 1851-1878, and found a steep descent at the onset of the war, with real wages not regaining their pre-war levels until the end of the 1860's. [44] Stephen DeCanio and Joel Mokyr also calculated the difference between what real wages for Northern non-farm workers would have been in the absence of inflation from 1861 on, and what they

[42] Mitchell, pp. 72-74; Kessel & Alchian, pp. 465-66.
[43] Engerman, pp. 187-88.
[44] Williamson, pp. 658-60.

actually were with the effects of inflation figured in for each year until the end of the war in 1865. They found that for 1861, there was no wage gap; in fact, real wages were actually higher than they would have been without any inflation. Thereafter, however, a gap emerges, in which the non-inflated real wages exceed the inflation-impacted wages for each subsequent year until 1865. [45]

In summary, the deterioration in the real value of wages vis-à-vis prices of all other goods may have created a temporary situation that increased the expected profitability of all enterprise, thus facilitating the entry of many smaller firms into the market. The relative decline in the price of capital goods caused by the wartime protectionist policies, and the crowding in effects of debt retirement discussed above that account for the post-war rebound may also have been beginning to take effect, further abetting the profitability of new enterprise by lowering the cost of credit, and the price of the capital equipment itself.

These effects do not, however, appear to have offset the crowding out effects of war debt upon capital formation; at least not by 1870. Overall, the Beard-Hacker thesis that the war spurred economic growth and industrialization is hard to substantiate. While there may have been some short-term factors that facilitated the entry of many new smaller firms into the market during and immediately following the war, overall, the war was a setback for the industrial North that retarded the rate of economic growth during

---

[45] DeCanio, Stephen, and Joel Mokyr. "Inflation and the Wage Lag during the American Civil War." *Explorations in Economic History* 14 (1977): 311-36., pp. 323-26.

the war years. Real growth in the economy marked by large increases in the level of investment and additions to capacity did not occur until the 1870's, as is seen in the resurgence in MES achieved by 1880, indicating that a resumption in capital accumulation may have led to a situation in which larger firms were again able to gain the upper hand. The Civil War must be regarded as a disruption in the normal course of economic growth and activity in which there may have been some short term disruptions or blips to investment activity that produced temporary alterations or adjustments in the standard mode of industrial organization of the economy. But then the economy resumed its course, and it was business as usual. The Civil War economic experience parallels Weiss's account of the increases to capacity that produced rising MES throughout American 20th century manufacturing industry history, only interrupted by the war emergency of World War II, a disruption in the course of normal economic activity that also produced relatively smaller additions to total capacity.

V. SUMMARY AND CONCLUSIONS

In this chapter, our empirical findings indicate that the industries that Chandler said were the great industries that experienced the greatest impact of the decline in transport costs and technological advance that led to large-scale production methods did not achieve great scale economies by 1880; the time by which, if Chandler's theory were correct, they ought to have. In our results that measure and quantify economies of scale through the method of MES, the general pattern of the industries surveyed is relatively great economies of scale as having been achieved by 1860, followed by a pronounced dip at 1870, and only modest increases by 1880 that do not regain their 1860 levels.

While the dips of 1870 make sense in the context of the Civil War aftermath shock, there is no rational explanation for the extremely low MES's observed at 1880 in the context of Chandler's hypothesis. If 1870 is the benchmark period in which to begin to expect to see the effects of transportation improvements upon scale economies in American industry, then 1880 is certainly a liberal allowance in terms of time to expect to see the effects of the railroads upon market expansion and financial intermediation to have been taking place; post-war resumption of investment and capital accumulation notwithstanding.

These results compel us to take a closer look at our data and to conduct deeper analyses in order to determine the root cause of these anomalous 1880 results. In the following chapter, it is revealed that flaws in the 1880 data for some industries may be responsible for these anomalous results, and also the fact that many of the industrial categories analyzed may have been more broadly defined industry conglomerations encompassing a wider range of products than the corresponding industries in the Atack article. Chapter Five conducts more thorough analyses of these data sets by looking at sample sizes and range distributions in order to see if there is a correlation between flawed data and lower-than-expected MES for 1880. For those industries found to contain flawed 1880 data, Chapter Five also reports the results of a search for alternative data for those industries, and results of analyses performed using whatever superior data was available. Chapter Five also, where possible, conducts disaggregated industry analyses based on finer product group distinctions in order to see how our results differ. It will be revealed that by mixing a flawed data set, or one with a downward trend in MES for one sub-group with that of another sub-group with a good data set and an

upward trend in MES, we obtained the end result of a downward MES trend for some industries. By disaggregating these into more "pure" industrial categories, we were able to remove the flawed portion of some of these conglomerations and see that for many groups, our results really aren't so bad after all.

Chapter Five also conducts MES analyses of the new group of fresh industries thus far unanalyzed in the right hand column of Table 4.1 in order to see if the Chandler hypothesis that these industry groups were less strongly impacted by the technological and transportation improvements of the era is correct, and also to inspect and disaggregate the data sets of these industries in turn, in order to determine what these industries' data characteristics and their MES results have to tell us about how faulty data may have affected the results of the left column industries. It will be revealed that faulty and misconglomerated data alone cannot account for these anomalous results, and that a reassessment of the Chandler hypothesis consisting of further industry data analyses may well be in order.

Chapter Five: ECONOMIES OF SCALE REVISITED: TAKING A CLOSER LOOK

Introduction—Data and Measurement Problems

In this chapter, we conduct a more thorough investigation as to the causes of the anomalous results of the previous chapter that showed declines in MES from 1860-80 in eight key industries that Chandler said were the great industries that experienced the greatest impact of the decline in transport costs and technological advance that led to large-scale production methods. The basic pattern of the industries surveyed--relatively great MES having been achieved by 1860, followed by a pronounced dip at 1870, and only modest increases by 1880 that do not regain their 1860 levels—is anomalous in that while the dips of 1870 make sense in the context of the Civil War aftermath shock, we would expect to see a greater rebound as having been achieved by 1880; the time, if Chandler's theory is correct, the effects of the railroads upon market expansion and financial intermediation on size and structure of industry ought to have been firmly in the saddle. We will examine the data more closely—particularly the 1880 data in which the anomalous results are contained—and attempt to "repair" those data sets found to be flawed by conducting new analyses using disaggregated industry conglomerations based on finer product group distinctions and new superior data where available, and comparing our results to similar analyses using the new group of fresh industries thus far unanalyzed in the right hand column of Table 4.1. Our final results indicate that faulty and misconglomerated data alone cannot account for the anomalous results of Chapter Four, and that a reassessment of the Chandler hypothesis and/or further industry data analyses may be desired in the future to further our knowledge and understanding of the true

trends of efficiency and size of firms wrought by the railroads in the late nineteenth century.

The first step in the investigation procedure surrounding lower-than-expected MES in 1880 was to ignore the anomalous results of 1870 and to conduct a new analysis skipping that year; in other words, computing MES as it emerged from 1860-80. The rationale for doing this is that the unusually low MES's of 1870 were the result of wartime conditions that favored the concentration of plants in the lower ranges of industry valued added percent. This may have occurred to the detriment of plants in the middle size ranges, creating small industry value added percents in that year that were easy to beat in the next period. While it is true that many firms may have moved into the small-to-medium size ranges in 1880, the middle-to-upper ranges may have filled up still more. But since these were not the smallest size ranges that increased their percentages since 1870, they were not the MES. However, I reasoned, if I were to compute MES since 1860, that might be another story. There was a high concentration of firms in the middle size ranges in 1860. If firms in the middle-to-upper ranges in 1880 had increased their percentages significantly above their 1860 levels by 1880, then it is possible that *these* firms may have been in the smallest range whose percent increased since 1860; not the firms in the small-to-medium ranges who may have risen since 1870, but not since 1860.

This theory did not hold water. Despite the fact that many more plants had moved into the upper scale ranges in 1880, the results from skipping 1870 produced MES in scale ranges for 1880 that were either equal to, or lower than the ranges computed by

comparing 1880 to 1870. There was not a single exception to this rule in any industry previously surveyed or in those that follow.

A far more plausible main hypothesis I determined, and endeavor to test now, is that part of the reason for the lower-than-expected MES's for 1880 is that sample sizes were very small in that year. The data samples, in other words, were not wholly representative of the gamut of firms. For instance, take an industry that ended up with a lower MES in 1880 than it started out with in 1860—say Beverages. This is a surprising result, given not only the conventional wisdom about what happened to scale of industry as time went on in this era, but also observation of size ranges over time from examining the data. In general, across industries, one notices that each year, the size distribution of plants is increasing in the upper direction. For instance, in 1850 there are few plants in the upper ranges. In 1860, the upper ranges fill up some more. In 1870, although there was an increasing concentration of firms in the lower ranges that produced a low MES in those years, many new plants entered the upper ranges to the point where there were at least some plants in each range all the way up to the top, $256,000+. The thing that happens in 1880 in Beverages, however, is that the size ranges become truncated at both ends, top and bottom. In other words, you have a bunch of empty extreme lower ranges, a bunch of empty extreme upper ranges, and a handful of average-sized plants in the middle.

It could be the case that since the sample sizes were small in that year, the plants the census takers obtained data on were naturally, by the law of averages, the *average*-sized plants. The very small ones and very large ones may indeed have existed, they just weren't taken account of. So since the average, medium-sized plants were all that existed

in the samples, naturally the MES existed somewhere in the medium range. It is entirely possible that if the sample sizes were larger, and included the output of all the very largest plants, these plants in the medium ranges would have comprised a lower fraction of total industry value added than actually shown, and larger plant size ranges could have been the ones that made a jump in share of total industry value added since 1870.

In looking at the sample size of Beverages for 1880, we find that this is certainly the case. There were only 11 plants in the sample that year!

Atack and Bateman's article on the Census samples reveals information about the 1880 Census that shows that my fears that the 1880 Census might not be wholly representative of the gamut of firms might not be unfounded. Atack and Bateman report that for the 1880 census, special experts on the industry in question were assigned to collect data on specific industries. These industries included iron and steel, cotton, woolens and worsteds, silk, beer, liquor, glass, coke, mining and drilling. Unfortunately, despite exhaustive investigation, no one has been able to locate all of the returns taken by the aforementioned experts. Thus many firms from these separately canvassed industries that appear in the 1880 samples are enumeration mistakes and were not generally tabulated from the regular returns by the Census Office, although they aren't missing in their entirety.[1]

So this means that for the 1880 samples for the industries in those categories, which include Beverages, credence ought not be held in them as representative at all of those industries. The hypothesis about small sampling size leading to truncation of the

[1] Atack, Jeremy and Fred Bateman. "Nineteenth-Century U.S. Industrial Development through the Eyes of the Census of Manufactures: A New Resource for Historical Research." *Historical Methods*, Fall 1999, Vol. 32, No. 4: 177-88, pp. 180, 185. This article is also available on line and downloadable at http://www.vanderbilt.edu/Econ/faculty/Atack/atackj.htm.

data for that year is also possible for these industries because of the omission of so many plants. Had these plants been included in the samples, it is likely that there would be many more plants in the upper and lower ranges. So it is likely that had these additional plants been included in the samples, total industry value added would have been greater, and the proportion held by small-to-medium-sized plants might have been smaller, thus MES might have been observed in higher size ranges.

In order to remedy this data deficiency, an exhaustive search for alternative data sources for at least the iron, steel and textile industries for some time from approximately 1875 until 1895 was conducted. Unfortunately, apart from some excellent iron and steel data, it yielded meager results. In 1890 and 1891, the U.S. Bureau of Labor issued two reports as part of its Annual Report of the Commissioner of Labor series; one covering iron, steel and coal (1890), the other covering textiles and glass (1892). [2] These books contain data on costs and output for a group of establishments in each industrial class for an approximate one-year period occurring sometime within 1888-90 (although some have a shorter period covered and terminal dates). For iron, for instance, it has pig iron, muck bar iron, finished bar iron, and steel in all its various forms; steel rails, steel ingots, etc. For textiles, similarly, it has separate groupings of cotton textiles, cotton yarns, woolen and worsted textiles, woolen and worsted yarns, etc. For convenience, I will often refer to these data simply as either the Bureau of Labor (BOL) data, or by their common title, *Cost of Production*, or by their common author, Commissioner of Labor.

[2] United States Bureau of Labor. Sixth Annual Report of the Commissioner of Labor, 1890. *Cost of Production: Iron, Steel, Coal, etc.* Washington, D.C.: U.S. Government Printing Office, 1890; United States Bureau of Labor. Seventh Annual Report of the Commissioner of Labor, 1891. *Cost of Production: **The textiles and glass**.* Washington, D.C.: U.S. Government Printing Office, 1892.

Upon locating these slightly later-than-optimal, but adequate data sources, I conducted a careful analysis of the product coding on the Atack-Bateman-Weiss (ABW) samples for iron and textiles for 1850-70 in order to determine whether there was sufficient correspondence between these and the BOL data for mobilization and incorporation of the latter into my survivor method analysis. Based on the ABW product coding, it appeared that the BOL data do incorporate the gamut of products that fall under the rubric of the three-digit SIC codes used in the former, apart from a few multi-product firms. I determined that the Commissioner of Labor books provide a very large sample for iron/steel and cotton and wool textiles that does correspond to the products included in the ABW samples under their respective categories. For instance, the BOL books have a large set of data for each variety of iron. Although the ABW data are titled simply "Iron" as per the SIC code 331 under which they are grouped in the data set, this coding includes steel and coke; both of which are to be found in at least a modicum in the ABW samples, and are in abundance in the BOL data. The fact that the BOL data are titled "Iron and Steel" may thus be counted as a purely semantic difference, perhaps reflective of the fact that by the time these books had come out, steel had begun to be increasingly used in place of iron in a variety of industrial processes, and the authors merely wanted to emphasize this fact.

These data are not limited to any particular state(s). While the samples of firms were drawn heavily from the Northeast, some Southern industry is also represented. Each industrial class also contained some data for some firms in Britain and Continental Europe.

These data contained all the data necessary to do an Atack-esque value added measurement, barring price of output. They contained each establishment's materials, labor, supplies and repair (capital) costs for the period, and output quantity. The iron volume also contained some prices data, such as the price of a ton of pig iron in Philadelphia at each month of the year over 1887-90, and for several other varieties and grades of iron. I was able to obtain price data for much of the remaining products from the various publications of the American Iron and Steel Association, U.S. Census Bureau and U.S. and state Departments of Labor (see explanatory notes of following analysis). Mobilizing these data to accommodate the *Cost of Production* output figures was pretty straightforward for iron and steel, due to the fact that most (but not all) firms in the series produced a single, homogeneous product, such as a single particular variety of pig iron or bar iron, so the task amounted to finding a single price per firm based on its output.

Textiles were much more complicated. In the industrial category of "cotton textiles", for instance, each firm produced a gaggle of different products that fall under that rubric. *Cost of Production* tells us *which* of these products each firm produced, but not how *many* pounds or yards of each; only how many *total* pounds and yards of textiles each firm produced. Since the products are non-homogeneous, they have different prices. If quantities of each product each firm produced were known, a weighting scheme to form a unique price estimate for each and every plant in the sample could have been devised. Unfortunately, since neither the quantities nor proportion of each sample firms' output were given, the textiles data could not be used.

There were also some chunks of the *Cost of Production* iron & steel data that had to be discarded for similar reasons. Many of the firms were multi-product, and the

quantities of each product they produced are unknown. Therefore it was impossible to assign a properly-weighted price estimate for their output. The data are arranged in the book in separate tables by variety of iron and steel product. So there is a separate table for pig iron, finished bar iron, etc. In each of those tables, there is a product description for each firm listed. While some of these firms produced a single, homogeneous product across the samples, for which a single price is available, others did not. So for pig iron, for instance, the variety of pig iron each firm produced is listed (hot blast charcoal, cold blast charcoal, Bessemer, etc.). While some sample firms produced a single, homogeneous variety of pig iron, say Bessemer, there were another bunch of firms with the product description "Run of furnace", which was used to designate the product of a furnace which produced several grades of pig iron in considerable quantities, the separate quantities of which are not listed in the table. The Finished bar iron table had a similar "Run of mill" product description category.[3] So the data for pig iron and finished bar iron incorporated in the following analysis has been truncated from its complete form in the original tables so as to purge the data of these multi-product firms, whose quantities or proportion of their various outputs are unknown.

There were also two entire tables for miscellaneous iron and miscellaneous steel products in which, in most cases, each establishment produced several different articles of numerous sizes. While the product description column lists only each firm's leading product, the cost data is for the entire mixed product. Thus there is no correspondence between a value of output figure computed from the price of the leading output multiplied

[3] Apparently the expression "run of the mill" was used in a completely opposite sense than its contemporary usage at the time the Commissioner of Labor books were written.

by its quantity, and the cost data. So the data from these miscellaneous categories also had to be discarded.

A detailed description of the exact product categories included and the source and methodology of construction of each product category's price estimate accompanies the results and commentary on the MES calculations for iron and steel using the *Cost of Production* data. This commentary and analysis is juxtaposed to the corresponding analysis using the ABW data that is reiterated for the sake of comparison in the below Section I. Suffice it to say, the *Cost of Production* data yield far more intuitively-pleasing results than those for iron and steel obtained using the ABW data, and for that reason have been included in the following tabular analysis.

Another factor possibly contributing to the lower-than-expected MES in 1880 for the industries surveyed in Chapter Four is the fact that all of the industrial categories analyzed, both in Chapter Four and in the analysis that follows, may be more broadly defined industry conglomerations than in the 1985 Atack article frequently referred to in Chapter Four. In comparing the SIC codes used to classify industries on the internet data samples to the SIC codes in the article, one notices that Atack uses the more precise 4-digit subgroupings contained within these 3-digit classifications; whereas on the internet samples, only the 3-digit product code is listed. The 3-digit codes on the internet data sets encompass the entire spectrum of 4-digit codes that fall beneath them. We do not know whether there is correspondence or not between these 3-digit codes on the internet data set, and the 4-digit codes in the article. The original data set Atack used to write the 1985 article is not available. Since the 1850-70 data contained product code delineations that would enable one to disaggregate the data based on finer product distinctions, it is

possible that the original data sets may have consisted of much finer groups. These data sets were delineated by an idiosyncratic system of industry coding that was recoded to SIC *ex post c.* 1987 to form the current internet data samples. In addition, Atack and Bateman did additional sampling on 1850-80 in order to generate self-weighting nationally representative samples, which is also reflected in the current internet data sets. It is thus entirely possible that the industrial categories currently analyzed are much broader, and encompass a wider range of products than the corresponding industries in the Atack article.

This is another X-factor that might be behind these anomalous results. For instance, in the analysis of the Tobacco industry below, it was found that by disaggregating it into separate components of Cigars and Chewing tobacco, flaws in the data set for Chewing tobacco were responsible for the anomalous results earlier obtained in the Tobacco analysis in Chapter Four. When Cigars were analyzed separately, they displayed a steadily ascending MES over 1860-80. It is possible that further decomposition of the internet data into more "pure" industrial categories might correct further "errors", and yield more intuitively pleasing results.

Unfortunately, without these original data sets, a precise analysis of the industries in the exact same manner as performed by Atack is impossible, so we must make do with the data classifications as they exist in the current internet samples. I did not do an in-depth inspection of the product codes for all the industries to ascertain the degree of correspondence between the internet data samples and the 4-digit industry descriptions in the Atack article; the main reason being that for the very year that such information would be most helpful for, 1880, there are no product codes delineation—a defect from

the original census manuscripts that neither I nor Atack can do anything about. Even if we were able to get finer industry distinctions from the earlier years, we would still be stuck with the broad ones from 1880 for which we observe the anomalous results for. The internet data sets also contain state samples, which are closer to the datasets that Atack used in 1985. However, the same difficulties mentioned above apply to these. These also contain no product code delineations for 1880, and we do not know if finer industry classifications exist in the original data sets in comparison to these, because these sets are unavailable. This is another issue of the data to be wary of and this problem is alluded to frequently in the below analysis.

The analysis that follows attempts to determine if these smaller-than-expected MES's for 1880 were due to small sample size by more carefully examining the data. The first section attempts to analyze more carefully the empirical results already presented in Chapter Four by inspecting sample sizes of the data, looking for evidence of truncation of the size distribution, and determining if there is a correlation between small sample size, truncated (top and bottom) size range distribution, and lower-than-expected MES. Such a correlation, if it exists, would tend to support the hypothesis that the smaller-than-expected MES's for 1880 were due to small sample size. It also checks for an increasing size range distribution over time. If the size range was increasing for previous periods, yet became truncated in 1880, this is further evidence that the smaller-than-expected MES's for 1880 were due to small sample size. The first section also compares the MES results using the superior DOL 1880 iron data to those using the flawed ABW 1880 iron data.

The second section attempts to, where possible, group similar industries together and disaggregate them so as to compare their MES tables in both forms. This is being done in order to see if the anomalous results remain, disappear, or are reinforced when industries are disaggregated in this manner, and sample sizes are reduced. For instance, in reference to Cotton and Wool textiles in the lower right Low-Technology/Low-Transportation cell of Table 4.1 which was not analyzed in Chapter Four, but is analyzed here, it is possible that an entire aggregated group of textiles displayed these anomalous results, but that that was due to the preponderance of cotton textiles in this group, which were known to have experienced a war-time depression relative to wool textiles. If disaggregated into cotton and wool textiles, it might show that wool textiles rebounded to a greater MES in 1880 than in the case of the aggregated results. Or, it is equally possible that this chopping down of sample size might produce even more anomalous results because it chops down the already-small sample size of 1880, thereby producing an even more truncated range distribution in that year, producing further anomalies.

The third section performs the same function as the first two sections, but for the new group of fresh industries thus far unanalyzed in the right hand column of Table 4.1 (which includes the textile categories mentioned above). This is being done not only to provide further testing of the hypothesis that small sample size may be responsible for the anomalous results, and to see how these results differ when disaggregated, but also to see if anomalous results even exist. For instance, it could be the case that sample sizes were better for these industries, and that 1880's results show greater scale rises than in the left column industries. Such results would point to the possibility that the results of the left column industries' MES have a downward bias, and that an upward revision of those

results would produce greater MES in 1880. Or, they could have good samples, yet show even smaller MES in 1880 than the left column industries. Such results would not only vindicate the hypothesis that small sample size is responsible for these anomalous results; it would also vindicate the Chandler hypothesis that these industry groups were less strongly impacted by the technological and transportation improvements of the era that promoted greater scale of industry. Comparison with the left column industries in order to test the Chandler hypothesis is a paramount reason for examining some of these right column industries. Fortunately, there were enough similar industries in the right column to provide a few monolithic single industry groups consisting of a sub-grouping of these similar disaggregated industries to test.

The fourth section describes the remaining right column of Table 4.1 industries that were not similar to each other enough in any way to be grouped together in any way to form monolithic single industry groups that could be disaggregated and analyzed separately, but are present in the Census samples in sufficient sample size in each year so as to permit a separate individual MES chart for all these industries for 1860, 1870, and 1880, should future need or desire arise.

The fifth and final section, the conclusion, summarizes the results produced by providing us a final comparison of right vs. left column industries to see who, in the final scheme of things, has “better” results, telling us in summary how botched sample size may have affected our results, and what insight the results provide in terms of a test of the Chandler thesis.

I. SUPPLEMENTATION OF TABLE 4.2: SAMPLE SIZE, TRUNCATION OF RANGE DISTRIBUTION, AND MES

In order to determine if there was this correlation between small sample size, truncated (top and bottom) size range distribution, and lower-than expected MES, I have amended Table 4.2 so as to include a description of the sample size and range distribution of all these industries for each year in which MES was ascertained. This means the final date; so for 1870-80, I am looking at the sample sizes and range distributions as they existed in 1880. I have also looked at the sample sizes from the other years in which a MES was ascertained, 1860 and 1870, because if sample sizes were also small and ranges were also truncated in those years, then one cannot point to this feature of the 1880 data as being a reason for its anomaly. In this section, we conduct a more thorough analysis of the data sets to see what happens when we face diminished sample sizes, and apply more skeptical scrutiny of those industries whose 1880 data was collected by "experts". The sample sizes listed pertain to the number of firms in the samples who possessed value added equal to or greater than zero. Firms with negative value added were not counted.

TABLE 5.1
Minimum Efficient Scale (MES), Sample size, and Range distribution for Selected Industries, 1860-1880 in Constant 1860 Dollars

Industry	MES, 1850-60	Sample size, 1850-60	Range distribution, 1850-60	MES, 1860-70	Sample size, 1860-70	Range distribution, 1860-70	MES, 1870-80	Sample size, 1870-80	Range distribution, 1870-80
Meat	450	Large (47)	Non-truncated	89,060	Medium (24)	Non-truncated	11	Large (249)	Non-truncated
Flour	2000	Large (516)	Non-truncated	28	Large (377)	Non-truncated	502	Large (789)	Non-truncated
Beverages	8000	Large (128)	Non-truncated	265	Large (99)	Non-truncated	1163	Small (11)	Truncated
Leather	8200	Large (244)	Non-truncated	86	Large (113)	Non-truncated	19,298	Large (117)	Non-truncated
Iron	560	Large (48)	Non-truncated	276	Medium (28)	Non-truncated	326	Small (17)	Somewhat Truncated
Tobacco	2000	Large (84)	Non-truncated	69	Large (146)	Non-truncated	256	Large (255)	Non-truncated
Clothing	50	Large (232)	Non-truncated	96	Large (268)	Non-truncated	130,200	Large (336)	Non-truncated
Shoes	67,000	Large (541)	Non-truncated	7	Large (519)	Non-truncated	33,792	Large (658)	Non-truncated

The results show that the two industries whose MES was higher in 1880 than in 1860, Leather and Clothing, both had good sample size and a normal size distribution. Less-than perfect sample size was a phenomenon that only appeared among the industries whose MES dropped. However, it was only two of the remaining 6 industries whose MES diminished, Beverages and Iron, that had less-than perfect sample sizes, and these were both industries whose 1880 data must be regarded with skepticism. Note their highly truncated 1880 data sets. This may not prove that the diminished MES is due to this flaw in the data, because it is worth noting that these drops do not happen to be any more precipitous than the drops seen in the industries with good sample sizes. The drop

in Beverages of 8000 to 1163 was a drop of 85.5%, and the drop in Iron of 560 to 326 was a drop of 41.8%. The drops in the other 4 industries with good sample sizes were: Meat, 97.5%; Flour, 74.9%; Tobacco, 87.2%; and Shoes, 49.6%. Thus we cannot rule out these surprising results of lower MES in 1880 than in 1860 to inadequacies of the data without more evidence.

We must therefore look at the actual numbers of the sample sizes of the industries with good sample size but diminishing MES. If the sample sizes diminished over time, and are therefore not as representative of the industry as the earlier samples, it would be a sound explanation for a diminishing MES observed without the truncation. We must also inspect the upper and lower extremities of their distributions, for while they may not be blanked-out zero spaces, they might still be sparse and thin relative to the two extreme tail ends in the earlier samples.

Of those 4 industries whose MES dropped but whose sample sizes were good, there not only were no significant drops in sample size; there actually were increases. It is therefore hard to make the case that the drops in MES were due to inadequacy of sample sizes.

If the sample sizes were good, then tiny fractions of industry value added in the extreme upper and lower ranges probably are indicative of the actual structure of the industry, and not of an inadequacy in the sampling procedure that overlooked the extremes and only caught the middle ground average plant. An examination of these percentages in these 4 industries shows that the percentage of industry value added in the upper ranges actually increased over time. In comparing just the upper ranges of size distribution in 1860 to that in 1880, only Shoes shows a shrinkage of proportion of value

added in the upper ranges. In examining the lower ranges as compared with 1860, there are also no significant proportional differences.

There is thus no evidence of a pattern of across the board truncation in the 1880 data. Beverages and Iron may have been, which may have contributed to a slightly lower MES than would have existed otherwise with better data. But the fact that the sample sizes for the other industries whose MES diminished were good and not truncated at all show that this hypothesis cannot be used to explain the diminished MES that appears in these industries in 1880. For the most part, these industries in 1880 continue and reinforce the trend of increasing concentration of industry value added in the upper ranges observed from 1850-70. Yet despite this increasing concentration in the upper ranges, it was the small-to-medium-sized plants that that picked up market share. However, had the sample size been still larger, there might have been observed still greater concentration of industry value added in the upper ranges, thus MES in the higher ranges.

However, if one were to look at the results excluding Iron and Beverages, they aren't quite as counter-intuitive. The ratio of industries whose MES diminished from 1860-80 to those whose MES increased becomes 4 to 2, or 2 to 1, instead of 6 to 2, or 3 to 1. Further computations done excluding the flawed 1880 industries might reveal a lower proportion of such anomalous industries in the samples, and may even prove such results to be the exception rather than the rule. It remains to be seen what tests of further industries, and sub-division thereof might reveal.

TABLE 5.2
Minimum Efficient Scale (MES), Sample size, and Range distribution for Iron & Steel,1860-88/90, in Constant 1860 Dollars, using Bureau of Labor Data

Industry	MES, 1850-60	Sample size, 1850-60	Range distribution, 1850-60	MES, 1860-70	Sample size, 1860-70	Range distribution, 1860-70	MES, 1870-88/90	Sample size, 1870-88/90	Range distribution, 1870-88/90
Iron & Steel	560	Large (48)	Non-truncated	276	Medium (28)	Non-truncated	2588	Large (91)	Non-Truncated

In Table 5.2 above, I have substituted the BOL data for iron & steel from 1888-90 discussed above for the flawed ABW 1880 iron data, recalculated MES, and displayed the results.[4] In other words, I have treated the BOL data from 1888-90 as data of a single

[4] The data used in this analysis were constructed from a variety of sources besides the Bureau of Labor's Sixth Annual Report of 1890, *Cost of Production: Iron, Steel, Coal, etc.* While all the data on output and costs were obtained from it, prices data used to compute output value (thus value added), and deflate prices when necessary, were obtained from the following sources: United States Census Office, 11th Census. *Report on Manufacturing Industries in the United States at the Eleventh Census: 1890.* Pt. 3, Selected Industries. Washington: Government Printing Office, 1895; American Iron and Steel Association. *Statistics of the American and Foreign Iron Trades.* Philadelphia: The Association. 1888, 1889; United States Department of Labor. *Bulletin of the Department of Labor.* Washington: Government Printing Office. Vol. V (1900), No. 29 (July, 1900); U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C., 1975), I; and Mitchell, Brian R. *International Historical Statistics: the Americas, 1750-2000*, 5th ed. Palgrave Macmillan, New York, 2003.

The data in *Cost of Production* were categorized in different industrial classes, which appear in different sections of the book. The data on output and costs that were used to perform the above analysis were only the data pertaining to pig iron, muck bar iron, steel ingots, steel rails, and coke that appeared on pp. 35-37, 51, 52, 110, 113, 152, 155, 164, 165, 234, and 236 of *Cost of Production*. Within those individual tables' categories, some firms were omitted based on their product description either due to the fact that the firms were multi-product, or there was an inconsistency between their output and cost data, or merely due to the fact that no price data was obtainable for that product. Thus the data used in the above analysis for pig iron consisted only of that for Hot Blast charcoal, Cold blast charcoal, Bessemer, Foundery No. 1, Foundery, and Gray Forge pig iron. The data used for steel ingots consisted only of that for the varieties of steel produced by the American firms in the table, which were Bessemer and Open hearth. The remaining industrial classes were of a uniform homogeneous variety, and contained no product description based upon which a different price could be assigned to them.

The prices data contained within *Cost of Production* that were used in the analysis applied only to Bessemer pig iron, Foundery No. 1 pig iron, Gray Forge pig iron, Steel rails and Coke, and appeared on pp. 103-04, 179, and 243. That pertaining to Gray forge pig iron is the price of Gray forge pig iron at Philadelphia on p. 103, not that at Pittsburgh that appears in the next column on p. 103 that was lake ore mixed. That pertaining to coke is that at Pittsburgh, except for the month of March, 1888, for which no Pittsburgh data was available. Instead, the price of coke at Connellsville, PA for that month was used.

alternative period (labeled simply "1888/90") with which to compare to the ABW 1870 iron data in order to obtain a new and different MES as it emerged from 1870 to the later period of 1888-90.

The table shows the very good result of a MES for 1888-90 of 2588; a MES that exceeds not only the low, Civil-War-induced MES of 276 for 1870, but also the

---

Prices data for Hot & Cold blast charcoal pig iron, and Bessemer & Open hearth steel ingots were estimated based on national aggregate data obtained from the *Census* of 1890 found on pp. 472 and 477. For each, the total value of output for 1890 was divided by the quantity of output in tons of 2000 lbs., then multiplied by 1.12 so as to convert to tons of 2,240 lbs. to be consistent with the *Cost of Production* data, thus providing single price estimates for 1890 for these products. These estimates were then deflated into the prices of 1888 and 1889 using the Warren-Pearson wholesale price index for metals and metal products (Series E 58) found in *Historical Statistics*, p. 201.

Prices data for Muck bar iron were obtained from *Statistics of the American Iron Trade for* 1888 (p. 21) and 1889 (p. 22). These data, originally presented in price per pound, were multiplied by 2,240 so as to be consistent with the data in *Cost of Production* which were in tons of 2,240 pounds.

Prices data for Foundery pig iron were estimated based on the monthly data on prices of Foundery No. 2 pig iron for 1889 and 1890 found in the *Bulletin of the Department of Labor*, p. 813. Prices data for 1888 were estimated by taking the average price of 1889, and deflating it into 1888 prices using the Warren-Pearson price index.

As matters of general practice, wherever monthly data were available, an average price was constructed for each firm based on its production run. When monthly data was not available, annual data was substituted in its place, regardless of whether the firm's production run occurred in a single year, or overlapped years. For firms whose production run began or ended at a day of the month other than the first or final one, its average price was a rounded estimate. So if a firm's total production run began or ended with a run that was less than 15 days out of a month—say it began at a day past the 15th of the month, or finished its run before the 15th of the month—that month's price was not counted in its average price. Only if the first and final months of the firm's production run consisted of over 15 days in the month was that month counted in the firm's price average. Production runs consisting of over 15 days in a month were weighted equally to runs that spanned an entire month.

Similar monthly averaging techniques were applied to the price deflating described above. In cases in which a firm's production run overlapped years, its final average price was computed based on the appropriate deflated price values. It is only natural to assume that since the firm's production run occurred over the course of more than one year, its price received for its product ought to be reflective of the prices that prevailed over that production run. This practice was also applied in order to maintain consistency with the costs data. The output value figure ought to correspond to the costs data found in *Cost of Production*, which were merely totals of the costs incurred over each firm's production run; therefore, they were costs that were paid for in the prices of different years, if the firm's production run overlapped years. To do the best job of ensuring an accurate value added measure, then, output value figures were computed using an average of prices of the different years.

Once value added figures were obtained, similar methods were applied again in deflating the final figures, in prices of 1888,1889, 1890, or some average thereof, to the prices of 1860 in preparation for computing MES figures that could be compared to those of earlier years using the ABW data. These deflator data were the same used to deflate the ABW value added data; the North American Wholesale Price Indices on p. 702 of *International Historical Statistics*. If a firm's production run overlapped 1888 and 1889, for example, its price deflator was an appropriate average of the deflators of 1888 and 1889 based on the number of months its production run covered in each year.

starting point MES of 560 for 1860. These results are a considerable improvement over those obtained using the flawed ABW 1880 iron data, which yielded a MES of 326 for 1880, which gave the impression that efficient scale had decreased from its1860 level.

The results may actually even understate the scale economies achieved by that later date, because many of the firms in the sample had shorter period covered and terminal dates than one year, as in the Census samples. Thus many of the firms appear as much smaller firms than they would be had the data included their entire annual output, which are unknown. Had annual outputs for these less-than-one-year firms been estimated in some way, perhaps by obtaining an average monthly output figure, multiplying that figure by the number of missing months in the firms' production run, and adding it to the existing figure, scale would have been even larger for many of these firms, thus adding more larger firms to the sample, and perhaps resulting in greater shares of industry value added held by the larger firms in the sample, thus producing an even larger MES for this period.

Had the BOL data been substituted into Table 5.1 for iron in place of the ABW data, and the later period of 1888-90 been used in place of 1880 as a final period with which to measure MES, the overall industries' results improve. There would now be three, not two industries whose MES was higher in 1880 than in 1860, all of which possessed good sample size and a normal size distribution. Only 5 industries experienced diminishing MES from 1860 to whichever final period we are comparing to. The BOL data also is of satisfactory sample size that stands up to the best of the ABW data, and is non-truncated, which further reinforces the general pattern observed in the other industries of increasing concentration of industry value added in the upper ranges

observed from 1850-70. The only industry with a truncated 1880 data set that would remain if the BOL data were substituted for the ABW data would be Beverages, also one of the flawed expert-collected data series. If one were to look at the results excluding just Beverages, and including the new iron data, they become much more intuitively pleasing. The ratio of industries whose MES diminished from 1860 to the later period to those whose MES increased becomes 4 to 3, or one and one third, instead of 3, the same ratio as computed including the ABW Iron and Beverages data.

II. SUB-SECTOR MES ANALYSES: HIGH PACE OF TECHNOLOGICAL PROGRESS/HIGH IMPACT OF TRANSPORTATION AND HIGH PACE OF TECHNOLOGICAL PROGRESS/LOW IMPACT OF TRANSPORTATION (COLUMN 1, TABLE 4.1)

Of the Table 4.1 left column industries that fall into the High pace of technological progress/High impact of transportation and High pace of technological progress/Low impact of transportation categories, there was only one, Tobacco Products, that represented a Major Industry Group as per the 1987 SIC manual. That group, 21, comprised a few individual Industry Groups that appeared in the ABW samples: 212 (Cigars), 213 (Chewing and Smoking Tobacco and Snuff) and 214 (Tobacco Stemming and Redrying).

Again, as explained in Chapter Four, a segmented analysis of Industry Group 208, Beverages, into its two subcategories 2085 (Distilled and Blended Liquors) and 2082 (Malt Beverages) as Atack did, is impossible because in the data set, they share the same SIC code, 208, and because for 1880, a period that Atack did not take into account in his study, there are no fields in the data set corresponding to individual final product codes,

quantities or value. Even for the other years, even if I were to look at their output codes on the data set, and determine what product was each plant's primary output, many plants in the data set in the 208 category produced a significant amount of say, Beer, which would fall under the 2082 Malt Liquors sub-category, and also a significant amount of say, Whiskey, which would fall under the 2085, Distilled, Rectified and Blended Liquors sub-category. So without further information, I cannot make any distinction between plants in the two categories.[5] These earlier data sets used an idiosyncratic set of industry codes, and then were recoded to SIC codes *ex post* to form the current data sets on the internet. So in the case of Beverages, one would need to look at the original data sets to see how the 208 data were divided into distilled vs. malt liquors.

The only other group that comprised more than one individual Industry Group analyzed above, Clothing, was an industry group of my own construction based on SIC classifications that could be construed to represent the group that also appeared in the ABW samples. This definition of Clothing, I think, is not the definition that Atack used in his 1985 study. The only industry category we have enough information to link "Clothing," as it appears in Table 4.1 with, that Atack actually could have run empirical analyses of, is Industry Group 232, Men's and Boys' Furnishing, Work Clothing, which I believe corresponds to Industry Group 2321, Men's, youth's, and boys' clothing, as it appears in the tables in Atack's article on pp. 34-35 and 40-41. Since this Industry Group was of extremely small sample size, and sometimes entirely absent from the ABW samples, I combined it with various other Industry Groups contained in the samples that could be so construed as to represent the broad category of "Clothing" as it appears in Table 4.1. However, there is no evidence that Atack ever included any of these other

[5] Atack is not sure what happened to the original data sets he used when he wrote the 1985 article.

Industry Groups in his 1985 study. I could take these sub-sections apart, and analyze them separately, but it wouldn't correspond to anything Atack did that I could hold up to his results for comparison.

I do not, as of yet, know how Atack obtained his results for this Industry Group with such small sample sizes. "Clothing", as it appears on Table 4.1, could not have included Industry Group 221 (Cotton textiles) or 223 (Wool textiles), because these are listed separately in Column 2 of Table 4.1, and are analyzed separately under their respective SIC codes in the 1985 article. Again, without the original data sets, and the recoding program he used to convert to SIC codes, there is no way to document exactly what data on the current internet data sets corresponds to 232 in the 1985 article.

Consequently, in looking for an industry in Column 1 that could be sub-divided using the SIC codes provided in the samples to see if the MES structure was any different for the individual goods than for the greater grouping, that only leaves us Tobacco Products. Of the individual Industry Groups within that Major Group, only 212 (Cigars), and 213 (Chewing and Smoking Tobacco and Snuff) were of sufficient sample size in the data to make such separate analyses meaningful (and even some of these were small in some years). 214 (Tobacco Stemming and Redrying) was entirely absent from some years, and in the years it existed, it was extremely small in sample size. The results for Cigars and Chewing and Smoking Tobacco and Snuff (labeled simply "Chew") are shown in Table 5.3 below. The aggregated results already displayed in Table 4.2 (which include whatever meager data for 214 there was) are displayed in the bottom row for the sake of comparison. Since Tobacco was in Atack's High pace of technological progress/Low impact of transportation category, it is unhighlighted in the table.

TABLE 5.3
Minimum Efficient Scale (MES), Sample size, and Range distribution for Tobacco Manufacture, 1860-1880 in Constant 1860 Dollars

Industry	MES, 1850-60	Sample size, 1850-60	Range distribution, 1850-60	MES, 1860-70	Sample size, 1860-70	Range distribution, 1860-70	MES, 1870-80	Sample size, 1870-80	Range distribution, 1870-80
Cigars	120	Large (62)	Non-truncated	69	Large (134)	Non-truncated	256	Large (241)	Non-truncated
Chew	2000	Medium (22)	Truncated	279	Small (11)	Truncated	524	Small (7)	Truncated
Tobacco (All)	2000	Large (84)	Non-truncated	69	Large (146)	Non-truncated	256	Large (255)	Non-truncated

The evidence from Tobacco supports the hypothesis that there is a correlation between small sample size, truncated size range distribution, and lower-than expected MES. By breaking down the individual categories of Cigars and Chew, we find that the anomalous results are only to be found in Chew, which had low sample size and truncated range distribution in every year. By removing chew from the data set, and analyzing cigars independently, we start off with a medium-sized MES in 1860, followed by an expected dip at 1870 due to war-time scale shrinkage, followed by an impressive rebound in 1880.

The results are all the more impressive given the fact that we started out with an aggregated Tobacco category that originally displayed anomalous results. It is apparent from looking at Column 2 of Table 5.3 that the original result for the MES of 2000 for Tobacco in 1860 was due to the presence of at least one, if not more medium sized-plants of $2000 in value-added coming from the small and truncated data samples of chew in that year. Had the sampling for Chew been greater in that year, perhaps there would have been many more plants in the lower ranges, producing a MES for Chew, and therefore

Tobacco as well, that was much lower. By removing this component of the data set that was perhaps flawed, and non-representative of the true structure of the industry, we obtain an untainted "pure" estimation of an industry that had good sample size, Cigars, and find that MES was not as great in 1860 as had been originally believed when combined with its flawed partner. This shrinking-down of 1860's MES produces results that gel nicely with the hypothesis that scale was increasing throughout the 19th century, and only interrupted by war-time abnormalities.

Except for the perhaps flawed separate Chew data, sample sizes only get better as the years go on, so there is no evidence of "veiled" truncation of the data set that a small data sample might produce. The range distributions fill up closer and closer to the top in accordance with the theory that scale was increasing over the years. All in all, this first segmentation of the data set has produced very encouraging results that show that it is very possible that small data sets for some industrial categories in some years may very well have produced anomalous results. It calls for closer scrutiny of other industries to see if the same factors may apply. If so, it could very well provide evidence pointing in the direction to show that even though sample sizes looked good and there was no observable truncation, veiled or otherwise, in the data sets for many of the Table 4.1 industries, inadequacy of sample size of a segment of some conglomerated industries may have been the culprit behind the anomalous results observed in some of those industries.

III. SUB-SECTOR MES ANALYSES: LOW PACE OF TECHNOLOGICAL PROGRESS/HIGH IMPACT OF TRANSPORTATION AND LOW PACE OF TECHNOLOGICAL PROGRESS/LOW IMPACT OF TRANSPORTATION (COLUMN 2, TABLE 4.1).

Below are analyses based on pairings together of industry groups in the right hand column of Table 4.1; the industries thought by Chandler to have *not* experienced a tremendous impetus to scale from the technological and transportation improvements of the day. This is being done in order to see if my test yields a similar result as Atack's. Atack found that the left column industries had the highest ratios of potentially optimal plants to total plants as computed in that article, which was an indicator of great scale economies as having been achieved over 1870-1900. Conversely, the right column industries had lower ratios, indicating that there had not been great scale economies achieved in these industries over this period. It would be interesting to see if the same results hold for the periods I am examining using this alternative methodology. In examining rises in MES in the left hand column industries, I did not get exactly robust results showing a clear pattern of rises in MES from 1860-80. I got very great MES in 1860, followed by a dip in 1870, and mild regaining of MES by 1880. It would be interesting to see if we get similar results for the right column industries, or if different, how they differ.

This procedure is also being done in order to determine if there was this correlation between small sample size, truncated (top and bottom) size range distribution, and lower-than expected MES for these industries. The general pattern observed in the Column 1 industries, that industries with good sample size tended to display the anomalous results of lower-than expected 1880 MES, showed us that small sample size *could* be partially to blame for these anomalous results, but we cannot automatically

attribute them to this problem. Perhaps examining the sample sizes and MES's of these industry groups might shed further light on this unexplained phenomenon.

The pairings are based on information provided in the Atack article, the 1987 SIC manual, and on my own inferences based on that information. In addition to seeing if scale gains were different in these industries than in the Column 1 industries, the other basic idea is the same as in the above Tobacco example: to see if scale gains were different for individual industries than for the larger broader industry class under whose rubric they fell under. For instance, in the first example to be discussed below, it would be interesting to look at a broad industry category, such as "Textiles", and then to take that apart into wool textiles and cotton textiles. As was discussed in Chapter Four, there was a tremendous disruption in the cotton textiles industry during the Civil War. However, this was offset by great growth in the wool textiles industry. So while an aggregated measure of the textiles industry might show little or no scale gains made in this period, a disaggregated measure might show that these little gains are due to a shrinking MES in Cotton, while Wool displayed great scale gains.

The fact that the pairings I have constructed appear together in the same cells in Table 4.1 is further testimony as to the legitimacy of these pairings constructions. The fact that technological and transportation improvements impacted them in similar ways is evidence of their similarity in character. As per the tables highlighting in Chapter Four, industries in the Low Technology/High Transport cell have been demarked in bold, and those in the Low Technology/Low Transport cell have been left unhighlighted.

Pair 1: Textiles (Cotton and Wool; SIC's 221 & 223)

Below are the 1987 SIC classifications of two groups that clearly go together; Cotton and Wool textiles. They share the same Major Industry 2-digit classification code: 21, Textile Mill Products. Since the 4-digit codes that Atack referred to represent these products in his tables are the only sub-groups within these 3-digit categories, there is probably close correspondence between the 3-digit codes the data are listed under in the data samples and the 4-digit codes Atack used in his study. However, even these results must be treated with caution in comparison with Atack's study because the current data sets on the internet are the result of additional sampling he and Bateman did in order to generate self-weighting nationally representative samples. The earlier, mid-80's datasets were not weighted. Again, without a copy of the datasets as they existed in the mid-80's, there is no way we can know for certain that we are dealing with the exact same data set Atack used in his study for these, or any of the industries currently being analyzed. The empirical results for Cotton and Wool separately are displayed in Table 5.4 below, along with their aggregation compiled and analyzed by me, which I have named simply "Textiles".

Industry Group 221: Broadwoven Fabric Mills, Cotton

2211 Broadwoven Fabric Mills, Cotton (only sub-group in this category)

Industry Group 223: Broadwoven Fabric Mills, Wool (including Dyeing

2231 Broadwoven Fabric Mills, Wool (Including Dyeing and Finishing) (only sub-group in this category)

TABLE 5.4
Minimum Efficient Scale (MES), Sample size, and Range distribution for Textiles, 1860-1880 in Constant 1860 Dollars

Industry	MES, 1850-60	Sample size, 1850-60	Range distri-bution, 1850-60	MES, 1860-70	Sample size, 1860-70	Range distri-bution, 1860-70	MES, 1870-80	Sample size, 1870-80	Range distri-bution, 1870-80
Cotton	205,500	Medium (37)	Non-truncated	999	Small (9)	Non-truncated	2232	Small (6)	Truncated
Wool	4000	Large (65)	Non-truncated	207	Medium (45)	Non-truncated	558	Small (15)	Truncated
Textiles (All)	19,000	Large (102)	Non-truncated	207	Large (54)	Non-truncated	558	Medium (21)	Truncated

Bearing in mind that Cotton and Wool textiles were among the industries whose 1880 data were collected by experts, and subsequently lost, we see that both the combined and separate results display the up-down-up-again pattern we are familiar with. To temporarily put aside the issue of the 1880 data, we find no evidence of an offsetting expansion of the wool industry to offset the depression the cotton industry experienced in the Civil War in 1870. Cotton actually has a greater MES than Wool in 1870. Both experience significant drops from their 1860 levels. Cotton dropped from 1860 to 1870 from 205,000 to 999; a drop of over 99%, and there was also a pronounced 95% drop in Wool from 4000 to 207. Of course, the sample size for Cotton for 1870 is extremely small; which might actually only reflect the fact that there were very few firms in the industry in that year, and that this is in fact, a realistic portrayal of the shrinkage of the industry that year. But the fact that there were many more plants unaccounted for is also very possible, and that had the sample size been greater, medium-sized plants would have weighed less, and MES could have been in a higher or lower range. The range

distribution for Cotton in 1870 is non-truncated, but only at its upper range, where in fact, over half of industry added existed in the $250,000+ range. Its lowest two ranges were completely empty. If the sampling bias was towards larger plants, veiled truncation of the lower ranges could imply a greater share of industry value added in those ranges, and could have produced an even smaller MES. This could very well have been the case, because in examining Wool, whose sample sizes were larger, we observe an even smaller MES for 1870. The aggregated Textiles computation also yields the familiar 1870 dip.

The over time range distributions for all three show the familiar increasing concentration of plants in the upper ranges in support of the hypothesis that had better sampling for 1880 existed, there would have been greater concentration of plants in the upper ranges, thus perhaps higher MES's than observed with the available data.

Pair 2: Printing and Publishing (Newspapers and Books; SIC's 271 & 273)

Below are the complete 1987 SIC classifications of groups that came under the rubric of the same Major Industry 2-digit classification code 27, Printing, Publishing and Allied Industries, that corresponds to the category of "Printing and Publishing" Atack defined that appears in his tables. I have presented below the entire set of 3-digit codes that fell under that rubric, along with the 4-digit codes that fell under their respective 3-digit industry groups, because Atack did not make any distinctions among the 3-digit categories that fell under this rubric in his paper. He simply assigned the SIC label "2700" to the data or collection of data he used to represent "Printing and Publishing" in his study. According to Atack, for his 2700 category, all of the 3-digit categories beginning with 27 that appear in the data set have been aggregated together. Therefore, I

have delineated below all those 3-digit categories, and have highlighted those that actually do appear somewhere in the ABW samples.

Disaggregating those individual 3-digit categories for separate analyses was complicated by the fact that for many, sample size was too small across the years to produce a meaningful analysis. A brief description of the frequency of occurrence of each 3-digit code in the samples has also been provided below. It is purely accidental that only two categories, 271 (Newspapers) and 273 (Books) are present in the samples in sufficient magnitude to permit a separate analysis, and a second "pair" has been produced this way; otherwise, I would have disaggregated the data into more than two groups. These two groups have been marked with an asterisk to indicate not only that they existed in the samples, but that they were present in sufficient magnitude to permit separate analyses.

According to Atack, all of the 4-digit code industries that fall under the rubric of a parent 3-digit code that appears in the Census samples are included in the samples under that 3-digit listing. For 271 (Newspapers), there was only one 4-digit code that was identical to its 3-digit parent, so it is pretty safe to assume all of the 271 samples in the data set are of uniform variety. For 273 (Books), there were two 4-digit codes; one that denoted book publishing and printing (2731), and one that denoted just book printing (2732). According to Atack, 273 in the samples meant book publishing and printing together and along with book printing. My own examination of the Census samples product codes for plants listed under 273 however, reveals that most of the product codes indicate book printing rather than publishing, so 273 might only mean 2732. And I can only verify this for the samples from 1850-70, because product code delineation is absent

from the 1880 samples. The remaining 3-digit industry groups not separately analyzed also have their 4-digit children listed purely for the sake of interest.

So the below empirical analysis will consist of Newspapers, Books, and a combined aggregate analysis of publishing that includes *all* of the below 3-digit codes that fall under the 2-digit code of Publishing in the data samples. These empirical results have been presented in Table 5.5 below following the SIC classifications of groups that came under the rubric of Major Industry 2-digit classification code: 27, Printing, Publishing and Allied Industries.

Major Group 27: Printing, Publishing, And Allied Industries (2700 in Atack's paper).

***Industry Group 271: Newspapers: Publishing, Or Publishing And Printing**

Frequent in all years.

2711 Newspapers: Publishing, or Publishing and Printing

Industry Group 272: Periodicals: Publishing, Or Publishing And Printing

Sparse in all years

2721 Periodicals: Publishing, or Publishing and Printing

***Industry Group 273: Books**

Kind of sparse in 1870, but enough to do a separate analysis of.

- 2731 Books: Publishing, or Publishing and Printing
- 2732 Book Printing

Industry Group 274: Miscellaneous Publishing

Sparse or completely absent from all years except 1870.

- 2741 Miscellaneous Publishing

Industry Group 275: Commercial Printing

Only 1880 has any at all.

- 2752 Commercial Printing, Lithographic
- 2754 Commercial Printing, Gravure
- 2759 Commercial Printing, Not Elsewhere Classified

Industry Group 276: Manifold Business Forms

- 2761 Manifold Business Forms

Industry Group 277: Greeting Cards

- 2771 Greeting Cards

Industry Group 278: Blankbooks, Looseleaf Binders, And Bookbinding

Sparse or absent from all.

- 2782 Blankbooks, Looseleaf Binders and Devices
- 2789 Bookbinding and Related Work

Industry Group 279: Service Industries For The Printing Trade

Sparse in all

- 2791 Typesetting
- 2796 Platemaking and Related Services

TABLE 5.5
Minimum Efficient Scale (MES), Sample size, and Range distribution for Printing and Publishing, 1860-1880 in Constant 1860 Dollars

Industry	MES, 1850-60	Sample size, 1850-60	Range distribution, 1850-60	MES, 1860-70	Sample size, 1860-70	Range distribution, 1860-70	MES, 1870-80	Sample size, 1870-80	Range distribution, 1870-80
Newspapers	381	Large (61)	Somewhat Truncated	172	Medium (36)	Non-truncated	5,394	Medium (20)	Somewhat Truncated
Books	920	Small (13)	Truncated	1,033	Small (8)	Truncated	363	Large (118)	Somewhat Truncated
Printing and Publishing (All)	707	Large (78)	Somewhat Truncated	172	Large (70)	Non-truncated	363	Large (148)	Non-truncated

The most striking pertinent feature of these publishing groups are the pleasing results observed in Newspapers that are similar to the phenomenon observed in the Cigars category of Tobacco products above. In the aggregated category of Printing and Publishing, we get the familiar "bad" result of large MES in 1860, followed by the dip of 1870, and the modest rise in 1880 that is still below the MES of 1860. However, when Newspapers are analyzed separately, we find the dip of 1870 followed by a regain in 1880 that supersedes the MES of 1860. Sample sizes for Newspapers are on the small side in 1880, and its range distribution is also somewhat truncated, but this need not discount the results, as a larger sample size in 1880 may have produced still greater concentration of plants in the upper ranges, yielding an even larger MES for 1880.

Books results are less satisfactory, but these may be disregarded due to inadequacy of samples sizes in the first two periods. Small samples sizes yielding truncated range distributions for 1860 and 1870 produce very unusual results of a rise from 1860 to 1870,

followed by a decrease to below its 1860 level in 1880. Had sample sizes been better, Books may have had a greater concentration of plants in the lower ranges in these years, producing smaller MES's than observed in those years, showing an ascending pattern. However, since there was no evidence of increasing concentration of plants in the upper ranges in any of the groupings over the years, and since sample sizes for all groupings were pretty good in 1880, there is little evidence of veiled truncation of the upper ranges that would conceal a real-life greater MES for Books for 1880, or the aggregated Printing & Publishing group either, for that matter. Newspapers thus stands alone as the only robust data set of the two sub-sets, and the disappointing results of the aggregated measure must be considered as due to the presence of the highly-flawed Books data.

Pair 3: Fabricated Wood (Millwork and Furniture; SIC's 243 & 251)

Below are the 1987 SIC classifications of two groups that can be so construed as to "go together"; Millwork and Furniture. While they do not share the same Major Industry 2-digit classification code (Millwork belonging to Major Group 24, Lumber and Wood Products, Except Furniture; Furniture to Major Group 25, Furniture and Fixtures), they are similar enough to be grouped together under a general grouping of fabricated wood products. Since the 4-digit codes that Atack referred to represent this group in his tables are the only sub-groups within these 3-digit categories, there is probably close correspondence between the 3-digit codes the data are listed under in the data samples and the 4-digit codes Atack used in his study. Again, however, we must remember that there was additional sampling done to generate these national weighted samples, while

the earlier work was not weighted. So without the original data set that still remains unaccounted for, we do not know if we are dealing with the exact same set of samples for these industries that Atack used in his 1985 study for Millwork and Furniture. A brief description of the 4-digit categories from the SIC manual below consisting of examples of the types of products that fell under each category provides us with testimony as to the similarity of the products. The empirical results for Millwork and Furniture separately are displayed in Table 5.6 below, along with their aggregation compiled and analyzed by me, which I have named, simply "Fabricated Wood".

Industry Group 243: Millwork, Veneer, Plywood, And Structural Wood

2431 Millwork
Fabricated woodwork like doors, blinds, awnings, stairs, window frames.

Industry Group 251: Household Furniture

2511 Wood Household Furniture, Except Upholstered
Tables, chairs, beds, etc.

TABLE 5.6
Minimum Efficient Scale (MES), Sample size, and Range distribution for Fabricated Wood, 1860-1880 in Constant 1860 Dollars

Industry	MES, 1850-60	Sample size, 1850-60	Range distribution, 1850-60	MES, 1860-70	Sample size, 1860-70	Range distribution, 1860-70	MES, 1870-80	Sample size, 1870-80	Range distribution, 1870-80
Millwork	350	Medium (34)	Non-truncated	34	Large (95)	Non-truncated	251	Large (208)	Non-truncated
Furniture	67,500	Large (160)	Non-truncated	172	Large (122)	Non-truncated	279	Large (226)	Non-truncated
Fabricated Wood (All)	67,500	Large (194)	Non-truncated	34	Large (217)	Non-truncated	251	Large (434)	Non-truncated

All three categories show the familiar up-down-up-again pattern, with 1880 gains still not equaling, or superseding MES of 1860. Size range distributions show only little-to-moderate filling up of the upper ranges as the years progressed, proving little further evidence of rising scale in these industries. There is little truncation of the range distributions in any years, nor of any drops of sample size in 1880 that might indicate veiled truncation concealing a higher-than-shown MES in 1880. Sample sizes of 1880 are actually the best observed for all three categories. Sample sizes over all years, for all categories, are actually quite good. We thus are left with little to show that the results are not indicative of the actual competitive scale conditions of these industries.

Pair 4: Fabricated Metal (Foundaries and Sheet Metal; SIC's 332 & 344)

Below are the 1987 SIC classifications of two groups that can be so construed as to "go together"; Grey Iron Foundaries and Sheet Metal. While they do not share the same Major Industry 2-digit classification code (Foundaries belonging to Major Group 33, Primary Metal Industries; Sheet Metal to Major Group 34, Fabricated Metal Products, Except Machinery and Transportation Equipment), they are similar enough to be grouped together under a general grouping of fabricated metal products. While there were more than one 4-digit codes within these 3-digit categories in the SIC manual, since Atack only referred to one of these in his article (the one I have highlighted below), I am assuming at least a modicum of correspondence between the 3-digit codes the data are listed under in the samples and these 4-digit codes Atack used in his study. Again, the 3-digit codes on the internet data samples do encompass the entire spectrum of 4-digit codes that fall beneath it. So all of the 4-digit subcodes have been listed below, but for the case of the 4-digit code that

Atack in his tables made a clear indication, that particular 4-digit code has been highlighted. Further, without the mid-80s data sets in hand, which used idiosyncratic coding, we cannot be sure of exactly what data in the 3-digit coding contained in the data sets corresponds to that in the 4-digit coding in the 1985 article. This murkiness is compounded by the fact that the internet data samples are the result of additional sampling done to generate weighted nationally representative samples. A brief description of the main 4-digit categories that Atack referred to in his article from the SIC manual below, consisting of examples of the types of products that fell under each category, provides us with testimony as to the similarity of the products. The empirical results for Foundaries and Sheet Metal separately are displayed in Table 5.7 below, along with their aggregation compiled and analyzed by me, which I have named, simply "Fabricated Metal".

Industry Group 332: Iron And Steel Foundries

3321 Gray and Ductile Iron Foundries
Pipes, castings, manhole covers, wheels, etc.

- 3322 Malleable Iron Foundries
- 3324 Steel Investment Foundries
- 3325 Steel Foundries, Not Elsewhere Classified

There were more 4-digit sub-groups that came under this 3-digit rubric. But since the 3-digit is all there is in the data set, and since it is this 4-digit classification of 3321 that Atack explicitly mentions in his article, I am assuming at least a modicum of correspondence between the 3-digit code these data are listed under in the samples and the 4-digit code Atack used in his study. Again, the 3-digit codes on the internet data

samples do encompass the entire spectrum of 4-digit codes that fall beneath it. Further, without the mid-80s data sets in hand, which used idiosyncratic coding, we cannot be sure of exactly what data in the 3-digit coding contained in the data sets corresponds to that in the 4-digit coding in the 1985 article. This murkiness is compounded by the fact that the internet data samples are the result of additional sampling done to generate weighted nationally representative samples. Therefore, we cannot be certain that all the stuff in the data set under 332 is this 4-digit classification.

Industry Group 344: Fabricated Structural Metal Products

3444 Sheet Metal Work
Metal awnings, canopies, ducts, mail chutes & collection boxes, roofing, stove pipes, ventilators, vats, wells.

- 3441 Fabricated Structural Metal
- 3442 Metal Doors, Sash, Frames, Molding, and Trim Manufacturing
- 3443 Fabricated Plate Work (Boiler Shops)
- 3446 Architectural and Ornamental Metal Work
- 3448 Prefabricated Metal Buildings and Components
- 3449 Miscellaneous Structural Metal Work

The same holds true as above with 332. There were more 4-digit sub-groups that came under this 3-digit rubric. But since the 3-digit is all there is in the data set, and since it is this 4-digit classification of 3444 that Atack explicitly mentions in his article, I am assuming at least a modicum of correspondence between the 3-digit code these data are listed under in the samples and the 4-digit code Atack used in his study. Again, the 3-digit codes on the internet data samples do encompass the entire spectrum of 4-digit codes that fall beneath it. Further, without the mid-80s data sets in hand, which used idiosyncratic coding, we cannot

be sure of exactly what data in the 3-digit coding contained in the data sets corresponds to that in the 4-digit coding in the 1985 article. This murkiness is compounded by the fact that the internet data samples are the result of additional sampling done to generate weighted nationally representative samples. Therefore, we cannot be certain that all the stuff in the data set under 344 is this 4-digit classification.

TABLE 5.7
Minimum Efficient Scale (MES), Sample size, and Range distribution for Fabricated Metal, 1860-1880 in Constant 1860 Dollars

Industry	MES, 1850-60	Sample size, 1850-60	Range distribution, 1850-60	MES, 1860-70	Sample size, 1860-70	Range distribution, 1860-70	MES, 1870-80	Sample size, 1870-80	Range distribution, 1870-80
Foundaries	20,730	Medium (41)	Somewhat truncated	131	Large (51)	Non-truncated	981,150	Medium (46)	Somewhat truncated
Sheet Metal	401	Small (5)	Somewhat truncated	169	Small (5)	Non-truncated	7,440	Small (10)	Somewhat truncated
Fabricated Metal (All)	20,730	Medium (46)	Somewhat truncated	131	Large (56)	Non-truncated	139,221	Large (56)	Non-truncated

All three categories display some of the best results seen so far. The familiar dip at 1870 is present, but 1880's MES for all three categories rebounds to a higher position than in 1860. Sample sizes for Sheet Metal are extremely small, so little credence can be held in its results, but when aggregated with Foundaries, whose sample sizes are very good, we get very good results for the aggregated Fabricated Metal category. Sample sizes are not huge overall, but are adequate. Barring Sheet metal, whose sample sizes were too small to check for for evidence of increasing scale over the years, we obtain mixed results when

examining the range distributions of Foundaries and Fabricated Metal. In Foundaries, one sees little evidence of increasing concentration of value added in the upper ranges until 1880, in which over 50% becomes concentrated in the upper-most size range. Similar results are seen in Fabricated Metal, in which almost 50% of industry value added is in the upper-most range. Although it is not an entirely consistent pattern of rising scale, it does at least indicate that scale was headed in the right direction in 1880. I do not know if these industries would be counted along with iron and steel as some of the special industries whose 1880 data is unaccounted for. In examining the sample sizes, we do not see any breaks in the pattern of sample size and quality established for earlier years that would point to a problem with the 1880 data.

IV. REMAINING UNPAIRED AND UNANALYZED : LOW PACE OF TECHNOLOGICAL PROGRESS/HIGH IMPACT OF TRANSPORTATION AND LOW PACE OF TECHNOLOGICAL PROGRESS/LOW IMPACT OF TRANSPORTATION (COLUMN 2, TABLE 4.1).

The following are other industries that appear in the right hand column of Table 4.1 that I have not analyzed MES for yet, because there is no discernable sub-division of them in the samples, and/or there's no way to link them into pairs as I have done for the several above. In the samples, they are all listed by their 3-digit industry codes. All of the 4-digit subcodes have been listed below, but for cases in which Atack in his tables made a clear indication of the 4-digit code of these industries that he surveyed, that particular 4-digit code has been highlighted. I would assume that there is at least a modicum of correspondence between the 3-digit code these data are listed under in the samples and the 4-digit code Atack used in his study. Again, the 3-digit codes on the internet data samples do encompass the entire spectrum of 4-digit codes that fall beneath it. Further,

without the mid-80s data sets in hand, which used idiosyncratic coding, we cannot be sure of exactly what data in the 3-digit coding contained in the data sets corresponds to that in the 4-digit coding in the 1985 article. This murkiness is compounded by the fact that the internet data samples are the result of additional sampling done to generate weighted nationally representative samples. Therefore, we cannot be certain that all the stuff in the data set under the below 3-digit classifications are their corresponding this 4-digit classification from the Atack article. For industries in which this linkage between the 3-digit code on the data set and the 4-digit code in the article is not clear due to a discrepancy between the coding system Atack used and that of the 1987 manual, the 4-digit codes are delineated along with explanatory notes that attempt to determine exactly which of these 4-digit product codes are implied by the 3-digit coding listed in the Census samples.

A brief description of each industrial group is also included; mainly just examples of the type of good that it includes. For each of these 3-digit groups, there is ample data in the samples with which to do an MES analysis for each period.

Industry Group 242: Sawmills And Planing Mills

2421 Sawmills and Planing Mills, General
Lumber making

Other codes:

- 2426 Hardwood Dimension and Flooring Mills
- 2429 Special Product Sawmills, Not Elsewhere Classified

Industry Group 325: Structural Clay Products

3251 Brick and Structural Clay Tile
Just like every kind of brick; for building & stuff.

Other codes:

- 3253 Ceramic Wall and Floor Tile
- 3255 Clay Refractories
- 3259 Structural Clay Products, Not Elsewhere Classified

Industry Group 205: Bakery Products

2051 Bread and Other Bakery Products, Except Cookies and Crackers

Other codes:

- 2052 Cookies and Crackers
- 2053 Frozen Bakery Products, Except Bread

Screwed-up thing with this one is that the SIC Atack used as "Bread and other Bakery Products" in his study, 2057, doesn't appear to exist in the 1987 codes. I checked the 1987 manual, which accounts for all changes in coding made since the previous 1972/77 manual, and there isn't anything about a change here. I'm assuming there's a modicum of correspondence between 2057 in the Atack paper and 2051 as it appears above circa the 1987 manual on account of the similarity in phrasing, and therefore that much, most, or perhaps all of the data that appear under 205 in the data set are this category, and not 2052 (cookies and crackers) or 2053 (Frozen bakery products).

Industry Group 235: Hats, Caps, And Millinery

2353 Hats, Caps, and Millinery
It's pretty much just plain old hats. Only 4-digit code under this rubric.

Industry Group 319: Leather Goods, Not Elsewhere Classified

3199 Leather Goods, Not Elsewhere Classified

This is “Saddlery and Harness” in all the Atack tables, and the 4-digit code above, 3199, the one that Atack did his analyses using, is the only 4-digit code listed under 319 in the 1987 SIC manual. In the manual, it includes a lot of other leather goods besides saddlery & harness: leather bags, aprons, jackets, whips, holsters, etc. But I’m assuming that if you did a thorough examination of the samples, and looked at each product code for all plants under the 319 SIC code, you’d find that most of the stuff these plants produced during these periods is stuff that could be considered as falling under the rubric of “Saddlery and Harness”, otherwise Atack wouldn’t have named it that.

Industry Group 352: Farm And Garden Machinery And Equipment

3523 Farm Machinery and Equipment

Other codes:

3524 Lawn and Garden Tractors and Home Lawn and Garden Equipment

Now this appears as SIC code 3522 in Atack’s analysis. Again, it’s the same screwed-up thing with this one as with the “Bread and other Bakery Products” category above. The SIC Atack used as “Farm Machinery and equipment” in his study, 3522, doesn’t appear to exist in the 1987 codes. I checked the 1987 manual, which accounts for all changes in coding made since the previous 1972/77 manual, and there isn’t anything about a change here. I’m assuming there’s a modicum of correspondence between 3522 in the Atack paper and 3523 as it appears circa the 1987 manual on account of the similarity in phrasing, and that all the data that appear under 352 in the data set are this category, and not 3524 (Lawn and Garden Tractors).

Industry Group 379: Miscellaneous Transportation Equipment

- **3799 Transportation Equipment, Not Elsewhere Classified**

Other codes:

- 3792 Travel Trailers and Campers
- 3795 Tanks and Tank Components

Atack used the phrase "Wagons and Carriages" to describe all the data listed under the 4-digit code 3799 in his study. I am assuming that he chose this industrial code because in modern days, wagons and carriages don't really come into play anymore, so they go into this esoteric, miscellaneous category. Even in the 1987 manual's description of 3799, all you see are

- All terrain vehicles (ATV)
- Automobile trailer chassis, except travel trailer
- Autos, midget: power driven
- Boat trailers
- Caddy cars
- Cars, electric: off-highway
- Electrocars for transporting golfers

I'm also assuming that if you were to go through the product codes in the actual data, and look at what plants under the SIC code 379 actually produced, most of it was stuff that could fall under the rubric of "Wagons and Carriages", otherwise Atack wouldn't have named it that.

I'm also assuming that under 379 in the data set, he hasn't included *too many* of the other 4-digit sub-groups that are listed above; 3792 (Travel Trailers and Campers) and 3795 (Tanks and Tank components), even though the 3-digit codes on the internet data samples do encompass the entire spectrum of 4-digit codes that fall beneath it.

V. SUMMARY AND CONCLUSIONS

In this chapter, our more thorough initial analysis of the eight industries surveyed in Chapter Four indicated that it is hard to make the case that flawed data sets consisting of small sample size and truncated firm size range distributions are what was responsible for the results in Chapter Four that refute the Chandler hypothesis. Of the six out of eight industries whose MES of 1880 was lower than 1860, only two had flawed data sets. Our initial results indicated that the trend of diminishing MES was not due to flawed data, but was rather an indicator of the actual structure of these industries.

After substituting newly-found superior data for 1888-90 for one of the two industries in the original study whose 1880 data was found to be flawed and whose MES declined, Iron, it was found that Iron's new 1888-90 MES exceeded its 1860 level. After decomposing one of the four industries with good data yet diminishing MES, Tobacco, into separate sub-groups of Cigars and Chewing tobacco, and analyzing these as separate industries, it was revealed that the anomalous results found in the original analysis of Tobacco may have been due to the presence of the Chewing tobacco data, which had low sample size, truncated data and diminishing MES when analyzed separately. With Chew removed from the data set, and analyzed as Cigars alone, the result was a robust, non-truncated data set with good sample size, and a rising MES pattern barring the expected dip at 1870.

After substituting the Cigars data set cleansed of its flawed component for the Tobacco data set used in the original study that was found to be flawed, and using the superior BOL Iron data in place of the original flawed ABW data for 1880, the ratio of industries with a 1880 MES that exceeded its 1860 level to those whose MES declined

rose from just 2/6 in the original study to 4/4; an even match. However, 3 out of 4 of those industries in the denominator whose MES diminished in 1880 from their 1860 levels appeared to have good data sets.

Consequently, our empirical findings for eight industries of the left column that Chandler believed were the industries that experienced the greatest impact of the decline in transport costs and technological advance that led to large-scale production methods and concomitant economies of scale by 1880 are far from encouraging. Even after substitution and purging of the flawed data from the study to the best of our ability, the eight industries contained are only evenly split between those whose MES rose in 1880 over their 1860 levels and those who declined. The four whose MES rose; Iron, Tobacco, Clothing and Leather, are not even clustered in the upper left quadrant of Table 4.1. These are the industries that supposedly gained great gains from both technological progress and transportation improvements. Among those four, only Iron and Leather tanning are to be found in this quadrant. However, if the industry whose data set was damaged beyond repair, Beverages, were not counted in the analysis, and the analysis were confined to only seven remaining industries in the left column, the results are a little better in that at least a majority, four out of seven, have increasing MES.

In comparing these results to those of the right column industries that Chandler believed were less strongly impacted by the technological and transportation improvements of the era, also with sample sizes and truncation patterns delineated, we find that when similar industries among this group were aggregated into single monolithic industry groups, four such groups were formed. Out of these four, our initial

analysis showed a majority of three displaying 1880 MES's that were below their 1860 levels.

In comparing these right column industries to the final results of the left column after substitution and purging of bad data, these results would appear to vindicate the Chandler hypothesis that these industries were in fact, much less strongly impacted by the technological and transportation improvements of the era. However, the data sets of the industries in that falling ¾ were far from perfect. Textiles, which was among the industries whose 1880 data was collected by experts and subsequently lost, displayed the decreasing MES in both its aggregated form and its disaggregated separate Cotton and Wool textiles analyses. In decomposing one of the industries with overall good data yet diminishing MES, Printing & Publishing, into separate sub-groups of Newspapers and Books, it was revealed that the anomalous results found in the original analysis of Printing & Publishing may have been due to the presence of the Books data, which had low sample size, truncated data and diminishing MES when analyzed separately. With Books removed from the data set, and analyzed as Newspapers alone, the result was a robust and only mildly-truncated data set with adequate sample size, and a rising MES pattern barring the omnipresent dip at 1870. Despite mild truncation of Newspapers data set for 1880, and lack of evidence of increasing concentration of plants in the upper ranges as having occurred over the years, this stands as an increase that cannot be discounted. After substituting the Newspapers data set cleansed of its flawed component for the Printing & Publishing data set used in the original study that was found to be flawed, the ratio of industries with a 1880 MES that exceeded its 1860 level to those whose MES declined rose from just 1/3 in the initial analysis to 2/2; an even match.

In summary, the right column industries fare no worse than the left column industries in their MES analyses; perhaps even better. After substitution and purging of the flawed data from the study to the best of our ability, the four industries contained are only evenly split between those whose MES rose over its 1860 level and those who declined; the exact same result as in the left column industries. Moreover, if the industry whose data set was damaged beyond repair, Textiles, were not counted in the analysis, and the analysis were confined to the three remaining industries in the right column, the results are even better in that a majority, two out of three (.66) had an MES that rose over its 1860 level as compared with the narrow majority of four out of seven (.57) in the left column industries after similar substitution, purging, and removal of the flawed Beverages table from the group. As with the left column industries, there is no clustering of the industries whose MES rose in the upper right quadrant of Table 4.1 that contains industries that had a low pace of technological progress but a high impact of transportation that Atack found had a greater average ratio of potentially optimal plants to total plants than the lower right cell that contains industries had both a low pace of technological progress *and* a low impact of transportation. While one of those whose MES rose, Fabricated Metal, is in this upper right quadrant, the other that rose, Printing and Publishing (Newspapers) is in the lower right quadrant.

We must therefore interpret our refined results of this chapter as still a refutation of the Chandler hypothesis; or at best, a tepid confirmation. Even after substitution and purging of flawed elements of the data, only half of the eight left column industries that Chandler believed experienced the greatest impact of the transportation and technological advances of the day experienced a MES in 1880 that exceeded their 1860 levels. The

sampling of four of the right column industries that he did not believe experienced as great an impact of the transportation and technological advances of the day, after similar substitution and purging, fare no worse in the analysis; if not better, which is very bad news for the Chandler hypothesis and also is a refutation of Atack's findings. However, the number of industries analyzed in the right column, four, is less than the eight we analyzed in the right column. It remains to be seen what insight further analysis of the remaining seven industries in the right column for which sufficient data permits (Sawmills, Bricks, Bread and baked goods, Millinery, Saddlery and Harness, Farm Machinery, Wagons and Carriages) might reveal.

Chapter Six: ECONOMIES OF SCOPE ESTIMATION

Introduction—Quantification of Economies of Scope

In this chapter, we develop more fully the discussion of economies of scope that began in the first three chapters by introducing the measure of economies of scope achieved by a given multi-product industry at any given time that is a modification of that employed by Friedlaender, Winston and Wang in their 1983 analysis of the structure of costs, technology, and productivity in the U.S. automobile industry.[1] Friedlaender, Winston and Wang's methodology as applied to a given multi-product industry in my model (taking footwear as a hypothetical example), consists of estimating a cost function for the entire industry at a given time, and applying the following definition:

$$S_c = \frac{[C(Y_s) + C(Y_b) + C(Y_{sl})] - C(Y_N)}{C(Y_N)} \qquad (1)$$

where (lower-case) *s* denotes output of shoes, *b* denotes output of boots, *sl* denotes output of slippers, and *N* denotes the collective output bundle.

Thus defined, *Sc* measures the economies of scope of the entire footwear industry by computing the individual costs of producing *each* product independently that the given industry produced. Then by subtracting the total combined costs of producing that bundle of goods jointly, and dividing that difference by the total combined costs of producing that bundle of goods jointly, a measure of the percentage cost savings (increases) that are due to joint production is obtained.

[1] Friedlaender, Ann F., Clifford Winston and Kung Wang. "Costs, Technology, and Productivity in the U.S. Automobile Industry." *The Bell Journal of Economics*, Vol. 14, No. 1 (Spring, 1983), 1-20, p. 15.

By computing *Sc* over successive time periods spanning the late nineteenth century, we obtain a quantifiable measure of the degree of economies of scope achieved in various American manufacturing industries because if the *Sc* of each respective industry rose over time, that serves as an indicator that the percentage cost savings that were due to joint production were increasing, thus increasing economies of scope as having been achieved over time in that industry. Our data used in the analysis, and the empirical results of this said *Sc* computation will be reviewed and discussed in this chapter. In addition, an attempt is made to determine whether our empirical results confirm or contradict the beliefs of Chandler as to which industries experienced these rising scope advantages that were said to have occurred over this period, and when they occurred.

The formulation displayed as Equation (1) above is a slight modification of the framework of the Friedlaender, Winston and Wang article, which estimated economies of scope in the Big Three American automobile producers (General Motors, Ford and Chrysler) from 1955-1979 by dividing their output into three output variables (small cars, large cars, and trucks) and estimating *Sc* based on three distinct disjoint product arrangements consisting of the joint costs of producing two out of the three outputs (say large cars and trucks), and the individual cost of producing the remaining good (small cars) by itself. They then subtracted the joint costs of the total output bundle *N* from that disjoint arrangement in the numerator just as shown above. They then constructed disjoint arrangements consisting of large cars plus small cars & trucks combined, and trucks plus small & large cars combined, thus producing three *Sc* industry estimates per

period that measure the scope economies advantages of an aggregated three-good arrangement over the three possible disaggregated arrangements in which only two out of the three goods are jointly produced.

Instead, I have used their definition to measure the economies of scope of the entire industry by computing the individual costs of producing *each* product independently that the given industry produced, and proceeded from there exactly as Friedlaender, Winston and Wang have done by subtracting the total combined costs of producing that bundle of goods jointly, and dividing that difference by the total combined costs of producing that bundle of goods jointly. This approach may seem a little cut & dry in comparison with Friedlaender, Winston and Wang's methodology, in that it makes no allowance for the possibility that there were firms that produced two out of three goods. So we are deprived of an indicator of the cost advantages that three-good firms might have had over two-good firms, and are only able to gauge the cost advantages of three-good firms over the completely disintegrated single-good structure.

However, this was a necessary departure in methodology due to this study's need for a single generic variable representing the economies of scope of each industry as a whole at each given time period, similar to the manner in which MES functions as a single "one size fits all" measure of economies of scale for an industry per time period, as discussed in Chapters Four and Five.

As it turns out, little is lost in painting with a broad brush in this manner. Due to data limitations (insufficient sample sizes for some industries, years; paucity of multi-output plants within multi-output industries, etc.), it was a struggle in most industries to construct a data set consisting of *two* aggregate output measures, let alone three. Of all

the industries surveyed, only one, Men's & boys' formal & work clothing, displayed a clearly identifiable, frequently occurring bundle of similar goods among the firms in the samples that was greater than two in number (coats, pants, and vests). The data sets for most industries displayed either very little integrated production, or when their production was integrated, it was in a willy-nilly, highly variegated pattern which would have required collapsing many other highly variegated goods into single categories even to just form a two-good pairing scheme, which would not tell us much about scope economies.

In situations in which a realistic collapsing of an industry's outputs into two (and only two) aggregate measures was possible, Friedlaender, Winston and Wang's and my formulation become identical, because when one computes the individual cost of producing one output of a two-output industry, that leaves us with only one other output produced by the industry. There is thus only one possible disjoint group arrangement with which to compare to the economies of joint production. The consequent *Sc* measure is thus the only *Sc* measure possible for the industry. Consequently, the "search" for a single unitary variable that represents the economies of scope of the industry as a whole at a given time period *isn't;* it is actually the only kind of scope measure available to us for most industries given data limitations.

Furthermore, even in the case of men's and boys' clothing, comparing the cost advantages of three-good production to one-good production as opposed to Friedlaender, Winston and Wang's comparison to two-good production may actually be more appropriate given the time period covered by this study. While Friedlaender, Winston and Wang's study was a 20th century one, during which large-scale, integrated,

diversified, continuous-process production technology was firmly in the saddle, my study concerns American industry in a state of transition from cottage industry to that large-scale production technology. So in order to highlight the gains from scope that may have been being made in light of these revolutionary changes in production methods, a comparison of joint to individual costs may actually provide a better indication of the gains from scope that may have been being achieved at this time, over and relative to the old-fashioned, mostly single-product methods that existed before the Industrial Revolution. And of course, a three-to-one good comparison is an omission from Friedlaender, Winston and Wang's study, which merely compares one integrated structure to another by comparing the marginal efficiency of a 3-output plant over a 2-output plant. Friedlaender, Winston and Wang's formulation makes no allowance for the possibility that automobile production could ever be wholly specialized, and thus might be an understatement of the true gains from scope, which I have here provided.

I. COST FUNCTION DISCUSSION

The type of industry cost function used in the above analysis is the hedonic, quadratic, second-order Taylor approximation around the mean cost function as employed by Friedlaender, Winston and Wang in their analysis, *sans* any variables corresponding to hedonic quality attributes or technological variables indicating organizational differences among firms (such as the degree of vertical integration) as Friedlaender, Winston and Wang were able to use and incorporate into their cost function for their 20th century study. [2] The below cost function is composed of variables corresponding to the only data

[2] Ibid., pp. 5, 9.

that were available on the plant level in the ABW data for the period on which I here focus. Thus it is a function of merely a vector of factor prices *w*, and a vector of output quantities, *y*, and a dummy variable for time, *T*, that captures time-related changes in costs and technology (see discussion on industry selection and input vector data set below for explanation of specific variables used in this analysis, that vary by industry). I thus write the cost function as:

$$\begin{aligned} C = {} & \alpha_0 + \sum_i \alpha_i (y_i - \bar{y}_i) + \sum_j \beta_j (w_j - \bar{w}_j) + \delta_T (T - \bar{T}) \\ & + \tfrac{1}{2} \sum_i \sum_m A_{im} (y_i - \bar{y}_i)(y_m - \bar{y}_m) + \tfrac{1}{2} \sum_j \sum_n B_{jn} (w_j - \bar{w}_j)(w_n - \bar{w}_n) \\ & + \tfrac{1}{2} D_{TT} (T - \bar{T})(T - \bar{T}) + \sum_i \sum_j F_{ij} (y_i - \bar{y}_i)(w_j - \bar{w}_j) \\ & + \sum_i D_{iT} (y_i - \bar{y}_i)(T - \bar{T}) + \sum_j D_{jT} (w_j - \bar{w}_j)(T - \bar{T}) + \varepsilon \end{aligned} \tag{2}$$

where C = total costs, $A_{im} = A_{mi} \forall i, m$; $B_{jn} = B_{nj} \forall n, j$; and ε represents the error term for the cost equation.

Before turning to the data discussion, it is useful to consider the economic interpretations of these parameters. The marginal cost of output *i* is given by

$$MC_i = \frac{\partial C}{\partial y_i} = \alpha_i + \sum_m A_{im} (y_m - \bar{y}_m) + \sum_j F_{ij} (w_j - \bar{w}_j) + D_{iT} (T - \bar{T}). \tag{3}$$

Thus each α_i represents the marginal cost of output type *i* when evaluated at the given output levels, factor prices, and time period. Just as in the case of the final empirical analysis using the estimated Equation (2) for each period (see below Section III.), the output levels and factor prices may be either means or totals for that time period.

II. DATA DISCUSSION

(1) Industry Selection Criteria

Cost functions were estimated for the eight industry conglomerations whose data sets were most well suited for such an analysis for 1850, 1860, and 1870. Of these eight, only four were estimated for 1880 due to another deficiency in the data for that year (besides the missing expert-collected data), which is missing data on individual input and output types, quantities and values, even for the non-expert-collected samples that survive. This was not due to loss of data, but due to the fact that the Census Office simply did not instruct its enumerators to collect any of these data that year, and instead merely reduced the measurement of raw materials and final products to their aggregate values. [3] This made a vector of output quantities and material input prices extremely difficult to construct, or even estimate. Nevertheless, an attempt to do so was made which is described and presented in the Appendix to this chapter.

Even some of the industry conglomerations for the earlier years contained missing or patchy data for output and input types, values, and quantities, which made construction of variables for total cost, input prices and output quantities difficult without chopping down the size of their data sets to near nothingness. Sufficient data on individual input and output type, value and quantity to form a data set consisting of enough observations with the full set of variables for at least two out of the three years was a prerequisite for an industry grouping for inclusion in the analysis.

---

[3] Atack, Jeremy and Fred Bateman. "Nineteenth-Century U.S. Industrial Development through the Eyes of the Census of Manufactures: A New Resource for Historical Research." *Historical Methods*, Fall 1999, Vol. 32, No. 4: 177-88, p. 180. This article is also available on line and downloadable at http://www.vanderbilt.edu/Econ/faculty/Atack/atackj.htm.

Industry conglomerations for the analysis were formed and selected based upon further criteria measuring the suitability of their respective data for such an analysis. For instance, another necessary feature of any data set for any industry was a clearly identifiable, frequently recurring pairing of similar goods in the bundle of goods produced by the multi-output firms in the samples. A willy-nilly, highly variegated pattern of goods production observed in an industry was a rejection because this would require collapsing many other highly variegated goods into single categories, which would not tell us much about scope economies of any one particular goods pairing. Discernable, frequently recurring pairing patterns that were observed in an industry group, or could be formed by aggregating the data of more than one industry group were thus an essential feature I looked for in determining which industry conglomerations were selected for the analysis.

By "frequently recurring", I mean there had to be an adequate number of observations of the two or three goods selected for the analysis within the samples, and there had to be at least a modicum of occurrences of the that good grouping being produced jointly by individual firms for evidence of any testable scope economies. Collapsing of similar outputs into single product categories was used for both these purposes of supplementing and bolstering a weak data set, and also to keep the number of outputs in the analysis down to two or a maximum of three. This is because if more outputs are used, the number of coefficient estimates explodes due to the interaction and squared terms in the type of cost functions employed in these type of analyses. [4]

[4] Besides the modified version of Friedlaender, Winston and Wang's hedonic, quadratic, second-order Taylor approximation around the mean cost function that appears in this study, see also the translog flexible functional form found in Stewart, Kenneth G., *Introduction to Applied Econometrics.* Thomson Brooks/Cole, 2005, p. 504, as well as the quite more elaborate version of the same in Shin, Richard T. and

Friedlaender, Winston and Wang for instance, initially divided their output into six categories in accordance with general market classifications: luxury cars, full-size cars, compact cars, subcompact cars, truck production, and a residual representing tractor production, changes in inventory, and non-automotive production; a residual obtained by subtracting the figures of sales on the first five things from total sales. But for their final empirical analysis, they aggregated further to produce three output variables: compact & subcompact cars ("small cars"), luxury & full size cars ("large cars"), and trucks. [5]

I therefore applied similar collapsing methods in construction of my data sets. In Tobacco for instance, rather than counting American cigars and Spanish cigars as two separate products, they were counted together in the same product group, Cigars. Homogeneity, or easy convertibility of units classification in order to facilitate such collapsing was an additional attribute of a data set that formed part of my criteria for industry selection. Collapsing American and Spanish cigars into a single category was simple, because they were both measured in the same units: number of cigars. Forming a second product category of loose tobacco was more complicated. While the multifarious varieties of loose tobacco, such as smoking, chewing and snuff, could be collapsed together in a similar manner as Spanish and American cigars, highly variegated units measurements in the case of this product group made things much more complicated. In the case in which sometimes loose tobacco is listed in pounds and other times in tons, one could be converted to the other easily. But if loose tobacco were in pounds, and a bunch of the other tobacco listings were in leaves, stems, lumps, or strips, as they sometimes were, there was no easy way to convert. One could purge a data set of the products

---

John S. Ying. "Unnatural Monopolies in Local Telephone." *The RAND Journal of Economics*, Summer, 1992, Vol. 23, No.2: 171-183, pp. 173-74.

[5] Friedlaender, Winston and Wang, pp. 7-8.

listed in more esoteric units measurements, but if doing so were to cut the data set down to an insufficient size, then that would be a disqualifying factor for that industry for inclusion in the analysis.

As it turned out, there was no industry that was completely free of its "freak" or "oddball" products that would not fit neatly under the rubric of one of the two or three main product group categories. All of the industry conglomerations were variegated by product type or heterogeneous units measurements to some extent, so some purging of goods was necessary for all of them. The industry conglomerations selected for the analysis are those that still contained ample observations of products that fell neatly into the main categories after this purging was done. All of the industries in the samples produced, in addition to a couple of principal outputs that appeared frequently in pairs, many other diverse products that were delineated in the samples, and contributed to the firms' total costs. In Flour, for instance, the frequently recurring product pair was barrels of wheat flour and bushels of corn meal. Besides those two, a few odd ones cropped up now and then, like rye, oats, bran, buckwheat, rice, pig slop, offal, grist, chicken feed—measured in various units like pounds, bushels, sacks, tins, etc. Sometimes there was even something in the data that was completely out of the rubric of basic grains production that was still produced by farms in the Flour category, like bread, cakes, shingles, lumber, boards, cloth, etc. Similarly, among the firms in the Shoes category, the basic frequently recurring pair was boots and shoes. Even after logical collapsing of ladies' shoes with men's shoes to form the broader category of "shoes", and aggregation of men's boots with ladies' boots to form the larger category of "boots", as Friedlaender, Winston and Wang did with similar types of cars, there were third outputs such as "repair

work" or goods simply listed as "miscellaneous" that were not measurable in units, but nevertheless, contributed to the firms' total costs.

Therefore, rather than attempting an elaborate collapsing scheme so as to include the goods that did not fit into the basic 2- or 3-good framework, I excluded them from my final data sets. In keeping with the Friedlaender, Winston and Wang framework of analysis, it is a fact that Ford, Chrysler and GM probably produced other types of motor vehicles that fall outside of the basic six (or collapsed three) categories that Friedlaender, Winston and Wang constructed, and even produced products and services that fall outside the general broad category of "motor vehicles". Friedlaender, Winston and Wang note that their data on total costs come from the firms' annual reports, and hence include cost of foreign and nonautomotive operations. They simply assumed that domestic production and foreign and nonautomotive production were disjoint, and note that they were able to disaggregate foreign and domestic operations costs aided by information in another analysis. But they say nothing about having been able to disaggregate automotive and non-automotive costs. So while their costs data probably included some nonautomotive costs, their output vector represented purely automotive output, and their cost function was estimated for domestic automotive production alone. [6] I have therefore mobilized the ABW data for cost function estimation in a similar manner. So as applied to the Flour industry for example, I took the ABW data on total costs for each firm; say a flour mill that produced wheat flour, corn meal, and a little pig slop, and simply omitted the quantity of pig slop it produced as a relevant variable in the analysis, predicated on the similar assumption that wheat flour and corn meal and pig slop production were disjoint.

[6] Ibid., p. 7.

(2) Final Industry Selection

These said criteria unfortunately excluded many industries from the analysis. Iron, which never had great sample sizes to begin with, did not appear to have been a heavily integrated industry. Those firms that were multi-product within its samples were an even smaller sliver out of the total. The multi-product firms produced different forms of iron, such as bar, pig, blooms, and "unspecified"—however, these did not appear in pairs. Collapsing them into a single category called simply "iron" was a possible option, but because their partner products were so highly variegated, a second goods category was off the table. They were very diverse casted items like doors, nails, wires, railings, and were listed in very variegated units definitions (tons, number, etc.).

Textiles was even more unmanageable. It had many multi-product firms, but the products were too highly variegated to collapse into a couple of neat categories of frequently-recurring pairs. Cotton-specializing firms alone, which were very few out of the total samples in the "Textiles" category, produced cotton goods, cloth, skirting, sheeting; different kinds of cloth, printed and unprinted; all in just a few samples! Wool-specializing firms, which were abundant in the samples, produced a myriad different things: woolens, yarn, rolls, satinets, flannel, blankets, carpets, cassimeres—in yards, pounds, feet, and number. It was nearly impossible to pick out a frequently-occurring pair combination. Virtually every multi-product firm had its own idiosyncratic output mix.

Consequently the data were mobilized for the handful of the industries with the most easily manageable data sets. Out of the thirteen major industry groupings compiled and discussed in the final scale analysis of Chapter Five, eight have been mobilized for

the scope analysis here. These are delineated below in Table 6.1, along with their respective output vectors. Of the eight I have organized as such, only five exhibit potential for robust *Sc* estimates; in other words, there was frequent incidence of the two- or three-good production among the firms in the samples across the years. The remaining three had problems such as infrequent appearance of firms with this pairing scheme, or frequent incidence of it in the earlier years, but infrequent or non-incidence of it in 1870, for example. These suitable, but less-than-exemplary industries appear denoted by an asterisk in the below table.

Intuitively, it would appear to make sense that an industry with a highly variegated product mix would be less able to exploit economies of scope than an industry that specialized in two or three main product lines. It is far more likely that an industry such as Men's' Clothing, that specialized in coats, pants and vests, would have more economies of scope than a textiles firm that produced a great variety of products. An industry with a more manageable data set was therefore probably also more likely to be an industry with greater potential for measurable economies of scope.

It is also worthy of noting that while Iron was completely unsuitable for analysis, its vertical cousin, Foundaries, which consisted heavily of fabricated and casted items made from iron, was suitable, but did not exhibit potential for robust *Sc* estimates. It is also noteworthy that while Textiles was unsuitable for analysis, the sub-conglomeration of its vertical cousin, Men's clothing, possessed one of the best data sets in the samples for such an analysis. A comparison of industries in the entire group reveals that the better the data set, the more likely that industry was one that concentrated on final, rather than intermediate goods. The ratio of industries that concentrated more heavily on final goods

to those that produced intermediate goods was much higher, six to one, in the industries that made it into the analysis than the same ratio among the rejects, which was just over one. This may lead one to believe that integration and economies of scope were much more heavily present in consumer goods than producer goods.

TABLE 6.1
Industry Groupings and Output Vectors for Scope Analysis

Industry Grouping	y_1	y_2	y_3
Shoes	Shoes, prs.	Boots, prs.	----
Flour	Wheat flour, bbl.	Corn meal, bu.	----
Men's clothing	Coats, nos.	Pants, prs.	Vests, nos.
Millwork	Sashes, nos.	Doors, nos.	----
Furniture	Bureaus, nos.	Bedsteads, nos.	----
Tobacco*	Cigars, nos.	Loose tobacco, lbs.	----
Foundaries*	Castings, tons	Plows, nos.	----
Meat*	Beef, lbs.	Mutton, lbs.	----

(3) Notes on Industry Conglomerations

The industry groups Shoes and Flour correspond exactly to the same groups as in the Scale analysis of Chapters Four and Five, those delineated by SIC codes 314 and 204, respectively.

Men's clothing was a sub-conglomeration of the conglomeration "Clothing" as it was organized and analyzed in Chapters Four and Five. While "Clothing" was composed of many inter-related industry groups, this new conglomeration is only composed of two of those that were originally included in "Clothing": **231, Men's And Boys' Suits, Coats, And Overcoats**; and **232, Men's And Boys' Furnishings, Work Clothing**. The

remaining industry groups were excluded from this analysis because they were too few in sample size to perform any kind of meaningful analysis upon as separate industry groups, and/or could not be analyzed in aggregation with Men's Clothing as defined above due to a heterogeneous product mix. This sub-conglomeration of 231 & 232, men's & boys' formal & work clothing, respectively, was of good sample size, and its two components share a similar pairing scheme. 231 was in the samples in abundance. While there were few 232's, those that did exist were able to be lumped in with the 231's due to a similar pairing scheme. The pairing scheme was "coats & pants" and often "vests" in a triplicate fashion. So a real 3-good analysis a la Friedlaender, Winston and Wang was possible with this conglomeration.

While industry group **235, Hats, Caps, And Millinery**, was of sufficient sample size for a separate analysis, its pairing pattern was completely distinct from, and not nearly as uniform as that of the 231 and 232 combination that made it into the analysis. Things were a little more variegated. Pairs in this industry category usually consisted of "bonnets" with some other kind of hats of a generic nature, or a variety of others such as fur hats, wool hats, caps, or something completely out of the rubric of hats, such as gloves and mittens. These second outputs were not only highly variegated, thus difficult to collapse into a second category, they often were missing output quantity data. Even "bonnets" itself was scant, having only one appearance among the output of the multi-product firms in this category in 1870. So this industry group was excluded from the analysis.

Millwork and Furniture, SIC codes 243 and 251 respectively, correspond exactly to the same groups as in the Scale analysis of Chapter Five, but have only been analyzed separately here, not together as in the industry conglomeration defined as Fabricated Wood in the Scale analysis. That is because they each have a totally different pairing scheme; a "sashes & doors" pairing for 243, and a "Bureaus & Bedsteads" pairing for 251.

Tobacco here corresponds exactly to the same group as in the Scale analysis of Chapters Four and Five; that is, the aggregation of 212 (Cigars), and 213 (Chewing and Smoking Tobacco and Snuff), barring the fact that 213 has been here renamed "Loose Tobacco" rather than "Chew" as in Chapter Five because it excludes 214 (Tobacco Stemming and Redrying), which was included in the "Chew" sub-conglomeration of Tobacco that was created for Chapter Five. That is because 214 did not contain any multi-output firms, was entirely absent from some years, and in the years it existed was extremely small in sample size (although there were several occurrences of it in 1880). 1850 and 1860 contained no samples of it at all. In 1870, there was one observation of it, and the only product that one firm produced was tobacco stems, an esoteric product that did not fit into either of the main pair group categories.

Cigars and Loose tobacco were aggregated in this manner due to a similar pairing scheme. While those firms in the 212 category did tend to specialize in cigars, and those in 213 in assorted varieties of loose tobacco, there were enough 212 firms that also produced some loose tobacco, and enough 213 firms that also produced some cigars that an aggregation of the two made sense in the context of the model.

While collapsing of the multifarious varieties of cigars was a simple process due to homogeneity of units classification, and therefore produced a very robust output vector, loose tobacco was more problematic. While chewing, smoking and snuff loose tobacco are not so heterogeneous in product type as to preclude collapsing, due to highly variegated units classification many observations measured in more esoteric units had to be omitted, leaving us only with those varieties of loose tobacco measured in pounds; and consequently, a less than robust output vector for this product group. While pounds were the most common unit, there were also leaves, stems, strips, hogsheads, boxes, lumps, and tobacco in unspecified units. I was firstly very leery of anything called strips, stems or leaves because I fear that these may be intermediate goods that firms that produced final tobacco goods for smoking, sniffing and chewing produced for other firms besides these final goods. So I omitted them. Hogsheads does have a pounds correspondence, but it only seemed to apply in the data to the intermediate stems, strips and leaves products, so I passed on any attempts at conversion of it. I also eliminated "Tobacco, Manufactured boxes" due to insufficient USDA information on exactly what boxes meant. Intuitively, it is probably something significantly more than a pound, the unit that most of the other non-cigar tobaccos are measured in. I got some idea of how much a case, bale & crate could be, but since these were units pertaining to cigar leaf tobacco in the USDA classification literature, an intermediate good for cigar-making, not a box of manufactured tobacco for final consumption, I assumed a similar product type correspondence for boxes of tobacco, so I eliminated it. Furthermore, its appearances in the samples were relatively infrequent, so eliminating it did not result in a huge loss of

data. Wherever tobacco in unspecified units appeared, its corresponding quantity was blank, so I omitted these as well.

Consequently, the resultant output vector consisted of well-filled-in columns corresponding to cigars, but columns corresponding to loose tobacco consisting largely of zeros. There is only an occasional firm that produced both, or just loose tobacco without any cigars. 1870 was the worst, as it contained some firms that produced only loose tobacco, but none that produced both (see data tables in Appendix to this chapter).

Foundaries here corresponds exactly to the same group as in the Scale analysis of Chapter Five, that designated by SIC code 332. Its sister industry group, with which it was aggregated and analyzed together as the industry conglomeration defined as Fabricated Metal in the Scale analysis, Sheet Metal, SIC code 344, has been excluded due to insufficient sample size for some years, a weak and inconsistent pairing scheme, and patchy data for output and input types, values, and quantities, which made construction of variables for total cost, input prices and output quantities difficult without chopping down the size of its data set to near nothingness.

While Foundaries' pairing pattern consisted of castings and plows, the only discernable pairing pattern for Sheet Metal was stoveware and tinware. While a collapsing scheme was possible for castings and plows due to units homogeneity, stoveware and tinware were much less manageable. While stoveware usually consisted of stove pipes, which were usually measured in number, tinware was always cited as exactly that—"tinware" with no units designation. Even if tinware had had some units

specification, it would have been of little use because it was frequently lacking output quantity data. Output quantity data was also weak for stoveware.

Since there was not much that could be done with the tinware data, any kind of output collapsing that could have been done with stoveware was pretty much rendered moot. While there were many observations of stove pipes in 1850, that diminished considerably in the later years as the sample sizes diminished. While there were the occasional observations of products such as “stoves”, “ovenware” and “stove casting”, these appeared too highly variegated to collapse with stove pipes.

This left only Foundaries, and its pair of castings and plows, as a possible two-output industry for the analysis. After collapsing and aggregating, Foundaries was still a very weak data set. While there were many observations of castings, plows were few and far between. When they did appear, they appeared alone, barring one incidence of them being produced jointly with castings in 1860.

Meat here corresponds exactly to the same group as in the Scale analysis of Chapters Four and Five; that designated by SIC code 201. The only discernable pairing pattern was Beef & Mutton. Firms that produced pork usually specialized in it, producing the product type “pork”, as well as ham, bacon, and sausages. So it was like an industry unto itself. However, a secondary pairing pattern could not be constructed within these pork-specializing firms because the pairing pattern that did exist within those that were multi-product was unclear and inconsistent; ham & pork; bacon & pork; bacon & sausages, etc. Furthermore, the pork firms were much smaller in sample size than the beef & mutton firms, and while the beef & mutton units classification was fairly consistently in pounds,

pork products' units were much more highly variegated. Sausages, for instance, could be measured in number, pounds, or barrels.

Leaving me with just the beef & mutton pairs to contend with, a robust data set was still a dream gone awry. While there were a few beef & mutton pairs in 1850, and several in 1860, 1870 was a dud. The 1870 data set was small in sample size overall, and the one beef & mutton pair it contained lacked output quantity data. In fact, there were only two firms that were listed as producing any quantity of beef at all in collapsible units, and none producing mutton whatsoever.

(4) Input Vector Data Set Discussion

The formation of the variables corresponding to the vector of output quantities in the above cost function has been discussed at length in the above section on industry selection. I now complete the discussion of the above cost function with an analysis of the variables corresponding to the vector of input prices, *w*, and total costs, *C*.

While the ABW data lack the detailed data for this period on hedonic quality attributes or technological variables indicating organizational differences among firms, such as the degree of vertical integration, as Friedlaender, Winston and Wang and Shin & Ying in their 1992 costs study of the telecommunications industry that focused on local exchange carriers[7] have been able to use and incorporate into their cost functions for their 20th century studies, the industries selected for this analysis do contain sufficient data with which to construct variables pertaining to basic input costs that are on par with these

[7] Friedlaender, Winston and Wang, pp. 5, 9; Shin, Richard T. and John S. Ying. "Unnatural Monopolies in Local Telephone." *The RAND Journal of Economics*, Summer, 1992, Vol. 23, No.2: 171-183, pp. 173-74.

analyses, and are in keeping with the necessary data for a basic generic form of a cost function that states that total cost is a function of a vector of factor prices and (in my case of a multi-output industry) a vector of output quantities.[8]

Shin and Ying & Friedlaender, Winston and Wang both only had three input prices in their cost functions; price of labor, capital, and other factors/materials. [9] The ABW data have good data for price of labor (as defined by Shin and Ying as "compensation per employee") because for most firms in the selected industries, they have the total amount paid in wages for the year, and the total number of persons (man, woman & child) employed in each year. So I simply divided the total amount paid in wages for the year for each firm by the total number of persons employed in each year to obtain an estimate of the average annual compensation per employee.

In absence of more information from Shin and Ying as to exactly how they defined "compensation per employee", this seemed a reasonable estimate. Shin and Ying do not say anything about this construction, except that it was compiled primarily from information on number of employees from annual reports, so I would assume that they are annual rates computed in some similar manner. Friedlaender, Winston and Wang's labor costs were estimated as the average hourly wage of domestic labor, which implies that they were computed based on actual wages data. While the ABW data have some figures on the average monthly cost of male, female and child labor, for many industries and years these data fields are blank, whereas the data on aggregate annual wages paid

[8] See Stewart, Kenneth G., *Introduction to Applied Econometrics*. Thomson Brooks/Cole, 2005, p. 478, or Berndt, Ernst R. *The Practice of Econometrics: Classic and Contemporary*. Addison-Wesley, 1991, Eq. 3.3, p. 63.

[9] For a complete description of Friedlaender, Winston and Wang's and Shin and Ying's input prices data construction, see Shin and Ying, pp. 174-75 and Friedlaender, Winston and Wang, pp. 7-8.

and number of hands employed were much more complete, so my approximation of Shin and Ying's method is much better suited for these data.

For price of capital, Friedlaender, Winston and Wang used data for return of firms' assets, which the ABW data do not contain. Shin and Ying used capital expenses divided by the average number of telephones or access lines. The ABW data have excellent figures for capital expenses for each firm. However, their output quantity data are not as neat and uniform as in Shin and Ying's study of efficiency in telephone service because ABW were dealing with many firms that produced a variety of products, measured in different units. It would have been impossible, for instance, to calculate price of capital per unit output in this manner for a tobacco firm that produced, say 800 cigars and 400 pounds of smoking tobacco in a year. So instead, I computed price of capital by dividing capital expense by total aggregate value of output as an approximation of what Shin and Ying did.

The price of capital used in this analysis is thus a real capital/output ratio. In the final empirical analysis, this ratio was converted to prices of a single year so as to better measure the real cost of capital faced by firms in the sample. So an industry that say, experienced diminishing cost of capital relative to the value of its output over time was said to have obtained capital more cheaply in real terms.

For price of materials, Shin and Ying constructed a variable called "price of other factors", which in the ABW data simply corresponded to price of materials. Shin and Ying defined it as "residual expenses divided by average number of access lines". All

"residual expenses"—those other than labor and capital in the context of the Shin and Ying article—would be encompassed by a variable in my data set called INPUTS_VAL, the aggregate value of all raw materials, including mill supplies and fuel. Barring labor and capital cost, the ABW data set lists no other expenses but these. Again, the same problem cropped up in applying Shin and Ying's price of materials method to my data as in applying their price of capital data to it. The ABW data have excellent figures for materials expenses for each firm. However, their output quantity data are not as neat and uniform as in Shin and Ying's study of efficiency in telephone service because they were dealing with many firms that produced a variety of products, measured in different units.

For price of materials, Friedlaender, Winston and Wang just used the price of steel plate per ton as a proxy. This was fairly reasonable for them, for that was the principal input of automobiles. I therefore applied a similar methodology to the ABW data by trying to identify a principal input for each industry, but instead of using some general generic price quoted on just one market as one would find in a reference book, as Friedlaender, Winston and Wang did, I constructed a proxy based on actual prices faced by firms in the samples.[10] Rather than inspecting the inputs of the industries, and identifying one or a couple of basic standard inputs for each industry for which price data were easily available in a reference book such as *the Statistical Abstract of the United States*, I opted for this strategy because of the greater degree of heterogeneity of the inputs of the industries in the ABW data. While it was possible to identify one or two basic inputs for most of the industries analyzed here, these inputs tended to be more differentiated than "steel" was as an input for cars. One would assume, naturally, that for shoes the price of leather could serve as a reasonable proxy for the basic price of a

[10] Friedlaender, Winston and Wang do not cite the source of their data for price of steel plate per ton.

material input. But leather is not a homogeneous product like steel. There were in fact a plethora of varieties of leather used as inputs for shoes in the ABW data, each with their own price, for which accurate, detailed data concerning is difficult to obtain, and frequently unavailable from the reference sources that exist from that era.

To construct an input price proxy, I first identified each input listed in the samples for each industry for each year, and discovered that for each industry, there was either one basic input (leather for shoes, yards of cloth for clothing, planks of lumber for millwork and furniture, pounds of tobacco leaf for cigars, chewing and smoking tobacco) or a couple of basic inputs (bushels of wheat & corn for flour, tons of pig iron & coal for iron foundaries, and various livestock animals for meat). Naturally, there were a few auxiliary inputs for each industry category, like leather and cloth for upholstery for furniture, and sometimes a more exotic input like mahogany, cherry, pine or walnut for furniture, or goat skins for shoes. But there was a clear pattern of one, or at most a handful, of basic inputs that were discernable for each industry.

Next, I tried to obtain prices for each input by dividing value of each input by its quantity. These were not available for all firms, because often either the input value, its quantity, or both were blank or zero in the data. But enough prices were computed this way to arrive at some conclusions.

It was discovered that no matter what the principal input(s) was (were), a basic price range could be discerned for it (them) that distinguished it (them) from the non-basic input items. So for instance, for furniture and millwork, the basic unit was foot planks of lumber, which always occurred within a certain basic modest price range, like $0.01 to $1.00 a foot. The only time I saw prices outside of that range was when it was

some ancillary item, like gallons of varnish or oil, skins for upholstery, or lumber coming in some larger units specification, like cords, thousands of planks, or tons. So by averaging all the prices that fell in the $0.01 to $1.00 range for each year, I reasoned that I could obtain a good estimate of the price of a basic unit input, which was foot planks of lumber. Very few firms listed their lumber inputs in those larger units, so by ignoring them, I was not losing too much valuable information about prices. There were still many more firms listing their lumber inputs in the basic plank feet unit.

Even for firms that had more than one basic input, such as flour, the price disparity existing between the two inputs, and their units measurement difference were not so great so as to preclude a similar type of analysis based on computing the average price of a basic unit input subject to a range restriction. For flour I saw that the two basic inputs were bushels of wheat & bushels of corn. There was no great price disparity between the two; they were both always between about $0.50 and $1.50 a bushel. And they were both in the same units, bushels. So I was spared the difficulty that would have existed if one of the two inputs was listed in tons, and therefore having to divide all the results of its prices by 2,420 to get it to fit in with the other before averaging them together, or separating all the corn prices from the wheat prices and creating two input price categories. So by dividing input value by input quantity, and taking an average of all the prices that appeared within that range, I was able to create a reasonably good proxy for the price of a basic unit input; call it “cereal” or “grain” if you wish.

This methodology solved the problem posed by a differentiated basic input, as described above pertaining to leather, because by averaging all the basic inputs’ prices together subject to a range restriction in a manner similar to that applied to bushels of

wheat and corn in flour, a proxy input price was formed that was a reasonably accurate measure of the price of a basic input. In shoes, although there were a variety of different types of leather inputs; sole sides, upper sides, calf skins, sole lbs., unspecified lbs., etc., there was nothing so widely variegated in highly variegated units that I could not use the method of dividing individual input value by respective quantity for all firms, and taking an average of all the prices that appear. The basic price of a unit input was in the $0.50-$3.00 range; sometimes there was something used a little more expensive and exotic like "goat skins", or some unidentified miscellaneous input item expense that was like $10 or $20 a unit. Sometimes there was something over $10 that was something like calf skins measured in dozens units. Despite inflation, this basic inputs price range was pretty consistent from 1850-70. So to simplify matters, to obtain an average, I just took the average of every item that was less than $10 in each year for a good proxy for the basic unit price of a basic unit input.[11]

Some kind of thing like this worked for all the industries I looked at that had more than one principal input. In meat for instance, although there were a variety of different livestock animals listed as inputs; cows, hogs, sheep, beef, beeves, their prices were not so highly variegated that they could not be all lumped in together to form an average of what a basic livestock animal cost for meat processors. Hogs were in the range of $4-$25, and cows and beef (beeves) were in the neighborhood of $20-$60. Sheep were very disparate in price and ranged from a very cheap $1 to $30 apiece. The only things that were less than $1 were non-basic inputs like pounds of coal, bushels of salt, marble slab

[11] In checking these proxy input price averages for each industry over the years, the pattern observed was that they were generally increasing within their respective range restriction, in accordance with what one would expect with inflation. So I determined that these were very realistic proxy measures.

feet, or meat measured in some smaller unit, like pounds of dead meat. The only time I saw anything over $100 was when it was meat measured in different units like tons (dead I am assuming). So I averaged everything that was over $1 and under $100 in order to obtain a proxy for the basic unit price of a basic unit input.

I considered this methodology to be no more of an over-simplification, and in some ways superior to that employed by Friedlaender, Winston and Wang, in consideration of the fact that Friedlaender, Winston and Wang used the price of steel as a basic input price proxy, which they also held as constant and uniform across all firms. Friedlaender, Winston and Wang also omitted all the other materials inputs that go into making a car, just as I have omitted the ancillary inputs. And in some ways, my proxies are superior to Friedlaender, Winston and Wang's in that they are based on actual prices faced by firms in the samples, not some general generic price quoted on just one market, such as the New York market, as I would most likely have had to contend with by consulting reference books. Unfortunately, for the 1880 data, I had no other recourse than to consult reference books to obtain input price proxies (see discussion in Appendix to this chapter).

For total costs, Friedlaender, Winston and Wang were able to use aggregate data from the firms' annual reports, which the ABW data do not contain. Shin and Ying estimated total costs by aggregating data on capital expenditures and expenses for factors excluding capital, which are given by operating expenses minus depreciation.

As an approximation of Shin and Ying's method of total cost construction, I aggregated the ABW data for capital expenses for each firm (the variable CAPITAL)

with the only data for non-capital operating expenses the data contained; the total amount paid in wages for year (the variable WAGE_BILL), and the aggregate value of raw materials including mill supplies and fuel (the variable INPUTS_VAL).

III. EMPIRICAL RESULTS AND ANALYSIS

In this section, I present the empirical results of the study, and provide a synopsis of the basic trends and patterns found in the results in order to determine the degree to which the results support the Chandlerian hypothesis in terms of which industries reaped the greatest benefits of scope economies with respect to the expansion of the railroad network as would be seen in ascending scope estimates over the time period in question.

Table 6.2 (a-h) presents the estimated economies of scope that were calculated for each industry for each year, using alternating means/totals raw data input for the input prices and output quantities (i.e. *w-means/y-totals, w-totals/y-means*, etc.) yielding four different input data sets, which are delineated in the far left column in each sub-table. Following Friedlaender, Winston and Wang's practice[12], for each of these means/totals combinations, I computed 3 different scope estimates using different values of small numbers in place of zeros for the disjoint cost predictions: 1, 10, and 100. The zero-replacement number used in each analysis is delineated in the far left column of Table 6.2 to the immediate right beside the input data set group. This amounted to 4 X 3 = 12 scope estimates per industry per year, and 24 for the industries for which 1880 data sets were able to be constructed. These were wholly separate analyses because a separate cost function that included the 1880 data was computed for each of these industries. These

[12]Friedlaender, Winston and Wang, pp. 15-16 and footnote 42, p. 16.

analyses appear as “double-deck” tables in the same sub-table as the 1850-70 analyses for the industries for which they apply, and are denoted by a hyphen followed by a capital “E” following each year in the year heading—the “E” denoting the fact that these analyses contain data for the year “Eighty”.

Varying these zero-replacement numbers usually did not create much variation in the results within each input data set. I held true to this practice across the board, including for Meat for 1870 whose actual mean and total value for Mutton was zero. So

TABLE 6.2
Industry Groupings Scope Analysis Estimates, 1850-1870 [1880]

Table 6.2 (a). Shoes

Input Data Set	1850	1860	1870	1850-E	1860-E	1870-E	1880-E
WmnYmn1	0.240823	0.129158	0.132358	0.245361	0.117324	0.122775	-0.02895
WmnYmn10	0.244643	0.131503	0.134302	0.249056	0.119753	0.124811	-0.02636
WmnYmn100	0.28285	0.154953	0.153747	0.286017	0.144044	0.145168	-0.00042
WmnYtot1	-0.56536	-1.01692	-0.68307	0.151045	-2.19622	0.278608	119.6342
WmnYtot10	-0.56534	-1.01691	-0.68303	0.151021	-2.19613	0.278514	27.479
WmnYtot100	-0.56516	-1.01678	-0.68268	0.150786	-2.19513	0.277573	27.4713
WtotYmn1	0.999845	1.001957	1.000602	0.999866	1.00162	1.000243	1.001248
WtotYmn10	0.999837	1.001946	1.000578	0.99986	1.001612	1.000226	1.001242
WtotYmn100	0.99976	1.001841	1.000343	0.999804	1.001523	1.000051	1.001183
WtotYtot1	0.936064	6.387836	1.080372	0.950264	3.473437	1.03408	3.371701
WtotYtot10	0.936057	6.387769	1.080347	0.950258	3.473406	1.034062	3.371681
WtotYtot100	0.935986	6.387104	1.080097	0.950204	3.473099	1.033881	3.37148

Table 6.2 (b). Flour

Input Data Set	1850	1860	1870	1850-E	1860-E	1870-E	1880-E
WmnYmn1	0.23398	0.095499	0.217353	0.248558	0.090223	0.273712	0.018847
WmnYmn10	0.236613	0.098168	0.219447	0.251116	0.092903	0.275674	0.020971
WmnYmn100	0.262943	0.124865	0.240387	0.276695	0.119709	0.295293	0.042212
WmnYtot1	-0.50437	-0.58504	-0.56528	-0.53215	-0.58571	-0.5691	-17.4822
WmnYtot10	-0.50435	-0.58503	-0.56525	-0.53213	-0.5857	-0.56907	-17.482
WmnYtot100	-0.50415	-0.58491	-0.56492	-0.53193	-0.58559	-0.56877	-17.48
WtotYmn1	1.00379	1.002622	1.011563	1.004276	1.002974	1.014193	1.004743
WtotYmn10	1.003777	1.002614	1.011532	1.004261	1.002965	1.014155	1.004737
WtotYmn100	1.00365	1.002538	1.011215	1.004111	1.002876	1.013776	1.004673
WtotYtot1	231.7391	-66.9525	-2.2556	-8.11176	-6.60286	-1.30394	-0.40287
WtotYtot10	231.7361	-66.952	-2.25552	-8.11164	-6.6028	-1.3039	-0.40287
WtotYtot100	231.7067	-66.9469	-2.25482	-8.11043	-6.60221	-1.30341	-0.40284

Table 6.2 (c). Men's clothing

Input Data Set	1850	1860	1870
WmnYmn1	-0.00738	-0.2333	-0.24038
WmnYmn10	0.031579	-0.21385	-0.2038
WmnYmn100	0.419741	-0.02008	0.160771
WmnYtot1	-1.95338	-1.27885	-1.68623
WmnYtot10	-1.95078	-1.27856	-1.68365
WmnYtot100	-1.92486	-1.27566	-1.65784
WtotYmn1	2.01323	1.910025	2.375191
WtotYmn10	2.013234	1.91004	2.368561
WtotYmn100	2.013282	1.910197	2.302275
WtotYtot1	3.051633	0.673977	-0.77688
WtotYtot10	3.051404	0.673943	-0.77517
WtotYtot100	3.049124	0.673604	-0.75807

Table 6.2 (d). Millwork

Input Data Set	1850	1860	1870
WmnYmn1	1.499427	0.244278	1.059855
WmnYmn10	1.509642	0.247866	1.063521
WmnYmn100	1.604521	0.281322	1.09782
WmnYtot1	-0.12823	-0.25386	-0.57797
WmnYtot10	-0.12634	-0.25349	-0.58018
WmnYtot100	-0.10811	-0.24986	-0.60088
WtotYmn1	1.412856	1.685678	1.021653
WtotYmn10	1.412781	1.685634	1.021582
WtotYmn100	1.412036	1.685198	1.020874
WtotYtot1	-0.32334	-0.16941	1.133047
WtotYtot10	-0.32332	-0.1694	1.132967
WtotYtot100	-0.32314	-0.16935	1.132174

Table 6.2 (e). Furniture

Input Data Set	1850	1860	1870
WmnYmn1	-0.30969	0.075866	-0.3631
WmnYmn10	-0.24418	0.174312	-0.20124
WmnYmn100	0.408694	1.153916	1.415417
WmnYtot1	-0.98677	-0.97058	-0.8247
WmnYtot10	-0.98413	-0.9648	-0.79705
WmnYtot100	-0.9578	-0.90692	-0.52066
WtotYmn1	0.590909	0.941305	0.996353
WtotYmn10	0.612153	0.950839	0.931965
WtotYmn100	0.824608	1.046188	0.287822
WtotYtot1	0.552011	0.642028	-0.77488
WtotYtot10	0.552704	0.644568	-0.75713
WtotYtot100	0.559638	0.669969	-0.57966

Table 6.2 (f). Tobacco*

Input Data Set	1850	1860	1870	1850-E	1860-E	1870-E	1880-E
WmnYmn1	1.219094	1.705935	0.355234	2.076544	1.664364	0.282973	0.293539
WmnYmn10	1.218356	1.706433	0.355386	2.074298	1.664184	0.283615	0.294532
WmnYmn100	1.21098	1.711408	0.356902	2.051831	1.662381	0.290033	0.304461
WmnYtot1	0.124653	-1.38326	51.95966	0.030383	3.041498	0.262598	29.23821
WmnYtot10	0.124492	-1.38322	51.95618	0.030344	3.041421	0.262581	29.23815
WmnYtot100	0.122877	-1.38288	51.92135	0.029956	3.040646	0.262414	29.23755
WtotYmn1	0.940254	0.980794	0.984174	0.825232	0.915334	0.947792	0.96384
WtotYmn10	0.940204	0.98076	0.984153	0.825142	0.915272	0.947754	0.963826
WtotYmn100	0.939703	0.980416	0.983942	0.824242	0.914656	0.947373	0.963677
WtotYtot1	0.297212	0.540109	0.402834	0.111284	0.18506	0.163126	0.179722
WtotYtot10	0.297195	0.54009	0.402825	0.111271	0.185049	0.163119	0.17972
WtotYtot100	0.297027	0.539905	0.402736	0.111144	0.184934	0.163053	0.179703

Table 6.2 (g). Foundaries*

Input Data Set	1850	1860	1870
WmnYmn1	-1.15888	-2.92911	1.833433
WmnYmn10	-0.94733	0.38862	-0.96724
WmnYmn100	1.189063	33.59179	-29.1429
WmnYtot1	-0.99663	-0.89277	-1.04581
WmnYtot10	-0.99007	-0.84774	-0.97147
WmnYtot100	-0.92443	-0.39743	-0.22779
WtotYmn1	0.998074	0.963958	0.994719
WtotYmn10	0.9982	0.962351	0.994593
WtotYmn100	0.999455	0.946264	0.993314
WtotYtot1	1.757864	1.645903	1.007331
WtotYtot10	1.755296	1.612229	1.003602
WtotYtot100	1.729611	1.275475	0.966292

Table 6.2 (h). Meat*

Input Data Set	1850	1860	1870	1850-E	1860-E	1870-E	1880-E
WmnYmn1	1.319933	-2.3082	1.630131	1.18297	0.984964	1.299663	0.59736
WmnYmn10	1.316407	-2.30258	1.63129	1.183355	0.983382	1.29872	0.597415
WmnYmn100	1.281101	-2.24629	1.642793	1.187283	0.967604	1.289669	0.597976
WmnYtot1	-1.2992	-1.07997	4.221603	-2.0579	-1.70937	1.826761	111.3913
WmnYtot10	-1.29738	-1.07982	4.238871	-2.05589	-1.70913	1.823291	111.3911
WmnYtot100	-1.27926	-1.07832	4.417107	-2.03586	-1.70676	1.790437	111.3891
WtotYmn1	1.577558	1.22034	-5.51679	0.995498	0.99524	0.788896	1.001207
WtotYmn10	1.583855	1.22112	-6.42854	0.995477	0.995232	0.789069	1.001207
WtotYmn100	1.646826	1.228926	17.67061	0.995273	0.995156	0.790802	1.001201
WtotYtot1	-0.2145	-9.32862	-0.71746	0.958631	0.941393	0.649219	1.475725
WtotYtot10	-0.21655	-9.32362	-0.74514	0.958609	0.941384	0.649431	1.475724
WtotYtot100	-0.23704	-9.27364	-1.09325	0.958396	0.941295	0.651562	1.475714

for the disjoint cost computations in which Mutton was a theoretical zero, its value was artificially augmented to 1, 10, or 100 instead of reduced. This created a little bit of a problem, because it meant that the disjoint cost of producing beef without mutton was always going to be equal to the cost of producing beef and mutton jointly, so that when joint costs were subtracted from the disjoint costs, the remainder was always simply the disjoint cost of producing mutton without beef; or producing a small amount, 1, 10, or 100 of each. So no matter what proxy value for mutton was used, zero or some other small number, the results would have showed greater disjoint costs than joint costs, thus positive scope economies (unless the disjoint costs of producing mutton without beef were positive while the joint costs were negative, as occurred in several of the predictions in which total values for input prices were used).

I also held true to this practice for industries that had very low, but greater than zero values for output means and totals. Foundaries for 1860, for instance, had a mean value for plows of 9. This meant that when 10 and 100 were used in its place in the

calculation of its disjoint costs of producing castings alone, these disjoint costs were usually greater than its joint costs in absolute value, so that when these disjoint costs and joint costs were the same sign, the scope estimate usually came out positive. So it is perhaps wise to look somewhat askance at Foundaries' estimates for 1860 using 10 and 100 as its zero values for plows when output means were used. This same phenomenon was also observed to some extent in Furniture, which had a mean value for bureaus in 1870 of 27.9, which when the disjoint costs of producing bedsteads alone were computed with a value of bureaus of 100, this was greater than bureau's value of 27.9 used when computing the joint costs. Thus we should look askance at Furniture's estimates using 100 as its zero value for bureaus when output means were used.

Referring back to Table 4.1, it can be recalled that in the upper left hand quadrant are listed the industries that Chandler believed were the great industries that experienced these great impacts of the decline in transport costs and technological advance that led to large-scale production methods. Two of the industries that made it into the Scope analysis, Meat packing and Flour milling, are in this quadrant. So according to Chandler, we ought to see the most robust results in those two industries. The remaining industries all fall into one of the medium categories; either the lower left quadrant that refers to industries that experienced a high impact of technical progress and a low impact of transportation, or the upper right quadrant that refers to a low impact of technical progress but a high impact of transportation. In the high-tech/low transport quadrant, we find tobacco manufacture, clothing and shoes, and in the low-tech/high transport quadrant, we find millwork, furniture, and foundaries.

In terms of specific mention of which industries reaped the most scope economies in the United States before WWI, Chandler explains that it was mainly in the dynamic industries of food, chemicals, and machinery groups in which cost advantages developed through utilizing economies of scope led to investment in related products.[13] Since the latter two industries are not represented in our study, that leaves us only food groups in which to check for robust and ascending scope estimates, which mirrors the predictions made in the upper left quadrant of Table 4.1.

Consequently, it is in the industry groups of Meat and Flour that we ought to see the best results. Chandler explains how it was that though diversification into related industries, economies of scope were utilized by these industries. In Meat, the impetus to diversification was the emergence of by-product industries such as fertilizer, soap, glue, and leather in its basic operating units, and in marketing and distribution by the addition of new product lines to their network, as they began to send dairy products and fruit through their refrigerated networks.

Similarly, in cereals production, new products could be produced that required similar raw materials or used similar production processes, or could be marketed through established distribution networks (i.e. nonrefrigerated facilities for moving one type of processed grain product could be used for others), and capabilities in marketing one set of branded packaged products could be easily transferred to another, so the leading grain processors began to diversify. Chandler explains how at Borden and at the cereal companies, diversification came from exploiting the economies of scope in its marketing and distribution organizations by moving into the production of cereals, coffee, and other

[13] Chandler, Alfred D. *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge: Harvard University Press, 1994, p. 92.

branded, packaged products. General Mills and Pillsbury diversified into breakfast cereals, cake mixes, biscuit mixes, and then animal feeds. Ralston Purina moved from animal feeds to cereals and other packaged foods for human consumption. Quaker Oats added new lines which included wheat cereals, farina, hominy, cornmeal, macaroni, spaghetti, poultry feeds, and developed a new chemical product called furfural made of oat hulls that would become increasingly used by producers of resin, agricultural and other chemicals, and later, of synthetic rubber.

Moreover, while technically not a "grains" producer, Chandler explains how the vegetable-oil refiner Corn Products Refining, besides developing Mazola salad and cooking oil developed and improved such brands as Argo starch, Karo syrup, Kre-Mel desserts, as well as Certos, a dextrose sweetener in its in-house laboratories. Its research department also led the company into chemicals with the development of new phenol-type plastics.[14]

Unfortunately, while the integrations Chandler describes as occurring in the meat industry are those that appeared in the last quarter of the 19th century, and at least partially coincide with the period our data cover, these massive integrations he describes in the cereals industry did not occur until mainly after the turn of the century.[15] Both, moreover, are considerably more advanced and variegated than the simple "wheat & corn flour" and "beef & mutton" product pairings our data and technique necessitated. Nevertheless, integration has to start somewhere, so it is not inconceivable that some of these scope effects could have been operating earlier. Certainly the railroads must have contributed something to the marketing and distribution networks that Chandler claims

[14] Ibid., pp. 40-41, 161-63.
[15] Ibid., pp. 18, 155.

gave impetus to this later diversification, and there is no theoretical difference between the type of scope economies presented by similar raw materials and production processes for an earlier, less sophisticated scope through integration that may have been acting earlier and setting the ball in motion. Unfortunately, the weakness of the Meat data set described above (and in further detail in the appendix to this chapter) makes us cast a shadow of doubt upon the results obtained from it. But the good thing, though, is that for both Flour and Meat there are 1880 scope estimates obtainable, which more closely approaches the era in which Chandler claims that the scope economies were more firmly in the saddle.

With respect to the other industries contained in the analysis, Chandler does not make any specific mention of them with respect to scope economies apart from the fact that that they may have contributed to the scope economies achieved by massive retailers like Macy's department store, giant mail order houses like Sears, Roebuck and Montgomery Ward, and chain stores like the Great Atlantic & Pacific Tea company and Woolworth. These were scope economies achieved through handling a number of related product lines through a single set of facilities, and also sometimes through backwards integration into manufacturing when they were not able to obtain a product at the price, quantity or specification required, or when they needed a product in such large volume that they could produce it steadily at minimum efficient scale and therefore as cheaply as independent suppliers. Sears, for instance, by 1906 owned nine factories wholly or in part, and by 1910 owned sixteen; most of which made shoes, clothing, furniture, lumber hardwood, tools, plumbing goods, stoves, sewing machines and light farm machinery. But these speak little of the economies of scope achieved by the independent suppliers of

these goods, or the individual facilities of these large integrated enterprises that produced these goods. Furthermore, as with the growth of the cereals industry described above, the major growth of these mass retail, chain store and mail-order companies did not occur until the early 20th century when they concentrated their outlets more in middle-sized towns and cities than in metropolitan centers or predominately rural areas.[16]

Given 12 or 24 scope estimates per industry per year, it was not hard to find some kind of ascending pattern in at least one of the input data sets for each industry. However, there was little consistency in which input data set this pattern was found, and it was often in the one that I thought to be the least intuitively pleasing of the four, which was *w-totals/y-means*. Nevertheless, there do appear to be some "winner" and "loser" industries among the bunch, using frequency of appearance of an ascending pattern within the four input sets as a criterion.

The two clear winners in the analysis are Shoes and, to a lesser extent, Flour. Shoes, which had one of the best data sets of the bunch, displays a more or less ascending and positive pattern of scope estimates in two of the four input sets, *w-totals/y-means* and *w-totals/y-totals* and also in the *w-means/y-totals* input set that included the 1880 data. One interesting phenomenon is the observance of a slight dip in the overall ascending scope estimates in 1870 in the *w-totals/y-means* and *w-totals/y-totals* input sets, followed by a rebound in the scope estimates for 1880 in the results for those input sets that included the 1880 data. This phenomenon mirrors that contained in many of the scale

[16] Ibid., pp. 28-31, 59-62.

estimates of Chapters Four and Five, including that of Shoes, that displayed a dip in the MES for 1870 corresponding to the post-Civil War aftermath shock.

The skyrocketing 1880 scope estimates that appear in the *w-means/y-totals* input set for Shoes are by no means unique phenomena, as they are mirrored in the exact same input set for Meat and Tobacco. Meat displays a steeply ascending scope pattern in this input set, including in its 1850-70 estimates. Although such steeply ascending results are not seen in any of Meat's other input sets, these are nonetheless encouraging results considering the weakness of the Meat data set discussed at length in the text above and the appendix below (particularly its 1870 estimates), and considering the weak results of the other industries in the analysis; most of whom had much better data sets than Meat.

The same may be said for the results for Tobacco in its *w-means/y-totals* input group. While these are not the most consistently rising estimates to be found in Tobacco, which are to be found in its *w-totals/y-means* inputs group, they confirm a definite pattern: in 3 out of the 4 industries for whom we were able to construct 1880 estimates, we have skyrocketing 1880 estimates in the *w-means/y-totals* input group. These results, if the study were confined to this input group, would serve as testimony to the efficacy of our methodology. Recalling that the 1880 data sets were constructed as perfectly integrated industries with each firm producing a positive quantity of each good in its output vector in homogeneous proportion to the composition of output on the national average level (see appendix to this chapter for more detailed discussion of these data), we would expect to see greater scope estimates for that year if there was any validity to the study, which indeed we do. While there are other instances of exploding estimates in other industries, such as in Flour for 1850 in its 1850-70 estimates in its *w-totals/y-totals*

inputs group, another appearance of them in Meat for 1870 in its *w-totals/y-means* inputs group for 1850-70, and another appearance of them in Tobacco for 1870 in its *w-means/y-totals* input group for 1850-70, these are scattered incidents that do not form a consistent pattern of clustering in a single year and inputs group.

Meat and Tobacco also display the dip in the scope estimates for 1870 followed by a rebound for 1880 in their results for their input sets that included the 1880 data that mirrors that contained in Shoes and in the scale estimates of Chapters Four and Five; Meat in its *w-totals/y-means* and *w-totals/y-totals* input groups, and Tobacco in its *w-means/y-totals* and *w-totals/y-totals* groups, and to a lesser extent in its *w-means/y-means* group. Whether this phenomenon is due to the post-Civil War aftermath shock or merely the weakness of the data sets for those industries for that year is another matter. Since the only other asterisked industry in the analysis, Foundaries, has no 1880 estimates, we have no basis for comparison. However, since this 1870 dip is also present in two of the ascending input groups for Shoes, an industry with a very good data set, we cannot rule out these post-war depression forces as a possible cause. Considering that these dips are seen in 3 out of the 4 industries surveyed that had 1880 estimates, we must therefore view it as an indicator of a distinct pattern.

Furthermore, the Chapters Four and Five scale estimates also display the 1870 dip as occurring for Tobacco, Shoes and Flour, although not for Meat. This means that out of the three industries that displayed a 1870 MES dip that also made it into the scope analysis with a complete 1850-80 analysis—Flour, Tobacco and Shoes—that dip is present again in the scope estimates for two out of those three, Tobacco and Shoes. Thus there is a parallel between the scale and scope estimates showing that there was

synchronicity between the two, as Chandler maintained. But we have produced new evidence here to indicate that the post-Civil War aftermath shock as described by many authors was indeed a real one that temporarily stymied economies of scale *and* scope; a factor not mentioned to any significant extent by Chandler, but is worthy of noting here in historical context. And our evidence indicates that scale and scope economies resumed in the era after 1870, as maintained by Chandler, and this is displayed in our results that show a recovery in full force as occurring by 1880. However, we must continue to bear in mind that these 1880 scope estimates assumed a fictional wholly integrated structure of industry.

It is quite strange that we do not see the exploding 1880 estimates in the *w-means/y-totals* input group for Flour with its good data set, whose results for that input group explode in the opposite direction, going down to a larger absolute value negative number for 1880. However, those disappointing results are offset by consistently rising scope estimates for its *w-totals/y-totals* estimates that included the 1880 data, and an overall ascending pattern for its *w-totals/y-means* estimates.

IV. SUMMARY AND CONCLUSIONS

In this chapter, our analysis of economies of scope yields results that are overall supportive of the Chandlerian hypothesis. Our method of empirical analysis, the *Sc* definition of economies of scope presented in Equation (1) that represents the percentage cost savings due to joint production, shows that in that in the food industries of Flour and Meat, which were the two industries among our analysis that were in the upper left hand quadrant of Table 4.1 that Chandler believed were the great industries that experienced

these great impacts of the decline in transport costs and technological advance that led to large-scale production methods, we do see results that show an ascending scope pattern in at least some of their input data groups. Flour contains results that display this pattern more conspicuously across its input groups than the typical industry of the bunch. While Meat does not stand out as above the average in terms of this characteristic of an ascending pattern across input groups, the fact that it fares no worse, and in fact better than some of its counterparts despite having a very weak data set speaks volumes. Had better data been available for Meat, particularly for 1870, who knows how the results could have differed. The only surprise in the bunch that Chandler would not have anticipated was Shoes, which was probably the most robust industry in the bunch in terms of displaying ascending scope results. One may say this is really not that much of a surprise, considering its very good data set. However, Clothing, which also had a very good data set, did not fare that well in terms of observation of an ascending pattern. So overall, we must view the robust results of Shoes as an unanticipated surprise result. The efficacy of our methodology is confirmed by the presence of exploding scope estimates for 1880 in 3 out of the 4 industries whose data included 1880 estimates that were derived from estimates of a perfectly integrated industrial structure, and by a dip in the scope estimates for 1870 followed by a rebound in 1880 seen in 3 of those 4 industries, which must be viewed as a continuation of a pattern observed in Chapters Four and Five that displayed the same frequently-occurring phenomenon in its scale estimates.

Chapter Seven: CONCLUSION

In wrapping up our study concerning the measurement and quantification of the relationship between railroadization in the United States in the mid-19th century and the subsequent evolution of the modern, large-scale, corporate form of industrial business organization marked by significant economies of scale and scope as described by Chandler, our preliminary comparison of the development and growth of the American, British and German railroad networks in Chapters Two and Three revealed that Chandler's claims that British industrialization of the mid-to-late nineteenth century was less heavily impacted by the railroads must be viewed with a certain degree of skepticism. While our comparison of railroad mileage phases data for the three countries essentially does correspond to and support Chandler's claims that a greater expansion of the railroad systems of the United States and Germany at mid-century and resultant vastness thereof with respect to Britain had occurred by the 1870's, and may have been instrumental in expanding markets, we are left wanting in terms of concrete evidence that this was a paramount factor contributing to a more concentrated industrial sector that was intensive in the new science-based technologies of the Second Industrial Revolution, and that these forces were set in motion by the 1870's. In comparing and interpreting rates of railroad physical capital accumulation of the three countries, while we do observe more rapid capital growth and accumulation in the German and American railroad systems than in Britain during the time leading up to the 1870's, one cannot ignore the sharp spikes in the British capital flow data in the 1840's and 1860's. Nor can one ignore that fact that Britain had far greater railroad mileage per square mile of national territory throughout the time period covered by this analysis. These revealed facts, in combination with the

revealed history detailing the strong dependence of Britain's railroad system on coal, and the strong dependence of its own, the American, and Continental railroad systems on its iron industry, leave us with an indicator of the possibility that the railroads may have had a far greater impact on the British industrial development at mid-century than Chandler gave them credit for. That is because he focused on market-expanding properties, and ignored the factor input demand effects of the railroads on manufacturing industries.

Moreover, our examination of the role of financial intermediaries in the growth of the railroad systems of the three countries makes us very skeptical about Chandler's claim that the American and German railroad systems were constructed using more extensive recourse to outside sources of finance than the British, and its ramifications for industrial development in the latter decades of the 19th century. Our literature survey indicates that Britain's railroads may have also been heavily financed by outside capital, and that this financing did have a dramatic impact on its capital markets, as evidenced by the development of a national market for railroad shares. Our principal empirical analysis of comparative financial intermediation effects from the railroads consisting of the stock of railroad financial capital data for the United States and Britain for 1830-1914 that were normalized by being measured relative to G.N.P. showed Britain in a strong lead all the way until the 1870's, which suggests that railroad finance played a stronger role in the British economy at least until the 1870's, and points to a stronger impact of the railroads on financial intermediation facilities in Britain than in the United States all the way until the 1870's.

Britain may have thus experienced a significant impact of the railroads on its industrial landscape that was different in character from the American case, and financial

augmentation from the railroads that was just as great, if not greater than that of the United States. Why this did not translate into rapid economic growth centered on the science-based technologies of the Second Industrial Revolution at the end of the 19th century is another question; but it is not at all clear from the evidence uncovered in this section that the answer is a lesser impact of the railroads on Britain's industrial development.

In the empirical analyses of economies of scale and scope that focused on American industry as it developed from 1850-1880 in the following chapters, we also find mixed evidence in support of Chandler's contention that the growth of the American railroad network did, in fact, expand markets and augment the American financial sector such that the result was a more concentrated, large-scale mode of industrial organization characterized by extensive and increasing economies of scale and scope in sync with the growth of its extensive railroad system.

In the analyses of economies of scale in Chapters Four and Five, it was found that even when the industries that Chandler said were the great industries that experienced the greatest impact of the decline in transport costs and technological advance that led to large-scale production methods were re-tested using superior data in place of that which was found to be flawed, or split into finer product group distinctions so as to cleanse and distill a product group of a flawed component, there were little scale economies achieved by 1880; the time by which, if Chandler's theory were correct, there ought to have been. In our results that measure and quantify economies of scale through the method of Minimum Efficient Scale (MES), the general pattern of the industries surveyed is relatively great economies of scale as having been achieved by 1860, followed by a

pronounced dip at 1870, and only modest increases by 1880 that often do not regain their 1860 levels. Even after substitution and purging of the flawed data from the study to the best of our ability, these eight principal industries were only evenly split between those whose MES rose in 1880 over their 1860 levels and those who declined. A similar examination of a sample of industries that Chandler believed were less strongly impacted by the technological and transportation improvements of the era for the sake of comparison yielded results that were no better or worse.

While the dips of 1870 make sense in the context of the Civil War aftermath shock, there is no rational explanation for the extremely low MES's observed at 1880 in the context of Chandler's hypothesis. If 1870 were the benchmark period in which to begin to expect to see the effects of transportation improvements upon scale economies in American industry, then 1880 is certainly a liberal allowance in terms of time to expect to see the effects of the railroads upon market expansion and financial intermediation to have been taking place; post-war resumption of investment and capital accumulation notwithstanding.

In the analysis of economies of scope in Chapter Six, we find results that are more supportive of the Chandlerian hypothesis. Our method of empirical analysis that represents the percentage cost savings due to joint production showed that in that in the food industries of Flour and Meat, which were the two industries among our analysis that Chandler believed were the great industries that experienced these great impacts of the decline in transport costs and technological advance that led to large-scale production methods, we saw results that showed an ascending scope pattern in at least some of their input data groups. The efficacy of our methodology is confirmed by the presence of

exploding scope estimates for 1880 in 3 out of the 4 industries whose data included 1880 estimates that were derived from estimates of a perfectly integrated industrial structure, and by a dip in the scope estimates for 1870 followed by a rebound in 1880 seen in 3 of those 4 industries, which must be viewed as a continuation of a pattern observed in Chapters Four and Five that displayed the same frequently-occurring phenomenon in its scale estimates.

Regarding the omnipresent dips at 1870 seen in both the scale and scope estimates, it appears that Chandler may have been incorrect in pointing to that date as the benchmark period in which to begin to expect to see the effects of transportation improvements upon scale and scope economies in American industry. He may have underestimated or overlooked the severity and duration of the Civil War aftermath shock that greatly retarded investment and capital accumulation in the economy well into the 1870's, not producing a recovery until the 1880's. Or perhaps the impact of the railroads upon scale and scope of industry were not felt until much later than Chandler believed they were—say 1900, as Atack's 1985 study suggested.[*]

[*] Atack, Jeremy. "Industrial Structure and the Emergence of the Modern Industrial Corporation" *Explorations in Economic History* 22, 29-52 (1985), p. 47.

APPENDIX TO CHAPTER SIX: Final Assembly of Data Set

The below tables delineate the final assembly of the raw data for the economies of scope analysis of Chapter Six for each of the eight selected industries for each year 1850, 1860 and 1870, and for the four of those industries that were estimated for 1880. Each table contains the data for total cost, price of capital, price of labor, price of materials and quantity of each output in each industry's final output vector for each firm. Each table also contains the mean and standard deviation of each of these variables, which appear in the bottom two rows of each table. The means and standard deviations of each variable have been computed on a per firm basis; that is, they are intended to capture the average quantity and standard deviation of each variable pertaining to each firm that was counted as being in that industry. Consequently, for output quantity, values of zero pertaining to the quantity of one of the outputs in the industry output vector produced by a firm that produced none of that output, but a positive quantity of the other, were included in the calculation of the mean and standard deviation for that output. So for instance, the mean and standard deviation of an output variable such as boots will include the output of boots produced by shoe firms that produced a positive quantity of shoes, but zero boots; or vice versa.

This final assembly has been significantly scaled down in number of observations from the original internet samples due to the need to eliminate those firms that lacked a complete set of variables. The assembly omits all firms in the samples who lacked sufficient data to construct variables for price of labor, capital, and value of inputs, and also omits any firm that did not produce a quantity of at least one of the outputs in its

respective industry output vector that was greater than zero; the exception to this latter rule, of course, being the 1880 estimates whose output quantities were estimated.

Positive figures for the variables for price of labor, capital, and aggregate value of inputs were the necessary and sufficient conditions for both a complete input price vector and total cost figure for each firm. Positive figures for price of labor and capital implied positive figures for total amount paid in wages for the year and for capital expenses for each firm. When aggregated with a positive figure for value of inputs, a complete estimate for total cost for each firm was constructed. A positive value for price of materials was a given, as this was an industry-wide average based on fragmentary data on individual input prices and quantities (see discussion in Chapter Six), or a proxy obtained from reference books in the case of the 1880 figures.

All dollar figures corresponding to total costs and input prices have been rounded to the second decimal place where necessary, and are expressed in current prices. In the final analysis, all dollar figures were converted to 1860 prices. The data for total cost and price of labor were converted using the North American Wholesale Price Indices in Brian Mitchell's *International Historical Statistics: the Americas, 1750-2000*.[1] Since the data for price of capital were constructed from a ratio of the cost of capital and the value of output, the price indexes used to convert these data are themselves ratios of the general price data contained in Mitchell and the Warren-Pearson product-group specific wholesale price index found in the Census Bureau's *Historical Statistics of the United States*.[2] Shoes were converted using the index for Hides and leather products (Series E

[1] Mitchell, Brian R. *International Historical Statistics: the Americas, 1750-2000*, 5th ed. Palgrave Macmillan, New York, 2003, p. 702.
[2] U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C., 1975), I, p. 201.

55); Flour and Tobacco, Farm products (Series E 53); Millwork and Furniture, House-furnishing goods (Series E 61); Foundaries, Metals and metal products (Series E 58); and Meat, Foods (Series E 54). The only exception was Men's Clothing, which was converted in exactly the same manner barring the fact that new data pertaining explicitly to Clothing from the updated 2006 edition of *Historical Statistics* were used to convert the 1870 data into 1860 prices.[3] The 1850 data for Men's Clothing were converted to 1860 prices as described above as using the Warren-Pearson price index for Textile products (Series E 56).

The data for price of inputs were converted solely using the Warren-Pearson indices. For some industries, the index differs from that used to construct the corresponding index for price of capital because the index was selected based on the intermediate inputs used to produce the product rather than its output. So for Millwork and Furniture, for instance, since their primary input was feet of lumber, Building materials (Series E 59) was selected rather than House-furnishing goods. Since the primary input of the Meat industry was livestock animals, the Farm products index was used instead of Foods. Since the primary input of Men's clothing was yards of cloth, the Textiles index was used for each year, including 1870, not the Clothing index from the 2006 edition. Since the primary inputs of Foundaries were about evenly split between iron and coal, I constructed an average composite index from the indices for Fuel and lighting (Series E 57) and Metals and metal products.

---

[3] See Peter H. Lindert's Table Cc49-57 *Consumer price indexes, for selected groups: 1851-1880 [Hoover]*, Series Cc54, in Carter, Susan B.,…[et al.], *Historical Statistics of the United States, Earliest Times to the Present*, Millennial Edition, Volume Three, Part C: Economic Structure and Performance (Cambridge University Press, 2006), p. 167.

The means terms used in the final empirical analysis (see Equation [2], Chapter Six) are also in constant 1860 prices. They were calculated by simply taking the converted means of each period, and taking the grand sample mean value for all three periods. They were not weighted by sample size. So even in the extreme case of Meat, in which there were only two firms in the sample for 1870, the 1870 data were assigned an equal weight of one third in the grand sample means in the case of a three-period analysis excluding the estimated 1880 data.

Poor, and therefore possibly misleading sample size notwithstanding, these 1870 Meat data were assigned equal weight in the means because for the most part, they did not display any wide variation from the means of the earlier years. So it is not too far off the mark to assume that these two firms were representative meat producers, and that an average of their production may not be too far off from an actual industry average for that year. The one exception to this was for the variable Mutton, whose average quantity went down from 620 in 1850, then up to 3678 in 1860, and then down to zero in 1870. Of the two firms contained in the sample for that year, none produced any Mutton. However, in light of the general deficiencies described above pertaining to the asterisked industries, this zero estimate was considered to be not too far off the mark from what one could expect from a faulty data set of even adequate sample size. Any attempts to remedy this deficiency of sample size through a re-weighting scheme were therefore viewed as “putting lipstick on a pig” (forgive the pun) and cast aside.

The Meat data set shared the same problem as Tobacco and Foundaries; that is, well-filled-in columns corresponding to one of the outputs in its output vector, but scant incidence of the other, leading to much smaller means figures for that variable when

averaging in these zero figures. In the case of Meat, this "good and bad" output pairing scheme was Beef and Mutton, respectively. While the zero figure for the mean for Mutton for 1870 is indeed a jump down from the earlier figures, it is a fact that the mutton quantity data is always more sparse than the beef data. Consequently, the average mutton quantity is always a lot smaller than for beef for each year. Even if the 1870 data were as good in sample size as the earlier years, the 1870 mutton mean would have likely been a small number anyway. So by averaging that zero in equally with the means of the earlier years, I did not think I was making an already-bad data set that much worse.

Further evidence in support of this contention may be found by examining the data sets of the other two asterisked industries, Tobacco and Foundaries, who also display wide variation in the means figures for their "bad" output variable across the years, despite adequate sample size for all years. Foundaries, whose "good and bad" pair was castings and plows respectively, had a mean of plows that dipped from 62.8 in 1850 down to the single digits in the later years. Tobacco, whose "good and bad" pair was Cigars and Loose Tobacco respectively, had a mean for Loose Tobacco that rose from 180 in 1850 to 6482 in 1860, and then went down to 1418 in 1870. These wide spreads between the means of these years appear to be caused by random fluctuations in the number of filled-in rows in which a firm produced a positive quantity of the "bad" output vis-à-vis the number of rows in which the entry corresponding to the "bad" output equaled zero. These large jumps in the means for these "bad" outputs may be therefore regarded as a general deficiency pertaining to an overall weak data set, not inadequate sample size. Since the other industries with a "bad" output variable also displayed wide variation in the mean of that variable, I could not make a principled conjecture that

Meat's small sample size for 1870 was the root cause of the anomalous mean figure for that year. This rendered a re-weighting of Meat's 1870 data in its grand sample mean moot, or superfluous at best. It is very likely that had more firms been included in the sample, they would also have been beef-specializing, and the mutton mean would have still been a small number when the total quantity of mutton for that year was averaged out by the total number of beef-producing firms.

Estimation of the missing materials inputs prices and output quantities data for the 1880 samples essentially involved consulting reference books for the input price that most closely corresponded to the proxies constructed from the 1850-70 data, and obtaining output quantities by dividing out the value of output for each firm in accordance with the proportions each output comprised of national aggregate industry data, then dividing that share of each firm's output value by its respective output price, thereby obtaining an output quantity for each firm in the samples that possessed the necessary and sufficient conditions for total cost and the remaining input price vector construction. The 1880 estimates are thereby a hypothetical estimate that assumes a wholly integrated structure in which each firm produced a positive quantity of each good in its output vector, and homogeneity of proportional composition of output between the macro and micro level. One could perhaps call these estimates, and any analysis of scope economies performed using them "potential" scope economies, because they measure the scope economies that could be achieved if each firm produced a positive quantity of each good in proportion to the national average. Since the firms in the 1880 estimates were not constrained by the necessity of possession of a positive quantity of a least one of the outputs in each

industry's output vector, a lot more of the firms in the samples "passed", and made it into the estimates. Consequently, the 1880 estimates tend to be much larger in sample size than their 1850-70 counterparts.

In construction of input price proxy estimates, data were selected that were as close as possible to the basic input product description of the earlier years both in terms of the type of material, its qualities and attributes, and its price range. Particular attention was paid to the course of change of the price proxy from the 1850-70 data over that time period, and the realistic outcome that one could expect by 1880 given the course of inflation of the appropriate product group as predicted by the Warren-Pearson indices.

For some industries, this was quite a challenge. For Flour, for instance, the input price proxy was essentially an average of the prices firms in the samples faced for two basic inputs, bushels of wheat and corn. So the challenge amounted to finding data for the price of both for 1880 that, when averaged together, made sense within the context of the data constructed from the 1850-70 samples. The course of the proxy grain price from 1850-70 went from $0.72 to $0.88 to $1.12 a bushel respectively; an ascending pattern that was completely in accordance with the Warren-Pearson farm products index for that period. However, the Warren-Pearson index displayed a dip at 1880 with an index number more closely corresponding to the 1850 and 1860 price levels. So in construction of my proxy, my objective was to hopefully obtain an estimate for 1880 somewhere in the $0.70-$0.90 range.

For the price of a bushel of wheat in 1880, I found a figure of $1.25 in the 2006 edition of *Historical Statistics* [4] and a price of $1.27 in the 1889 *Statistical Abstract of the*

[4] See Michael R. Haines's Table Cc205-266 *Wholesale prices of selected commodities: 1784-1998*, Series Cc206, in Carter, Susan B.,…[et al.], *Historical Statistics of the United States, Earliest Times to the*

United States.[5] Since the prices were so close together, I figured I had a pretty reliable ballpark figure in taking the average of the two, and estimating the price of a bushel of wheat as $1.26.

For the price of a bushel of corn, it was more difficult to obtain an estimate due to the lack of a reliable means of distinguishing the price of a bushel of corn harvested for grain production from the price a bushel of the final good of actual milled corn meal. Faced with a menu of widely disparate prices for the above in the data sources overseen, and anticipating the need for a measure of the price of milled corn meal for the output quantities estimation; *and* bearing the mind the need for an estimate that would drag the composite measure down to something in the $0.70-$0.90 range when averaged in with the wheat price obtained above; *and* predicating my choice on the logic that milled corn meal would naturally be more expensive than corn in its raw form harvested for eventual milling into grain, I naturally gravitated toward the lower of the prices found in the data sources for my estimate for the price of a bushel of corn.

On the same page of the above-cited *Statistical Abstract* that the wheat price was taken from, there was a price of a bushel of corn listed of $0.551. In the 1882 edition of *Statistical Abstract* however, there was a price of corn of $0.396 per bushel listed that was an average value per bushel calculated by dividing the total value of the corn crop by the total annual product of corn for 1880.[6] Since this was listed alongside figures for total crop area in acres, average yield per acre, and average value of yield per acre, and

---

Present, Millennial Edition, Volume Three, Part C: Economic Structure and Performance (Cambridge University Press, 2006), p. 204.

[5] U.S. Treasury Department, Bureau of Statistics, *Statistical Abstract of the United States.* 1889. Twelfth Number. Document No. 1310. (First Reprinting, Johnson Reprint Corporation, New York, London, 1964), p. 310.

[6] U.S. Treasury Department, Bureau of Statistics, *Statistical Abstract of the United States.* 1882. Fifth Number. Document No. 394. (First Reprinting, Johnson Reprint Corporation, New York, London, 1964), p. 159.

since it was lower than the former price quoted, I assumed this to be a more reliable estimate for the price of a bushel of corn harvested for grain or meal production, and assumed the former to be the price for a bushel of milled corn meal, even though it appeared alongside one of the figures I used to form my proxy for the price of a bushel of wheat harvested for flour production in the 1889 *Statistical Abstract*. So I saved the former price for use as an estimate for the price of corn meal for the output quantities estimation procedure, and went with the $0.396 price for my estimate for the price of a bushel of raw corn. In addition, in the in the 2006 edition of *Historical Statistics,* I found the nearly exact same price of $0.39 per bushel of corn harvested for grain.[7]

So by averaging the price of a bushel of wheat of $1.26 with the price of a bushel of corn of $0.396, I obtained a proxy estimate for the price of a basic bushel of grain input for the Flour industry for 1880 of $0.828 (or 0.83 as it appears in the tables) which is completely in sync with the basic price ranges that the earlier proxies fell into, and is in keeping with the anticipated price estimate from the course of inflation of farm products' prices described in the Warren-Pearson index.

A further challenge encountered in forming input price proxies was the highly predictable discrepancy between the prices formed from the heterogeneous ABW data that came from actual firms' Census returns, that took into account all of the multifarious inputs that went into the production of their products, and the "one-size-fits-all" reference book data for prices of one or a few basic inputs that I had no other choice but to rely upon to

[7] See Alan L. Olmstead and Paul W. Rhode's Table Da693-706 *Corn, barley and flaxseed – acreage, production, price, and corn stocks: 1866-1999*, Series Da697, in Carter, Susan B.,…[et al.], *Historical Statistics of the United States, Earliest Times to the Present*, Millennial Edition, Volume Four, Part D: Economic Sectors (Cambridge University Press, 2006), p. 97.

form my 1880 price proxies. To briefly recapitulate on the above notes in the main chapter text concerning material input price construction, it can be recalled that the input composition that was detailed in the ABW data was always more varied than that which could be obtained by picking out a quoted market price—the multifarious varieties of leather that were used in shoe production, not to mention all the auxiliary inputs for each industry category, like leather and cloth for upholstery for furniture, and sometimes more exotic inputs like mahogany, cherry, pine or walnut for furniture—and that the process of input vector constriction amounted to identifying one, or at most a handful of basic inputs that were discernable for each industry, obtaining prices for each input by dividing the value of each input by its quantity, and restricting the results of these calculations to those that fell within a basic price range could be discerned that distinguished the basic input items from the from the non-basic input items, and then averaging them together to form a proxy.

While this process greatly simplified the matter of input price estimation, it was not so cut & dry as to completely eliminate any non-basic material input that went into the production of the final good. Allowances had to be made for the price variation that one would expect to observe in a differentiated basic input, and this price variation had to be taken into account in constructing the price average so as to provide a more accurate indicator of the price of a basic input. Thus, the price range restrictions were devised so as to be narrow enough to omit all the non-basic items that went into the production of a given good, like gallons of varnish or oil and skins for upholstery for the industry of Furniture for example, whose basic input was foot planks of lumber. But the range was also devised to be wide enough so as to include the more-than-occasional incidence of

more exotic, and usually more expensive materials that were used to construct furniture, but still fell under the rubric of the "basic" material of lumber. Thus mahogany, cherry, pine and walnut wood were included because while they were more unusual, they were still just different varieties of the basic material input of wood, thus they were important components of the main input of the furniture industry. So they were included so as to form a more realistic estimate of the price of the basic input of lumber faced by these firms. This was part of the reason I considered my proxies to be superior to Friedlaender, Winston and Wang's in that by basing them on actual prices faced by firms in the samples, not some general, one-size-fits-all, generic price quoted on just one market, I was able to incorporate these differences in materials inputs costs caused by the inclusion of these more exotic inputs, thereby creating more realistic price estimates.

Nowhere in the construction of the 1880 materials prices estimates was this discrepancy between the heterogeneous ABW data and the one-size-fits-all reference book data more evident than in Tobacco. This discrepancy made it hard to find an 1880 proxy that fit the price ranges of the proxies of the ABW data and their predicted inflation patterns, and matched the more varied input composition of the ABW tobacco data. But by pulling together data from disparate sources, and constructing a weighted average of them that was just right (in a similar manner to the average of bushels of wheat and corn described above), I was able to construct a proxy that made total sense in terms of the input price proxies of the earlier periods I constructed, and also dovetailed and matched what I perceived to be the input product type characteristics of the tobacco firms in the ABW data.

The price trends and inflation patterns for the proxies formed from the ABW data for basic material input unit for Tobacco, pounds of tobacco leaf, showed an ascending pattern from 1850-70 of $0.20, $0.25, and $0.46 per pound, respectively. The Warren-Pearson index for Farm Products displayed the same ascending pattern over this period, but with a dip in prices down to more in the range of the 1850-60 levels by 1880. However, the quoted market prices for tobacco leaf for 1880 that I found tended to be much lower than even these; in the $0.05-$0.15 range. The 1882 *Statistical Abstract* listed a price of tobacco of $0.11 per pound that was an average value per pound calculated by dividing the total value of the tobacco crop by the total production of tobacco in pounds for 1880.[8] The 2006 edition of *Historical Statistics* listed a price of $0.081 per pound.[9]

Sensing that something was wrong, I decided to check the details of the input composition for Tobacco in the ABW data more carefully for the possibility of the presence of more exotic and expensive tobacco inputs that may have driven their average input costs a little higher than the quoted prices for basic, run-of-the-mill tobacco leaf. I was well aware that the ABW data tended to be heavily intensive in cigar production; a luxury item that may have been relied more heavily on imported or more expensive varieties of tobacco than basic chewing or smoking tobacco. Apart from the proverbial glamour and mystique surrounding cigar-smoking, the frequent incidence of output products coded with fancy names like "Spanish cigars" as opposed to plain old "Cigars" led my hunch in this direction. It turned out that my hunch was correct. In the input

---

[8] *Statistical Abstract* (1882), p. 162.

[9] See Table Da755-765 *Cotton, cottonseed, shorn wool, and tobacco – acreage, production, price, and cotton stocks: 1790-1999*, Series Da765, in Carter, Susan B.,…[et al.], *Historical Statistics of the United States, Earliest Times to the Present*, Millennial Edition, Volume Four, Part D: Economic Sectors (Cambridge University Press, 2006), p. 111.

products coding for Tobacco for 1850-70, besides the occasional incidence of pounds of "Spanish leaf", one sees the frequent incidence of pounds of "Processed tobacco" that tended to be in the $0.20-$0.50 range, and even sometimes regular tobacco listed as "Leaf, lbs." that had prices in that range.

Further confirmation that cigar production tended to be heavily intensive in more exotic and expensive varieties of tobacco was provided to me by further exploration of data sources. The 1895 *Statistical Abstract* lists a price for imported tobacco leaf for 1880 as $0.503 per pound. These data are presented in a column entitled "Other leaf" that is beside another column entitled "[Leaf tobacco] Suitable for cigar wrappers" that does not contain any data prior to 1884, but in the subsequent years of 1884-1895, the price of this variety of tobacco leaf is very high; in the $0.70-$1.30 range per pound. But I noticed that for the years prior to 1884, the figures for "Other leaf" tend to be higher than in the years immediately following the inclusion of the separate category of cigar leaf tobacco; in the $0.50-$0.60 range for 1879-83, whereas after the data for cigar wrapper becomes available, these data drop down into the $0.40-$0.50 range for a good four years or so before they return to their 1879-83 levels. I took this drop in price as an indicator that perhaps the very expensive imported cigar leaf tobaccos were averaged in with this generic "Other leaf" measure prior to 1884. If that were the case, it would point to a strong linkage between more expensive, imported varieties of tobacco and cigar production.[10]

Notwithstanding, these data not only reinforced my hunch that cigars' inputs were more expensive and exotic than basic chewing and smoking tobacco (or at least, that the

[10] U.S. Treasury Department, Bureau of Statistics, *Statistical Abstract of the United States.* 1895. Eighteenth Number. (First Reprinting, Johnson Reprint Corporation, New York, London, 1964), p. 384.

more expensive imported varieties of tobacco tended to end up being used to produce cigars); they provided me a seemingly reliable source to quote from with which to construct a proxy than embodied the additional costs faced by cigar makers that made their price of a basic unit input of tobacco leaf more expensive than the typical quoted prices for conventional, domestic leaf, and would thus be more in sync with the proxies formed from the ABW data.

To construct such a proxy, I firstly constructed an initial proxy of the price of a basic unit input of the price of a pound of run-of-the-mill, domestic tobacco leaf by constructing an equally-weighted average of the above-cited *Statistical Abstract* (1882) and *Historical Statistics* (2006, Vol. 4) data that equaled $0.10 per pound when rounded to the second decimal place. I then used that figure to construct another composite that was an un-equally weighted average of that figure with the figure of price for imported tobacco leaf for 1880 of $0.503 per pound from the 1895 *Statistical Abstract*. By ascribing a weight of 0.60 to the proxy for basic domestic leaf, and a weight of 0.40 to the price of imported leaf, I obtained a price of $0.26 per pound for tobacco leaf that is in complete correspondence with the price ranges of my earlier proxies from the ABW data, matched the predicted price trend as predicted by the Warren-Pearson index, and appears, from inspection of the input codes, to match approximately the proportions in which we observe exotic tobacco leaf appearing as an input in the production process for the (primarily) cigar-making firms that comprise the bulk of the data for the tobacco industry in the ABW data.

The data used to construct material input prices for Shoes and Meat were both taken from the 1880 *Census of Manufactures*.[11] The price of the basic unit input for Shoes, Sides of leather, was calculated by taking the data for total value of products of Tanned leather and Curried leather, dividing each by the total number of sides and skins of each produced, and then taking an equally-weighted average of the two price measures that resulted.[12] For the price of the basic unit input for Meat that corresponded to that used in my 1850-80 proxy estimates (see discussion on material inputs in main chapter text), I took the total value of hogs, beeves and sheep slaughtered, divided each by their respective number of beasts slaughtered, and took an equally-weighted average of the three different prices per beast that resulted.[13]

Material input prices estimation for the remaining four industries in the Scope analysis—Men's Clothing, Millwork, Furniture and Foundaries—was rendered moot due to my inability to acquire the necessary data with which to construct output quantities estimates for these industries. The essential methodology used to construct these estimates was to firstly obtain the aggregate value of output of each good in the industry output vector, then divide these output values by the value of the aggregate output of the entire industry to determine the fraction that that each good comprised of the output value of the total industry. Once these percentages were determined, they were applied to the individual output values of each firm in the samples to obtain an estimate of the share of output

[11] United States Census Office, 10th Census. *Report on the Manufactures of the United States at the Tenth Census: 1880.* Volume 2. Washington: Government Printing Office, 1883.
[12] *Census* (1880), pp. 462-63.
[13] Ibid., pp. 474-75.

value that each good accounted for. In turn, each of these shares was divided by the appropriate product price to determine the quantity of each good produced by each firm.

A price for each good could be determined by dividing the aggregate output value of each good by its quantity—or an aggregate output value could be determined by multiplying its quantity by its price. If separate data were not available, an aggregate industry value could be estimated by summing the aggregate output value of each good. But without at least two out of three values for each good—price, quantity and aggregate value—it was impossible to perform the above-described procedure.

Thus, the output quantities estimation procedure and data sources for just the four industries whose material inputs prices were delineated above are all that are presented here. Unfortunately, only two of the "good" industries—Shoes and Flour--made it into the 1880 analysis along with the other two, Meat and Tobacco, being among the three "bad" industries demarked with an asterisk indicating less-than-optimal data set characteristics (see discussion on Final Industry Selection and Notes on Industry Conglomerations, main chapter text).

Wherever possible, the data used for aggregate output value of an industry were that which encompassed all the outputs and products produced by that industry, so that the percentages of the industry value accounted for by the two main products would sum to less than one. This was done in order to keep the keep the cost function characteristics uniform across periods, and to obtain more realistic output quantity estimates. It can be recalled from the main chapter text discussion on Industry Selection Criteria that collapsing of outputs was done in order to form a more robust data set, and to keep the number of outputs in each output vector to a minimum. Due to heterogeneity of output

types, some purging of outputs that did not fit neatly under the rubric of one of the main product group categories was done, and justified on the predicate that these purged outputs were not produced jointly with the main products. Nevertheless, the costs data for each firm in the data set for 1850-70 do encompass the cost of producing these purged items, although their output vector does not take them into account. In order to maintain this continuity and to obtain more realistic output quantities that took into account the existence of unspecified products that comprised a portion of the output values of firms in the samples, I tried to leave some open space in the output values of each firm to account for these unspecified items, and only to divide out by price the portion of their output values that the main products accounted for to obtain the firms' output quantities.

Fortunately, I was able to obtain such aggregate output values for three out of the four industries that were included in the 1880 data sets. This was not to be taken for granted, because for each of these industries, it appeared that these unspecified items did account for a significant share of the aggregate industry output value. Although the Shoes industry had a value of unspecified products that was only a tiny fraction of its total value, the Meat industry had many other products besides the two main ones of beef and mutton that comprised its value. It can be recalled from the Notes on Industry Conglomerations in the main chapter text that pork comprised a large percentage of the output of the firms in the samples, but was purged from industry output vector due to an unclear and inconsistent pairing pattern that was completely disjoint from beef or mutton. But this preponderance of pork in the ABW samples is echoed in the *Census of Manufactures* for 1880, which shows many varieties and large quantities of pork products contributing to the total value of products of the Slaughtering and Meat-packing

industry—so much so that after isolating the values comprised by beef and mutton, together they comprised only 21% of the total value of all products for 1880.[14] The tobacco industry too was affected by the infusion of unspecified products not included in the vector of main outputs, as seen by the prominent role that the newly-found popularity of cigarettes had begun to play in the tobacco industry. Isolating the value of output of the two main product groups, cigars and loose tobacco, and leaving a space in the value of aggregate output that was accounted for by cigarettes was no easy task, but an essential one in trying to obtain realistic output measures derived from realistic estimations of the fractions of firms' output values that were allocated towards production of just the two main goods.

But when such separate data was not available, as in the case of Flour, an aggregate industry value was estimated by summing the aggregate output value of each good. The two primary outputs of the Flour industry were barrels of wheat flour and bushels of corn meal. The aggregate value of output of wheat flour was calculated by first taking the aggregate output of wheat flour for 1880 listed in the 2006 edition of *Historical Statistics* [15] in units of short tons (2000 lbs.), and converting it to barrels at a rate of 196 pounds per barrel. This figure was used to calculate the value of this aggregate output by multiplying it by the price of a barrel of wheat flour for 1880 given in the 2006 edition of *Historical Statistics*.[16]

---

[14] Ibid.

[15] See Jeremy Atack and Fred Bateman's Table Dd366-436 *Physical output of selected manufactured products: 1860-1997*, Series Dd368, in Carter, Susan B.,…[et al.], *Historical Statistics of the United States, Earliest Times to the Present*, Millennial Edition, Volume Four, Part D: Economic Sectors (Cambridge University Press, 2006), p. 627.

[16] See Michael R. Haines's Table Cc205-266 *Wholesale prices of selected commodities: 1784-1998*, Series Cc212, in Carter, Susan B.,…[et al.], *Historical Statistics of the United States, Earliest Times to the Present*, Millennial Edition, Volume Three, Part C: Economic Structure and Performance (Cambridge University Press, 2006), p. 204.

The value of the aggregate output of corn meal was more difficult to obtain due to lack of a reliable figure for aggregate output quantity. While the above-cited price of a bushel of corn of $0.551 from the 1889 *Statistical Abstract of the United States* [17] was settled on for an estimate of the price of a bushel of milled corn meal, that price listing contained no corresponding output quantity listing. I could find no other estimates for any other aggregate quantity of corn meal other than that from which the price of corn of $0.396 from the 1882 edition of *Statistical Abstract* was derived that was an average value per bushel calculated by dividing the total value of the corn crop by the total annual product of corn for 1880.[18] For lack of any more reliable estimate for the aggregate quantity of corn meal, this quantity was used in its place even though it probably is the quantity of corn in its raw form harvested for cereal production. So I used it as an estimate for the total quantity of output of corn meal on the assumption that one bushel of corn made about one bushel of corn meal, and that most of the corn harvested was eventually ground into corn meal. Although it is worthy of noting that in another table in the 1882 *Statistical Abstract*, the same quantity figure is listed in a table entitled, "Quantity of Indian Corn Produced, and of Corn and *Corn Meal* (emphasis added) Imported, Exported and Retained for Consumption in the United States, from 1866 to 1882, inclusive",[19] which shows that this assumption of quantitative parity between corn in its raw harvested form and in its ground cereal form may not be too far off the mark. This said quantity was multiplied by the said price of a bushel of corn meal of $0.551 to obtain the estimate for the value of output of corn meal.

---

[17] *Statistical Abstract* (1889), p. 310.
[18] *Statistical Abstract* (1882), p. 159.
[19] Ibid., p. 125.

These said values of output of wheat flour and corn meal were then summed to obtain the value of aggregate output of the Flour industry, and the percentages that each comprised of this aggregate measure were applied to the individual output values of the firms in the samples, and each share was divided out by the appropriate product price described above to obtain each firm's individual output quantities estimates.

The output quantities for the two primary products of the Tobacco industry were Cigars and pounds of Loose Tobacco; a composite that encompassed chewing and smoking tobacco, dip and snuff.

The value of the output of Loose Tobacco was obtained from the total value of products of the chewing, smoking, and snuff segment of the Tobacco industry for 1880 found in the 1880 *Census of Manufactures*.[20]

Since the 1880 *Census* data do not contain an isolated figure for the value of cigars, only an aggregated figure for the combined value of cigars and cigarettes, the value of the output of cigars was estimated by using converted 1890 price data (the earliest obtainable for cigars and cigarettes) from the *Bulletin of the Department of Labor* for 1900 and 1880 quantity data from the 2006 edition of *Historical Statistics* to construct a ratio that represented the value of cigars out of the combined value of cigars and cigarettes listed in the 1880 *Census*. A value of cigars was calculated by taking the price of cigars (cheroots) for 1890 listed in the *Bulletin of the Department of Labor* for 1900,[21] converting it to 1890 prices using the Warren-Pearson index for Farm products (Series E 53), and multiplying that figure by the quantity of cigars produced in the United States

[20] *Census* (1880), p. 24.
[21] United States Department of Labor. *Bulletin of the Department of Labor*. Washington: Government Printing Office. Vol. V (1900), No. 29 (July, 1900), p. 745.

for 1880 listed in the 2006 edition of *Historical Statistics*.[22] A similarly-constructed value of cigarettes was calculated from the same sources, and the ratio that cigars comprised out of the sum of these cigars and cigarettes values was applied to the total value of products of the cigars and cigarettes segment of the Tobacco industry from the 1880 *Census* for an estimate of the proportion of output value of the cigars and cigarettes industry that was accounted for by cigars alone.

These said values of output of Loose Tobacco and Cigars were not summed to obtain the value of aggregate output of the Tobacco industry. Instead, the said value of output of Loose Tobacco was summed with the total value of products of the cigars and cigarettes segment of the Tobacco industry for 1880 found in the 1880 *Census* to obtain such a measure.[23] That is because, although the ABW are lacking any output for cigarettes in their product coding for 1850-70, it does appear that by 1880, cigarette production had come to comprise a significant per cent of the output of the Tobacco industry. Since the ABW data were used to construct the aggregate Census data for that year, which did list the value of cigarettes produced, it is a reasonable conjecture to suppose that cigarettes did comprise at least a significant share of the output of the firms in the ABW samples for 1880, although this does not appear to have been the case for earlier census years. Further testimony to the increasing popularity of cigarettes as a smoker's choice is found in the above-cited table from *Historical Statistics* from which the quantity of output of cigars was obtained. The table shows, beginning in 1870, the quantity of cigarettes starting out small relative to cigars, but increasing rapidly to surpass

---

[22] See Jeremy Atack and Fred Bateman's Table Dd366-436 *Physical output of selected manufactured products: 1860-1997*, Series Dd376, in Carter, Susan B.,…[et al.], *Historical Statistics of the United States, Earliest Times to the Present*, Millennial Edition, Volume Four, Part D: Economic Sectors (Cambridge University Press, 2006), p. 627.

[23] *Census* (1880), p. 24.

cigars by 1900, and later to dwarf cigar production by the mid-20th century. So I considered it to be a fairly safe estimate to say that by 1880, at least a few of the firms in the samples were getting busy producing at least a modicum of cigarettes, and that on average, some portion of the output value of these firms, both on the firm-level and in the aggregate, came from sale of cigarettes. But to keep the cost function the same, I only estimated the output quantities of Cigars and Loose Tobacco.

These said values of output of Loose Tobacco and Cigars were each divided by the said value of aggregate output of the Tobacco industry to obtain the percentage of the value of aggregate output of the Tobacco industry that each comprised. To obtain firm-level output quantities, these percentages were applied to the individual output values of the firms in the samples, and each share was divided out by the appropriate product price. The price of cigars used was the same price obtained from the converted *Department of Labor* data described above. The price of Loose Tobacco used was that obtained by dividing the value of output of the chewing, smoking, and snuff segment of the Tobacco industry from the 1880 *Census* by the quantity of output of the Manufactured tobacco and snuff industry from the *Historical Statistics* table cited above.

The output quantities for the two primary products of the Meat industry in the analysis were pounds of beef and mutton.

The value of the output of the beef industry was obtained by taking the price of beef per barrel for 1880 listed in the 1889 *Statistical Abstract*,[24] converting it to pounds at

[24] *Statistical Abstract* (1889), p. 310.

a rate of 196 pounds per barrel, and multiplying that price by the quantity of beef sold fresh in the United States in 1880 listed in the 1880 *Census of Manufactures*.[25]

The value of the output of the mutton industry was obtained by taking the price of mutton per pound for 1890 (the earliest price I was able to find) listed in the *Bulletin of the Department of Labor* for 1900, [26] converting it to 1880 prices using the Warren-Pearson index for foods (Series E 54), and multiplying that figure by the quantity of mutton sold fresh in the United States for 1880 listed in the 1880 *Census of Manufactures*.[27]

These said values of output of beef and mutton were not summed to obtain the value of aggregate output of the meat industry. Instead, they were each divided by the total value of all products of the Slaughtering and Meat-packing industry for the United States for 1880 listed in the 1880 *Census of Manufactures* [28] and the percentages that each comprised of this aggregate measure were applied to the individual output values of the firms in the samples, and each share was divided out by the appropriate product price described above to obtain each firm's individual output quantities estimates.

The output quantities for the two primary products of the Shoes industry in the analysis were pairs of shoes and boots. The value of the output of each of these industries was taken from the 1880 *Census*.[29] These said values of output of shoes and boots were not summed to obtain the value of aggregate output of the shoes and boots industry. Instead,

---

[25] *Census* (1880), p. 474.
[26] United States Department of Labor. *Bulletin of the Department of Labor*. Washington: Government Printing Office. Vol. V (1900), No. 27 (March, 1900), p. 285.
[27] *Census* (1880), p. 475.
[28] Ibid.
[29] Ibid., p. 458.

they were each divided by the total value of all products of the Shoes and Boots industry for the United States for 1880 listed on the same table in the 1880 *Census*, and the percentages that each comprised of this aggregate measure were applied to the individual output values of the firms in the samples. These shares were then divided out by the appropriate product price, which was calculated by dividing the value of output of each product by its quantity (listed on the same table in the *Census*) to obtain each firm's individual output quantities estimates.

The three of the eight industries compiled whose data sets did not exhibit potential for robust *Sc* estimates as described in the main chapter text appear denoted by an asterisk in the below tables as in Table 6.1 in the main chapter text.

Table A.6.1. Shoes

A.6.1. (a.) 1850

Shoes	**1850**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Shoes (prs.)	Quantity of Boots (prs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	4,568.00	96.00	0.21	2.05	2,500	0
2	1,360.00	180.00	0.30	2.05	1,000	0
3	1,550.00	360.00	0.29	2.05	312	0
4	1,600.00	360.00	0.50	2.05	365	0
5	1,020.00	240.00	0.07	2.05	100	100
6	7,360.00	240.00	0.83	2.05	1,200	0
7	1,132.00	432.00	0.08	2.05	175	400
8	2,260.00	360.00	0.20	2.05	500	0
9	831.00	108.00	0.22	2.05	400	0
10	2,616.00	307.20	0.11	2.05	650	0
11	791.00	198.00	0.11	2.05	300	0
12	4,632.00	258.86	0.44	2.05	375	300
13	5,056.00	205.09	0.17	2.05	1,000	1,000
14	1,020.00	140.00	0.40	2.05	5,000	0
15	3,444.00	168.00	0.40	2.05	1,200	0
16	8,620.00	208.00	1.00	2.05	5,000	0
17	960.00	330.00	0.09	2.05	200	0
18	1,130.00	240.00	0.18	2.05	300	4
19	2,200.00	300.00	0.25	2.05	1,000	0
20	740.00	180.00	0.10	2.05	400	0
21	805.00	180.00	0.76	2.05	250	0
22	3,080.00	360.00	0.25	2.05	500	0
23	670.00	120.00	0.16	2.05	300	0
24	586.00	168.00	0.10	2.05	333	0
25	8,810.00	189.23	0.76	2.05	2,000	1,000
26	1,605.00	210.00	0.25	2.05	400	0
27	1,600.00	120.00	0.19	2.05	3,000	50
28	1,420.00	300.00	0.30	2.05	230	0
29	1,025.00	200.00	0.15	2.05	470	0
30	1,620.00	180.00	0.24	2.05	500	0
31	611.00	96.00	0.03	2.05	600	0
32	1,554.00	126.00	0.39	2.05	638	145
33	1,640.00	280.00	0.10	2.05	500	0
34	1,340.00	180.00	0.33	2.05	400	0
35	979.00	252.00	0.33	2.05	500	0
36	3,160.00	420.00	0.39	2.05	800	500
37	1,545.00	180.00	0.13	2.05	700	0
38	730.00	240.00	0.10	2.05	200	0
39	1,287.00	180.00	0.08	2.05	400	90
40	4,444.00	324.00	1.00	2.05	1,448	0
41	810.00	240.00	0.06	2.05	20	80
42	1,300.00	300.00	0.02	2.05	750	0
43	940.00	240.00	0.67	2.05	300	0

44	692.00	192.00	0.44	2.05	85	0
45	2,750.00	300.00	0.10	2.05	1,000	0
46	822.00	372.00	0.20	2.05	140	200
47	4,264.00	294.86	0.27	2.05	0	15,000
48	3,600.00	360.00	0.14	2.05	1,900	0
49	592.00	312.00	0.05	2.05	100	150
50	2,600.00	400.00	0.11	2.05	1,819	0
51	3,660.00	240.00	0.40	2.05	1,420	0
52	1,024.00	312.00	0.23	2.05	500	0
53	2,094.00	248.00	0.44	2.05	0	550
54	725.00	300.00	0.24	2.05	50	125
55	6,724.00	333.33	0.21	2.05	3,000	1,350
56	1,060.00	240.00	0.06	2.05	550	0
57	1,592.00	360.00	0.60	2.05	500	0
58	2,700.00	360.00	0.21	2.05	0	1,000
59	8,589.00	364.00	0.58	2.05	600	1,050
60	5,160.00	360.00	0.08	2.05	500	6,000
61	754.00	192.00	0.14	2.05	80	108
62	3,592.00	52.00	0.44	2.05	600	825
63	1,000.00	300.00	0.06	2.05	0	100
64	1,254.00	300.00	0.13	2.05	150	400
65	1,135.00	420.00	0.31	2.05	100	250
66	4,844.00	312.00	0.53	2.05	300	600
67	2,050.00	300.00	0.29	2.05	150	250
68	497.00	120.00	0.27	2.05	120	25
69	3,462.00	240.00	0.30	2.05	400	500
70	2,120.00	300.00	0.53	2.05	300	0
71	830.00	240.00	0.10	2.05	300	0
72	14,140.00	420.00	0.15	2.05	200	1,650
73	5,800.00	360.00	0.18	2.05	600	950
74	1,160.00	120.00	0.50	2.05	525	0
75	1,116.00	240.00	0.29	2.05	435	0
76	1,132.00	156.00	0.50	2.05	500	0
77	1,285.00	300.00	0.29	2.05	0	340
78	9,135.00	203.33	0.05	2.05	1,200	2,880
79	3,000.00	300.00	0.21	2.05	700	600
80	1,680.00	260.00	0.12	2.05	600	0
81	1,482.00	396.00	0.27	2.05	250	0
82	2,000.00	200.00	0.26	2.05	776	0
83	1,596.00	260.00	0.06	2.05	600	225
84	986.00	216.00	0.31	2.05	900	0
85	3,060.00	240.00	0.38	2.05	0	260
86	1,440.00	180.00	0.86	2.05	100	200
87	3,000.00	200.00	0.35	2.05	1,000	0
88	3,228.00	259.20	0.49	2.05	1,000	0
89	7,740.00	300.00	0.17	2.05	3,000	900
90	3,600.00	240.00	0.47	2.05	1,500	500
91	1,595.00	360.00	0.38	2.05	500	0
92	725.00	240.00	0.35	2.05	200	60
93	1,482.00	396.00	0.27	2.05	250	0
94	1,044.00	222.00	0.19	2.05	364	0
95	1,105.00	240.00	0.10	2.05	350	100
96	1,591.00	260.00	0.05	2.05	600	225

97	1,810.00	240.00	0.13	2.05	550	0
98	2,080.00	360.00	0.28	2.05	30	250
99	4,440.00	360.00	0.63	2.05	600	0
100	6,040.00	170.53	0.17	2.05	3,000	0
101	19,632.00	312.00	0.14	2.05	8,107	0
102	3,127.00	216.00	0.42	2.05	1,000	300
103	24,000.00	180.00	0.82	2.05	1,600	0
104	3,180.00	280.00	0.65	2.05	2,000	0
105	33,600.00	315.00	0.24	2.05	1,200	11,268
106	17,480.00	245.14	0.05	2.05	25,000	0
107	2,510.00	210.00	0.07	2.05	3,000	0
108	940.00	180.00	0.04	2.05	1,250	0
109	1,470.00	300.00	0.42	2.05	1,200	0
110	1,420.00	210.00	0.37	2.05	1,200	0
111	1,278.00	288.00	0.56	2.05	900	0
112	1,218.00	264.00	0.60	2.05	840	0
113	47,225.00	81.87	0.10	2.05	1,120	0
114	2,448.00	210.00	0.12	2.05	2,880	0
115	4,505.00	300.00	0.21	2.05	800	500
116	1,764.00	288.00	0.09	2.05	2,000	0
117	1,400.00	270.00	0.14	2.05	320	250
118	975.00	300.00	0.28	2.05	400	0
119	444.00	144.00	0.40	2.05	0	150
120	1,376.00	288.00	0.49	2.05	400	0
121	11,230.00	312.86	0.09	2.05	0	7,390
122	2,200.00	200.00	0.33	2.05	1,800	0
123	4,600.00	171.43	0.25	2.05	2,000	0
124	1,517.00	264.00	0.37	2.05	0	300
125	5,940.00	294.00	0.17	2.05	3,500	0
126	1,025.00	300.00	0.50	2.05	300	0
127	21,160.00	136.00	0.13	2.05	70,000	0
128	67,400.00	177.39	0.20	2.05	80,000	0
129	9,320.00	216.00	0.23	2.05	400	2,850
130	10,548.00	160.42	0.28	2.05	8,000	2,000
131	11,394.00	173.74	0.15	2.05	10,600	2,600
132	3,544.00	176.00	0.67	2.05	1,500	0
133	965.00	216.00	0.06	2.05	1,200	0
134	2,276.00	352.00	0.22	2.05	125	500
135	16,095.00	180.00	0.28	2.05	12,000	1,500
136	1,624.00	204.00	0.05	2.05	5,200	0
137	1,576.00	300.00	0.33	2.05	600	0
138	3,110.00	280.00	0.49	2.05	0	500
139	1,190.00	180.00	0.17	2.05	0	350
140	26,080.00	197.65	0.26	2.05	0	8,000
141	19,000.00	195.00	0.15	2.05	0	12,480
142	10,650.00	200.00	0.10	2.05	0	3,500
143	64,720.00	210.87	0.18	2.05	25,000	16,000
144	22,240.00	138.67	0.10	2.05	30,000	0
145	21,540.00	206.15	0.17	2.05	0	14,000
146	90,680.00	137.74	0.15	2.05	275,000	0
147	84,600.00	146.67	0.19	2.05	92,000	0
148	10,980.00	135.00	0.35	2.05	14,000	0
149	76,504.00	128.00	0.11	2.05	100,000	0

150	15,120.00	104.00	0.27	2.05	25,000	0
151	500.00	300.00	0.10	2.05	7,550	0
152	1,852.00	312.00	0.10	2.05	700	500
153	10,057.00	170.12	0.40	2.05	10,000	0
154	42,700.00	150.00	0.26	2.05	75,000	0
155	1,030.00	240.00	0.08	2.05	1,440	0
156	703.00	168.00	0.17	2.05	0	300
157	1,050.00	300.00	0.05	2.05	200	200
158	4,080.00	180.00	0.25	2.05	2,400	0
159	5,920.00	160.00	0.18	2.05	6,420	0
160	15,800.00	156.00	0.11	2.05	21,000	0
161	5,540.00	204.00	0.07	2.05	20,400	0
162	5,294.00	212.00	0.06	2.05	12,000	0
163	35,772.00	346.21	0.13	2.05	0	20,000
164	8,500.00	160.00	0.06	2.05	0	4,500
165	2,193.00	128.00	0.05	2.05	3,000	0
166	15,839.00	269.71	0.54	2.05	0	3,200
167	1,056.00	152.00	0.24	2.05	500	0
168	12,114.00	230.18	0.17	2.05	0	4,368
169	3,620.00	188.57	0.14	2.05	0	2,000
170	4,634.00	198.00	0.10	2.05	0	2,500
171	725.00	300.00	0.14	2.05	175	0
172	42,896.00	316.98	0.17	2.05	60,000	0
173	12,072.00	221.45	0.12	2.05	0	8,100
174	2,240.00	280.00	0.20	2.05	800	0
175	1,320.00	360.00	0.30	2.05	400	0
176	10,050.00	240.00	0.35	2.05	1,700	0
177	40,500.00	240.00	0.08	2.05	66,000	0
178	157,496.00	195.98	0.83	2.05	150,000	0
179	21,400.00	168.00	0.13	2.05	20,000	1,500
180	1,330.00	240.00	0.19	2.05	1,000	0
181	2,676.00	240.00	0.05	2.05	3,120	0
182	810.00	240.00	0.03	2.05	900	0
183	2,970.00	240.00	0.02	2.05	3,000	0
184	27,740.00	186.00	0.22	2.05	36,000	0
185	927.00	264.00	0.04	2.05	2,000	0
186	1,612.00	270.00	0.12	2.05	2,400	0
187	1,950.00	150.00	0.02	2.05	2,500	0
188	1,225.00	240.00	0.04	2.05	1,500	0
189	859.00	264.00	0.13	2.05	1,300	0
190	1,340.00	300.00	0.13	2.05	2,000	0
191	835.00	300.00	0.13	2.05	1,000	0
192	803.00	288.00	0.13	2.05	1,000	0
193	687.00	192.00	0.13	2.05	1,000	0
194	2,900.00	171.43	0.06	2.05	3,500	0
195	1,272.00	156.00	0.06	2.05	3,000	0
196	846.00	240.00	0.13	2.05	1,300	0
197	798.00	288.00	0.13	2.05	1,000	0
198	741.00	216.00	0.07	2.05	1,200	0
199	1,140.00	240.00	0.06	2.05	900	0
200	872.00	216.00	0.05	2.05	1,200	0
201	3,934.00	288.00	0.01	2.05	0	3,120
202	920.00	240.00	0.03	2.05	1,500	0

203	1,205.00	240.00	0.14	2.05	1,000	0
204	1,049.00	204.00	0.17	2.05	1,500	0
205	16,301.00	3,801.00	0.05	2.05	2,500	0
206	929.00	204.00	0.09	2.05	1,500	0
207	2,432.00	300.00	0.40	2.05	5,400	0
208	2,796.00	228.00	0.36	2.05	3,000	0
209	1,917.00	156.00	0.43	2.05	2,000	0
210	15,798.00	240.00	0.52	2.05	14,200	0
211	2,776.00	228.00	0.36	2.05	3,000	0
212	66,008.00	200.10	0.13	2.05	72,000	0
213	1,736.00	216.00	0.31	2.05	1,800	0
214	3,846.00	228.00	0.35	2.05	4,500	0
215	3,490.00	200.00	0.29	2.05	4,000	0
216	5,436.00	156.00	0.44	2.05	7,500	0
217	3,312.00	198.00	0.28	2.05	5,000	0
218	4,636.00	174.00	0.24	2.05	6,000	0
219	1,987.00	216.00	0.25	2.05	2,500	0
220	1,588.00	222.00	0.04	2.05	2,500	0
221	4,452.00	115.20	0.45	2.05	2,000	0
222	5,077.00	130.40	0.24	2.05	2,589	0
223	7,492.00	232.00	0.13	2.05	5,000	0
224	7,055.00	212.00	0.21	2.05	5,000	0
225	8,035.00	168.00	0.77	2.05	3,000	1,000
226	1,832.00	216.00	1.00	2.05	225	0
227	1,636.00	312.00	0.21	2.05	400	50
228	1,737.00	300.00	0.15	2.05	400	0
229	693.00	288.00	0.54	2.05	250	0
230	2,481.00	211.20	0.12	2.05	200	800
231	3,586.00	312.00	1.25	2.05	850	0
232	697.00	192.00	0.22	2.05	300	0
233	1,478.00	300.00	0.29	2.05	300	300
234	996.00	240.00	0.07	2.05	0	300
235	1,520.00	240.00	0.20	2.05	0	400
236	5,900.00	300.00	0.15	2.05	4,000	800
237	1,000.00	300.00	0.17	2.05	600	0
238	13,510.00	184.00	0.27	2.05	6,000	0
239	970.00	240.00	0.21	2.05	600	0
240	1,380.00	240.00	0.86	2.05	250	150
241	3,552.00	144.00	0.06	2.05	0	2,880
242	7,450.00	300.00	0.02	2.05	2,000	0
243	2,570.00	240.00	0.48	2.05	1,000	0
244	1,484.00	192.00	0.16	2.05	7,800	0
245	2,059.00	240.00	0.64	2.05	300	300
246	2,638.00	232.00	0.06	2.05	2,000	0
247	4,260.00	222.86	0.50	2.05	1,500	0
248	908.00	240.00	0.16	2.05	550	0
249	2,500.00	300.00	0.40	2.05	1,000	0
250	693.00	288.00	0.54	2.05	250	0
251	1,962.00	182.40	0.08	2.05	2,500	0
252	5,842.00	262.91	0.38	2.05	1,600	0
253	860.00	180.00	0.17	2.05	500	0
254	1,330.00	240.00	0.07	2.05	700	0
255	2,570.00	300.00	0.55	2.05	728	0

256	950.00	300.00	0.22	2.05	400	0
257	2,400.00	300.00	0.92	2.05	650	0
258	3,820.00	264.00	1.60	2.05	400	0
259	912.00	312.00	0.60	2.05	250	0
260	28,346.00	174.00	0.29	2.05	41,600	0
261	840.00	240.00	0.43	2.05	300	0
262	2,760.00	300.00	0.37	2.05	1,000	0
263	1,590.00	180.00	0.27	2.05	700	0
264	1,980.00	240.00	0.64	2.05	700	0
265	2,165.00	180.00	0.13	2.05	1,800	0
266	29,428.00	162.16	0.27	2.05	30,000	0
267	1,200.00	300.00	0.13	2.05	250	0
268	1,176.00	288.00	0.07	2.05	400	0
269	4,152.00	96.00	0.38	2.05	2,000	0
270	4,140.00	220.00	0.13	2.05	3,600	0
271	7,256.00	432.00	0.10	2.05	0	2,000
272	1,650.00	200.00	0.19	2.05	500	0
273	1,300.00	300.00	0.05	2.05	700	0
274	1,580.00	360.00	0.10	2.05	0	70
275	685.00	480.00	0.05	2.05	624	0
276	886.00	168.00	0.46	2.05	208	0
277	1,137.00	300.00	0.14	2.05	160	200
278	6,800.00	200.00	0.50	2.05	4,000	0
279	1,080.00	240.00	0.13	2.05	1,500	0
280	1,429.00	240.00	0.55	2.05	150	150
281	3,220.00	165.00	0.79	2.05	1,000	0
282	712.00	312.00	0.13	2.05	0	250
283	1,405.00	240.00	0.33	2.05	0	500
284	1,570.00	240.00	0.78	2.05	0	300
285	1,450.00	300.00	0.76	2.05	350	0
286	2,708.00	264.00	0.33	2.05	600	0
287	6,954.00	48.00	0.42	2.05	3,000	0
288	10,048.00	216.00	0.31	2.05	8,000	0
289	625.00	300.00	0.13	2.05	300	0
290	2,084.00	216.00	0.38	2.05	550	100
291	6,212.00	108.00	0.04	2.05	0	4,000
292	7,450.00	300.00	0.02	2.05	12,000	0
293	1,966.00	116.57	0.29	2.05	400	360
294	1,125.00	300.00	0.33	2.05	416	0
295	3,588.00	255.43	0.22	2.05	0	1,000
296	800.00	360.00	0.24	2.05	400	0
297	2,180.00	240.00	0.15	2.05	500	0
298	910.00	180.00	0.33	2.05	350	0
299	5,464.00	190.29	0.88	2.05	1,000	0
300	1,320.00	240.00	0.17	2.05	600	0
301	2,240.00	300.00	0.20	2.05	500	312
302	4,890.00	267.27	0.17	2.05	800	1,400
303	1,780.00	360.00	0.12	2.05	6	0
304	23,625.00	258.00	0.19	2.05	4,966	8,870
305	1,639.00	240.00	0.34	2.05	300	200
306	10,340.00	234.00	0.67	2.05	4,000	0
307	3,560.00	240.00	0.74	2.05	0	360
308	7,170.00	144.00	0.12	2.05	0	7,020

309	6,730.00	153.60	0.57	2.05	6,000	0
310	5,968.00	150.78	0.22	2.05	0	6,000
311	3,494.00	149.54	0.37	2.05	9,000	0
312	5,550.00	25.00	0.18	2.05	5,000	0
313	2,665.00	440.00	0.46	2.05	700	0
314	794.00	192.00	0.23	2.05	200	0
315	1,380.00	240.00	0.11	2.05	500	0
316	594.00	144.00	0.27	2.05	160	30
317	1,598.00	120.00	0.53	2.05	600	150
318	642.00	192.00	0.29	2.05	400	0
319	3,320.00	264.00	0.22	2.05	1,872	0
320	1,305.00	200.00	0.23	2.05	1,200	0
321	1,758.00	336.00	0.20	2.05	0	420
322	4,778.00	216.00	1.00	2.05	1,872	0
323	13,945.00	168.00	0.74	2.05	3,500	2,000
324	56,980.00	310.40	0.30	2.05	1,500	17,000
325	4,854.00	291.43	0.19	2.05	1,040	626
326	2,610.00	200.00	0.32	2.05	1,800	0
327	1,270.00	240.00	0.03	2.05	500	0
328	1,074.00	312.00	0.21	2.05	400	0
329	1,200.00	300.00	0.20	2.05	500	0
330	715.00	180.00	0.07	2.05	250	0
331	1,780.00	240.00	0.74	2.05	600	0
332	1,330.00	240.00	0.49	2.05	450	0
333	945.00	200.00	0.13	2.05	400	0
334	2,320.00	240.00	0.36	2.05	1,402	0
335	788.00	216.00	0.46	2.05	200	100
336	1,335.00	108.00	1.11	2.05	0	185
337	416.00	216.00	0.11	2.05	0	50
338	1,012.00	216.00	0.07	2.05	425	121
339	892.00	180.00	0.24	2.05	200	125
340	707.00	44.00	0.42	2.05	225	175
341	1,211.00	240.00	0.17	2.05	400	100
342	1,574.00	192.00	2.00	2.05	400	0
343	8,937.00	162.86	0.50	2.05	6,800	0
344	3,800.00	150.00	0.13	2.05	3,700	0
345	613.00	144.00	0.04	2.05	300	0
346	1,610.00	130.00	0.12	2.05	1,300	0
347	2,182.00	216.00	0.05	2.05	900	0
348	6,200.00	206.25	0.09	2.05	3,500	0
349	810.00	180.00	0.20	2.05	318	0
350	2,782.00	216.00	0.37	2.05	1,300	0
351	5,234.00	192.00	0.50	2.05	1,100	1,000
352	1,626.00	288.00	0.33	2.05	500	0
353	1,860.00	145.71	0.12	2.05	2,500	0
354	2,262.00	192.00	0.26	2.05	1,000	0
355	1,530.00	156.00	0.22	2.05	1,872	0
356	6,534.00	360.00	0.26	2.05	1,200	0
357	3,980.00	252.00	1.23	2.05	500	0
358	2,730.00	192.00	0.13	2.05	2,000	0
359	1,645.00	240.00	0.22	2.05	768	0
360	2,148.00	216.00	0.33	2.05	288	0
361	2,688.00	248.00	0.25	2.05	1,400	0

362	3,140.00	300.00	0.66	2.05	350	300
363	4,261.00	240.00	0.53	2.05	560	825
364	4,863.00	229.33	0.34	2.05	2,200	650
365	5,243.00	204.00	0.35	2.05	3,300	0
366	954.00	270.00	0.22	2.05	225	0
367	2,347.00	120.00	0.31	2.05	900	0
368	1,090.00	180.00	0.29	2.05	300	0
369	1,094.00	240.00	0.17	2.05	600	0
370	2,750.00	200.00	0.49	2.05	500	0
371	2,234.00	136.80	0.35	2.05	1,500	0
372	2,875.00	300.00	0.42	2.05	900	0
373	2,347.00	300.00	0.25	2.05	750	0
374	622.00	264.00	0.20	2.05	220	0
Mean	6,082.24	245.08	0.29	2.05	4,890.71	641.57
S.D.	13,921.32	198.20	0.25	0.00	19,929.71	2,344.13

A.6.1. (b.) 1860

Shoes	**1860**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Shoes (prs.)	Quantity of Boots (prs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	1,695.00	480.00	0.74	1.81	200	50
2	1,000.00	300.00	0.50	1.81	500	0
3	3,130.00	360.00	0.41	1.81	300	200
4	1,800.00	300.00	0.50	1.81	250	125
5	1,980.00	225.00	0.24	1.81	200	150
6	5,175.00	384.00	0.16	1.81	1,600	300
7	804.00	336.00	0.09	1.81	150	150
8	8,200.00	300.00	1.25	1.81	1,800	0
9	1,424.00	408.00	0.12	1.81	430	180
10	1,190.00	300.00	0.19	1.81	150	50
11	4,580.00	396.00	0.29	1.81	400	500
12	860.00	300.00	0.50	1.81	100	40
13	1,330.00	240.00	0.48	1.81	250	100
14	2,012.00	130.29	0.31	1.81	1,000	0
15	12,120.00	266.09	0.20	1.81	15,000	0
16	8,394.00	270.00	0.44	1.81	8,216	0
17	2,062.00	210.00	0.10	1.81	1,248	0
18	6,218.00	252.00	0.07	1.81	2,080	520
19	770.00	360.00	0.13	1.81	208	50
20	3,360.00	288.00	0.32	1.81	2,500	0
21	1,448.00	360.00	0.06	1.81	805	0
22	3,800.00	300.00	0.09	1.81	0	1,000
23	2,420.00	240.00	0.25	1.81	100	500
24	1,024.00	252.00	0.22	1.81	500	100
25	2,360.00	300.00	0.06	1.81	1,000	400
26	2,400.00	300.00	0.11	1.81	600	250

27	2,410.00	300.00	0.41	1.81	350	360
28	14,360.00	258.46	0.29	1.81	3,360	1,600
29	980.00	240.00	0.25	1.81	200	60
30	3,670.00	300.00	0.21	1.81	200	400
31	4,360.00	300.00	0.25	1.81	600	0
32	8,175.00	300.00	0.83	1.81	3,500	0
33	1,230.00	300.00	0.46	1.81	72	108
34	7,460.00	360.00	0.33	1.81	500	365
35	790.00	240.00	0.29	1.81	300	0
36	3,200.00	300.00	0.66	1.81	250	200
37	1,160.00	360.00	0.71	1.81	0	100
38	12,200.00	420.00	0.25	1.81	2,000	0
39	4,460.00	360.00	0.22	1.81	180	480
40	1,720.00	240.00	0.14	1.81	919	0
41	1,300.00	300.00	0.45	1.81	400	0
42	1,820.00	360.00	0.24	1.81	100	150
43	719.00	300.00	0.28	1.81	200	30
44	1,227.00	240.00	0.20	1.81	280	0
45	8,000.00	300.00	0.50	1.81	2,000	0
46	3,190.00	300.00	0.86	1.81	150	200
47	1,696.00	264.00	0.42	1.81	312	144
48	4,220.00	324.00	0.42	1.81	800	500
49	1,456.00	168.00	0.28	1.81	260	150
50	929.00	192.00	0.63	1.81	300	0
51	2,575.00	300.00	0.15	1.81	125	125
52	762.00	240.00	0.02	1.81	200	50
53	1,200.00	300.00	0.27	1.81	500	100
54	2,420.00	240.00	0.07	1.81	0	600
55	1,793.00	240.00	0.56	1.81	150	208
56	2,472.00	300.00	0.38	1.81	150	520
57	1,040.00	240.00	0.20	1.81	100	150
58	1,540.00	180.00	0.14	1.81	0	100
59	11,590.00	360.00	0.70	1.81	600	130
60	1,415.00	240.00	0.33	1.81	100	300
61	1,580.00	240.00	0.44	1.81	300	0
62	2,645.00	360.00	0.09	1.81	200	700
63	835.00	360.00	0.46	1.81	150	0
64	1,795.00	240.00	0.31	1.81	150	250
65	2,575.00	300.00	0.51	1.81	150	450
66	950.00	300.00	0.41	1.81	75	150
67	1,185.00	300.00	0.53	1.81	150	100
68	4,660.00	300.00	1.24	1.81	500	250
69	3,137.00	240.00	0.10	1.81	480	720
70	615.00	240.00	0.40	1.81	100	75
71	2,684.00	300.00	0.32	1.81	300	300
72	2,100.00	300.00	0.14	1.81	300	300
73	1,232.00	360.00	0.35	1.81	250	100
74	3,310.00	300.00	1.33	1.81	500	0
75	935.00	360.00	0.09	1.81	0	220
76	3,432.00	240.00	0.52	1.81	350	400
77	5,860.00	360.00	0.32	1.81	800	1,250
78	3,940.00	360.00	0.18	1.81	0	1,000
79	1,388.00	384.00	0.24	1.81	50	150

80	1,695.00	420.00	0.05	1.81	150	300
81	1,018.00	216.00	0.41	1.81	100	250
82	2,320.00	312.00	0.95	1.81	75	200
83	550.00	120.00	0.08	1.81	0	104
84	1,375.00	660.00	0.31	1.81	100	250
85	3,164.00	240.00	0.51	1.81	0	800
86	11,816.00	288.00	0.88	1.81	300	2,000
87	2,140.00	300.00	0.67	1.81	150	150
88	800.00	360.00	0.24	1.81	200	68
89	2,450.00	300.00	0.59	1.81	400	200
90	1,525.00	300.00	0.33	1.81	300	200
91	1,025.00	300.00	0.44	1.81	75	175
92	1,092.00	336.00	0.08	1.81	200	150
93	4,700.00	375.00	0.50	1.81	500	500
94	3,300.00	300.00	0.29	1.81	1,000	150
95	3,030.00	360.00	0.28	1.81	600	250
96	9,272.00	384.00	0.34	1.81	700	700
97	1,470.00	300.00	0.23	1.81	250	200
98	2,780.00	360.00	0.17	1.81	1,000	0
99	2,590.00	272.00	0.17	1.81	416	443
100	1,116.00	240.00	0.59	1.81	100	100
101	4,744.00	224.00	0.69	1.81	1,200	200
102	1,505.00	300.00	0.40	1.81	500	0
103	3,318.00	300.00	2.94	1.81	200	50
104	4,048.00	288.00	0.42	1.81	700	587
105	2,800.00	300.00	0.20	1.81	900	0
106	1,350.00	300.00	0.47	1.81	200	150
107	779.00	252.00	0.19	1.81	110	105
108	1,450.00	200.00	0.32	1.81	125	200
109	1,140.00	300.00	0.22	1.81	600	0
110	2,199.00	480.00	0.38	1.81	500	200
111	1,906.00	360.00	0.38	1.81	400	150
112	2,860.00	300.00	0.14	1.81	200	400
113	4,914.00	267.43	0.77	1.81	400	400
114	2,762.00	312.00	0.28	1.81	600	350
115	6,986.00	336.00	0.57	1.81	1,000	1,000
116	1,906.00	330.00	0.17	1.81	300	350
117	804.00	204.00	0.15	1.81	160	150
118	670.00	240.00	0.07	1.81	75	300
119	896.00	240.00	0.73	1.81	100	100
120	1,716.00	43.20	0.22	1.81	300	500
121	1,013.00	90.00	0.36	1.81	300	150
122	1,682.00	180.00	0.88	1.81	300	150
123	1,204.00	168.00	0.13	1.81	500	0
124	1,176.00	264.00	0.40	1.81	50	128
125	1,432.00	300.00	0.50	1.81	350	0
126	1,505.00	300.00	0.44	1.81	500	0
127	991.00	384.00	0.37	1.81	100	100
128	6,117.00	318.86	0.32	1.81	700	600
129	10,800.00	300.00	0.50	1.81	3,300	1,100
130	900.00	120.00	0.40	1.81	150	125
131	6,539.00	537.60	0.05	1.81	1,000	2,500
132	4,579.00	336.00	0.10	1.81	800	830

133	821.00	216.00	0.40	1.81	50	125
134	2,420.00	240.00	0.11	1.81	550	600
135	1,250.00	240.00	0.23	1.81	100	208
136	1,080.00	180.00	0.13	1.81	250	300
137	832.00	216.00	0.17	1.81	100	158
138	1,250.00	240.00	0.11	1.81	60	260
139	740.00	240.00	0.52	1.81	250	70
140	1,722.00	336.00	0.63	1.81	225	200
141	6,758.00	214.80	0.44	1.81	1,200	570
142	3,643.00	240.00	0.56	1.81	424	450
143	1,955.00	240.00	0.73	1.81	350	300
144	1,185.00	240.00	0.72	1.81	100	125
145	4,063.00	300.00	1.37	1.81	150	416
146	935.00	180.00	0.29	1.81	160	150
147	940.00	240.00	0.47	1.81	100	150
148	500.00	300.00	0.20	1.81	20	0
149	1,840.00	240.00	1.25	1.81	200	0
150	7,328.00	300.00	1.24	1.81	300	500
151	4,370.00	350.00	0.13	1.81	800	0
152	9,779.00	312.00	0.16	1.81	0	1,940
153	1,190.00	300.00	0.31	1.81	50	100
154	985.00	360.00	0.17	1.81	500	200
155	11,498.00	193.71	1.90	1.81	3,000	300
156	735.00	360.00	0.13	1.81	0	100
157	2,270.00	284.00	0.11	1.81	300	300
158	7,414.00	300.00	0.78	1.81	1,200	750
159	13,924.00	232.62	0.25	1.81	18,720	0
160	5,700.00	400.00	0.10	1.81	500	300
161	8,784.00	225.82	0.42	1.81	3,000	1,300
162	4,350.00	250.00	0.34	1.81	1,400	1,200
163	1,452.00	300.00	0.06	1.81	200	400
164	7,925.00	204.00	0.54	1.81	1,500	1,700
165	4,096.00	429.00	0.65	1.81	500	500
166	1,248.00	360.00	0.32	1.81	100	150
167	21,165.00	320.00	0.10	1.81	1,000	4,000
168	5,026.00	216.00	0.22	1.81	4,000	1,400
169	8,297.00	117.00	0.46	1.81	6,500	800
170	2,930.00	360.00	0.09	1.81	300	1,200
171	7,044.00	173.14	0.12	1.81	0	5,000
172	19,734.00	210.63	0.06	1.81	0	25,000
173	55,740.00	190.36	0.15	1.81	0	50,000
174	15,700.00	145.95	0.20	1.81	30,000	0
175	61,600.00	240.00	0.14	1.81	54,000	0
176	108,232.00	264.97	0.33	1.81	50,000	30,000
177	17,088.00	288.00	0.16	1.81	20,200	0
178	103,128.00	346.33	0.24	1.81	108,000	0
179	76,330.00	355.38	0.25	1.81	0	40,000
180	95,584.00	297.88	0.25	1.81	90,000	0
181	800,000.00	416.67	1.00	1.81	595,000	0
182	27,300.00	384.00	0.12	1.81	0	6,000
183	12,705.00	285.47	0.48	1.81	0	2,496
184	96,500.00	300.00	0.08	1.81	0	3,000
185	2,850.00	300.00	0.10	1.81	3,000	0

186	69,396.00	311.32	0.11	1.81	75,000	0
187	5,445.00	240.00	0.16	1.81	3,900	0
188	7,510.00	216.00	0.14	1.81	8,160	0
189	2,050.00	400.00	0.15	1.81	150	300
190	58,450.00	150.00	0.21	1.81	72,000	0
191	22,372.00	233.38	0.18	1.81	37,440	0
192	24,962.00	220.80	0.01	1.81	0	18,720
193	51,200.00	360.00	0.21	1.81	0	24,000
194	134,250.00	300.00	0.07	1.81	0	75,000
195	2,866.00	188.00	0.23	1.81	1,600	100
196	3,086.00	309.00	0.09	1.81	300	1,200
197	3,215.00	360.00	0.07	1.81	312	0
198	299,333.00	250.00	0.27	1.81	290,000	0
199	188,420.00	229.68	0.36	1.81	150,000	0
200	5,852.00	250.29	0.14	1.81	7,500	500
201	20,080.00	249.60	0.14	1.81	0	27,000
202	17,900.00	168.00	0.06	1.81	18,000	0
203	7,120.00	283.64	0.13	1.81	10,000	0
204	29,468.00	259.20	0.09	1.81	77,000	0
205	16,520.00	197.14	0.41	1.81	15,000	0
206	4,185.00	165.00	0.50	1.81	1,500	0
207	33,600.00	189.23	0.14	1.81	0	37,000
208	68,500.00	223.64	0.18	1.81	0	7,600
209	23,350.00	152.94	0.22	1.81	13,000	13,000
210	69,200.00	315.00	0.40	1.81	70,000	0
211	35,340.00	2,400.00	0.22	1.81	3,000	0
212	1,660.00	280.00	0.20	1.81	600	0
213	80,700.00	300.00	0.13	1.81	0	50,000
214	29,560.00	251.25	0.06	1.81	90,000	0
215	67,200.00	271.58	0.13	1.81	80,000	0
216	15,000.00	230.77	0.30	1.81	5,200	800
217	6,196.00	198.00	0.14	1.81	10,000	0
218	27,400.00	300.00	0.04	1.81	0	30,000
219	25,608.00	312.00	0.15	1.81	31,200	0
220	206,900.00	295.71	1.16	1.81	0	48,000
221	8,300.00	300.00	0.38	1.81	2,000	0
222	23,600.00	274.29	0.04	1.81	20,000	0
223	4,875.00	240.00	0.38	1.81	4,000	0
224	5,465.00	240.00	0.49	1.81	0	2,600
225	72,174.00	291.89	0.14	1.81	73,600	0
226	19,910.00	404.00	0.12	1.81	0	12,700
227	3,434.00	255.00	0.08	1.81	3,700	0
228	30,370.00	312.50	0.08	1.81	0	15,000
229	5,384.00	192.00	0.08	1.81	6,000	0
230	100,443.00	273.68	0.27	1.81	0	46,000
231	800.00	300.00	0.25	1.81	800	0
232	685.00	300.00	0.03	1.81	0	750
233	806.00	336.00	0.02	1.81	480	0
234	1,450.00	300.00	0.02	1.81	1,500	0
235	14,252.00	296.00	0.26	1.81	15,500	0
236	1,900.00	300.00	0.48	1.81	1,450	0
237	43,500.00	200.00	0.04	1.81	0	50,000
238	3,315.00	360.00	0.74	1.81	800	100

239	8,652.00	180.92	0.15	1.81	8,500	0
240	3,452.00	288.00	0.40	1.81	1,050	0
241	968.00	270.00	0.10	1.81	100	100
242	2,623.00	240.00	0.95	1.81	150	150
243	3,755.00	165.00	0.04	1.81	2,744	0
244	3,086.00	174.00	1.16	1.81	400	150
245	1,975.00	240.00	0.31	1.81	1,400	0
246	8,960.00	384.00	0.25	1.81	700	857
247	4,040.00	288.00	0.50	1.81	0	450
248	26,040.00	315.43	0.20	1.81	5,700	1,600
249	836.00	336.00	0.22	1.81	200	700
250	655.00	180.00	0.57	1.81	75	75
251	1,775.00	300.00	0.25	1.81	400	220
252	1,486.00	318.00	0.03	1.81	364	0
253	1,880.00	260.00	0.17	1.81	400	0
254	2,060.00	320.00	0.20	1.81	200	0
255	2,666.00	211.20	0.50	1.81	100	360
256	660.00	300.00	0.07	1.81	150	100
257	1,069.00	312.00	0.23	1.81	100	300
258	1,000.00	288.00	0.82	1.81	0	104
259	5,404.00	288.00	0.55	1.81	312	728
260	1,685.00	300.00	0.51	1.81	50	300
261	3,744.00	126.00	0.40	1.81	600	1,100
262	1,235.00	240.00	0.06	1.81	500	600
263	722.00	432.00	0.14	1.81	40	40
264	1,062.00	240.00	0.05	1.81	200	200
265	16,700.00	288.00	0.18	1.81	2,600	0
266	2,650.00	300.00	0.22	1.81	100	300
267	1,178.00	360.00	0.29	1.81	20	100
268	3,807.00	274.29	0.36	1.81	75	450
269	709.00	384.00	0.06	1.81	192	0
270	2,196.00	237.00	0.18	1.81	100	600
271	3,750.00	42.86	0.12	1.81	0	1,714
272	7,220.00	360.00	2.20	1.81	312	200
273	1,680.00	240.00	0.13	1.81	250	250
274	1,210.00	240.00	0.19	1.81	250	200
275	3,254.00	240.00	0.59	1.81	250	400
276	2,375.00	360.00	0.72	1.81	60	275
277	3,475.00	300.00	1.29	1.81	100	200
278	3,160.00	300.00	0.27	1.81	300	700
279	2,662.00	300.00	0.29	1.81	400	625
280	813.00	156.00	0.06	1.81	100	330
281	993.00	312.00	0.83	1.81	100	100
282	1,470.00	300.00	0.32	1.81	300	100
283	2,480.00	360.00	0.61	1.81	200	350
284	1,128.00	312.00	0.52	1.81	709	160
285	1,400.00	200.00	0.04	1.81	260	540
286	2,435.00	180.00	0.59	1.81	300	200
287	1,310.00	180.00	0.13	1.81	300	300
288	5,256.00	256.00	0.84	1.81	1,200	225
289	4,895.00	270.00	0.43	1.81	1,092	312
290	1,568.00	384.00	0.15	1.81	300	650
291	1,018.00	240.00	0.12	1.81	500	0

292	2,400.00	200.00	0.23	1.81	500	260
293	1,555.00	300.00	0.40	1.81	500	170
294	8,464.00	240.00	0.78	1.81	600	650
295	2,104.00	144.00	0.18	1.81	250	400
296	12,278.00	334.00	0.27	1.81	5,000	2,000
297	1,184.00	192.00	0.64	1.81	200	0
298	2,261.00	312.00	0.09	1.81	600	525
299	1,537.00	240.00	0.58	1.81	129	139
300	1,400.00	360.00	0.28	1.81	300	200
301	1,990.00	420.00	0.34	1.81	300	200
302	1,205.00	360.00	0.16	1.81	0	200
303	5,520.00	240.00	1.04	1.81	250	600
304	782.00	240.00	0.64	1.81	75	100
305	970.00	300.00	0.11	1.81	80	80
306	2,406.00	384.00	0.64	1.81	0	268
307	1,457.00	240.00	0.42	1.81	112	200
308	1,975.00	168.00	0.39	1.81	200	300
309	1,814.00	312.00	0.46	1.81	250	200
310	11,284.00	312.00	0.52	1.81	300	1,400
311	5,880.00	288.00	0.11	1.81	1,872	0
312	2,430.00	384.00	0.05	1.81	0	480
313	854.00	480.00	0.13	1.81	0	156
314	1,147.00	300.00	0.43	1.81	100	100
315	2,184.00	288.00	0.31	1.81	150	468
316	938.00	288.00	0.17	1.81	20	300
317	2,927.00	288.00	0.10	1.81	300	400
318	1,330.00	240.00	0.20	1.81	700	0
319	3,807.00	274.29	0.38	1.81	75	450
320	1,030.00	480.00	0.09	1.81	0	150
321	1,185.00	480.00	0.25	1.81	100	0
322	4,630.00	180.00	0.53	1.81	600	400
323	4,600.00	300.00	0.19	1.81	5,000	0
324	2,014.00	300.00	0.41	1.81	300	350
325	2,620.00	240.00	0.17	1.81	936	400
326	1,783.00	300.00	0.27	1.81	0	350
327	962.00	156.00	0.30	1.81	400	0
328	2,600.00	200.00	0.93	1.81	400	225
329	3,430.00	288.00	0.98	1.81	600	150
330	4,162.00	320.00	0.45	1.81	830	420
331	4,720.00	330.00	0.22	1.81	450	800
332	1,485.00	300.00	0.13	1.81	200	400
333	6,330.00	264.00	0.02	1.81	1,080	5,160
334	2,200.00	150.00	0.60	1.81	200	300
335	1,670.00	360.00	0.09	1.81	500	0
336	1,392.00	156.00	0.24	1.81	200	350
337	2,170.00	200.00	0.87	1.81	200	200
338	2,963.00	255.00	0.24	1.81	416	520
339	1,970.00	240.00	0.35	1.81	250	520
340	717.00	300.00	0.14	1.81	100	70
341	1,268.00	300.00	0.15	1.81	0	180
342	1,240.00	120.00	0.50	1.81	250	0
343	1,225.00	300.00	0.14	1.81	200	200
344	1,796.00	300.00	0.06	1.81	500	300

345	10,650.00	300.00	0.33	1.81	2,000	1,000
346	1,280.00	240.00	0.26	1.81	250	300
347	1,130.00	240.00	0.13	1.81	50	225
348	1,396.00	288.00	0.22	1.81	300	250
349	1,090.00	300.00	0.45	1.81	200	200
350	2,268.00	240.00	0.55	1.81	750	150
351	6,900.00	300.00	1.33	1.81	600	0
352	850.00	360.00	0.36	1.81	200	60
353	1,870.00	240.00	0.33	1.81	850	0
354	1,696.00	139.20	0.14	1.81	1,800	0
355	1,085.00	300.00	0.08	1.81	400	300
356	1,271.00	120.00	0.89	1.81	300	75
357	5,400.00	300.00	0.20	1.81	0	1,000
358	777.00	312.00	0.20	1.81	100	100
359	1,476.00	300.00	0.24	1.81	250	100
360	1,430.00	240.00	0.21	1.81	300	150
361	850.00	300.00	0.27	1.81	0	75
362	1,150.00	300.00	0.40	1.81	270	50
363	2,138.00	360.00	0.15	1.81	260	360
364	16,960.00	312.00	0.03	1.81	20,000	0
365	2,520.00	240.00	0.13	1.81	200	350
366	1,065.00	240.00	0.29	1.81	600	100
367	21,290.00	300.00	1.44	1.81	2,500	2,020
368	1,194.00	240.00	0.43	1.81	400	0
369	1,097.00	432.00	0.30	1.81	80	150
370	1,870.00	240.00	0.24	1.81	450	150
371	4,668.00	240.00	0.36	1.81	642	546
372	1,268.00	240.00	0.13	1.81	300	150
373	820.00	360.00	0.13	1.81	600	0
374	1,145.00	240.00	0.19	1.81	400	100
375	996.00	168.00	0.36	1.81	600	75
376	1,250.00	240.00	0.62	1.81	500	0
377	4,800.00	300.00	0.67	1.81	1,000	0
378	2,500.00	300.00	0.38	1.81	650	0
379	8,280.00	468.00	0.05	1.81	300	2,870
380	1,432.00	216.00	0.53	1.81	200	150
381	1,416.00	288.00	0.40	1.81	300	60
382	1,166.00	240.00	0.48	1.81	250	100
383	1,620.00	120.00	0.29	1.81	600	300
384	866.00	300.00	0.12	1.81	100	150
385	1,730.00	300.00	0.10	1.81	280	260
386	1,591.00	288.00	0.19	1.81	500	350
387	1,530.00	240.00	0.30	1.81	500	150
388	1,455.00	300.00	0.43	1.81	300	225
389	1,696.00	139.20	0.30	1.81	1,200	0
390	2,051.00	150.00	0.36	1.81	600	100
391	662.00	360.00	0.07	1.81	300	75
392	1,420.00	210.00	0.71	1.81	50	150
393	1,100.00	240.00	0.37	1.81	82	60
394	543.00	240.00	0.38	1.81	65	7
395	1,332.00	150.00	0.74	1.81	150	100
396	4,080.00	216.00	0.67	1.81	1,000	300
397	1,533.00	300.00	0.18	1.81	300	300

398	1,540.00	180.00	0.63	1.81	200	80
399	1,614.00	123.00	0.15	1.81	625	160
400	1,982.00	240.00	0.68	1.81	300	100
401	10,306.00	120.00	4.48	1.81	192	150
402	1,150.00	210.00	0.43	1.81	218	110
403	8,670.00	220.00	0.20	1.81	3,500	1,200
404	40,072.00	259.16	0.48	1.81	26,000	1,500
405	3,277.00	300.00	0.18	1.81	500	500
406	1,210.00	240.00	0.19	1.81	200	104
407	3,850.00	360.00	0.07	1.81	1,700	600
408	650.00	240.00	0.18	1.81	150	50
409	2,363.00	256.00	0.12	1.81	625	225
410	914.00	144.00	0.17	1.81	400	12
411	17,828.00	300.00	0.20	1.81	5,600	0
412	4,660.00	320.00	0.42	1.81	1,200	0
413	11,044.00	255.53	0.42	1.81	0	600
414	4,655.00	228.00	0.25	1.81	600	600
415	1,260.00	360.00	0.30	1.81	550	0
416	6,124.00	304.00	0.28	1.81	0	1,100
417	875.00	300.00	0.28	1.81	0	200
418	1,113.00	288.00	0.63	1.81	700	0
419	23,244.00	305.14	0.31	1.81	21,000	0
420	1,665.00	300.00	0.47	1.81	150	150
421	1,259.00	420.00	0.34	1.81	624	0
422	3,100.00	300.00	0.35	1.81	0	630
423	2,689.00	288.00	0.10	1.81	900	300
424	5,150.00	360.00	0.38	1.81	0	850
425	13,500.00	360.00	0.07	1.81	0	2,000
426	1,780.00	280.00	0.10	1.81	50	300
427	1,193.00	264.00	0.16	1.81	150	130
428	1,240.00	300.00	0.20	1.81	0	120
429	2,099.00	312.00	0.20	1.81	600	450
430	4,023.00	201.60	0.25	1.81	800	600
431	621.00	324.00	0.17	1.81	50	50
432	3,620.00	360.00	0.26	1.81	1,000	600
433	1,507.00	144.00	0.06	1.81	1,000	50
434	4,935.00	200.00	0.13	1.81	5,000	250
435	978.00	120.00	0.47	1.81	450	0
436	1,595.00	360.00	0.21	1.81	150	300
437	3,940.00	360.00	0.75	1.81	0	1,200
438	1,380.00	660.00	0.40	1.81	0	100
439	4,750.00	900.00	1.00	1.81	0	200
440	991.00	600.00	0.09	1.81	12	75
441	1,820.00	900.00	0.40	1.81	0	150
442	2,220.00	720.00	0.08	1.81	0	240
Mean	10,703.62	288.78	0.36	1.81	5,582.11	1,692.87
S.D.	45,183.71	135.47	0.37	0.00	34,395.20	7,403.03

A.6.1.(c.) 1870

Shoes	**1870**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Shoes (prs.)	Quantity of Boots (prs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	6,116.00	999.00	0.05	2.93	300	125
2	1,680.00	266.67	0.17	2.93	125	200
3	5,200.00	360.00	0.16	2.93	200	425
4	1,590.00	125.00	0.35	2.93	100	50
5	7,475.00	500.00	1.33	2.93	80	250
6	447.00	100.00	0.06	2.93	40	0
7	1,080.00	150.00	0.08	2.93	80	100
8	1,125.00	150.00	0.07	2.93	200	150
9	1,120.00	300.00	0.14	2.93	75	20
10	1,414.00	200.00	0.05	2.93	80	200
11	1,150.00	200.00	0.19	2.93	150	90
12	1,704.00	600.00	0.45	2.93	0	144
13	730.00	100.00	0.20	2.93	25	130
14	1,300.00	450.00	0.34	2.93	50	100
15	2,875.00	500.00	0.31	2.93	100	500
16	950.00	200.00	0.11	2.93	35	200
17	1,340.00	50.00	0.80	2.93	25	100
18	5,080.00	400.00	0.13	2.93	200	520
19	745.00	300.00	0.33	2.93	25	100
20	1,215.00	200.00	0.47	2.93	25	100
21	13,687.00	600.00	0.73	2.93	500	1,000
22	1,368.00	250.00	0.20	2.93	100	200
23	7,022.00	666.00	0.14	2.93	100	328
24	1,597.00	225.00	0.20	2.93	50	200
25	350.00	17.50	0.10	2.93	36	36
26	3,325.00	250.00	0.80	2.93	200	250
27	2,370.00	200.00	0.19	2.93	50	400
28	1,264.00	600.00	0.63	2.93	11	75
29	825.00	150.00	0.06	2.93	25	350
30	5,267.00	600.00	0.16	2.93	50	700
31	5,700.00	400.00	1.00	2.93	500	0
32	2,956.00	112.50	0.14	2.93	150	10
33	5,340.00	500.00	0.10	2.93	300	400
34	1,446.00	100.00	1.12	2.93	25	100
35	6,565.00	175.00	1.16	2.93	100	250
36	1,400.00	66.67	0.35	2.93	100	100
37	3,650.00	300.00	0.05	2.93	0	416
38	7,723.00	750.00	0.38	2.93	280	450
39	520.00	110.00	0.26	2.93	150	100
40	1,155.00	275.00	0.59	2.93	25	75
41	1,105.00	100.00	0.26	2.93	90	120
42	1,208.00	200.00	0.08	2.93	52	208
43	30,000.00	90.91	0.17	2.93	2,000	5,000
44	1,340.00	312.00	0.07	2.93	311	107

45	8,794.00	200.00	0.41	2.93	350	1,050
46	4,400.00	266.67	0.70	2.93	150	1,100
47	2,325.00	200.00	0.09	2.93	390	0
48	2,750.00	266.67	0.48	2.93	133	300
49	844.00	125.00	0.30	2.93	0	200
50	7,204.00	520.00	0.31	2.93	520	520
51	1,470.00	450.00	0.13	2.93	30	200
52	1,540.00	250.00	0.21	2.93	125	100
53	2,450.00	300.00	0.42	2.93	100	250
54	12,634.00	1,000.00	0.47	2.93	178	220
55	3,370.00	450.00	0.10	2.93	250	485
56	1,217.00	200.00	0.08	2.93	52	208
57	1,775.00	600.00	0.13	2.93	200	200
58	4,000.00	171.43	0.11	2.93	3,000	0
59	1,048.00	50.00	0.21	2.93	50	170
60	8,274.00	625.00	0.81	2.93	200	400
61	1,647.00	378.50	0.09	2.93	19	150
62	4,550.00	333.33	0.43	2.93	150	500
63	2,628.00	333.33	0.34	2.93	100	350
64	2,150.00	500.00	0.34	2.93	20	70
65	1,580.00	300.00	0.07	2.93	100	313
66	1,922.00	33.33	0.10	2.93	12	280
67	2,200.00	166.67	0.09	2.93	40	300
68	9,200.00	360.00	0.81	2.93	100	900
69	919.00	364.00	0.08	2.93	75	100
70	2,206.00	200.00	0.57	2.93	25	250
71	670.00	50.00	0.33	2.93	30	150
72	4,000.00	200.00	0.72	2.93	0	500
73	924.00	400.00	0.19	2.93	0	75
74	681.00	20.00	0.34	2.93	180	75
75	2,009.00	25.00	0.99	2.93	120	72
76	2,428.00	200.00	0.43	2.93	100	312
77	2,402.00	175.00	0.48	2.93	200	300
78	4,200.00	200.00	0.53	2.93	0	500
79	4,600.00	333.33	0.56	2.93	250	250
80	865.00	66.67	0.18	2.93	75	100
81	1,480.00	150.00	0.19	2.93	200	300
82	17,960.00	565.71	0.39	2.93	500	1,500
83	5,724.00	416.00	0.20	2.93	350	626
84	50,000.00	224.00	0.24	2.93	30,000	0
85	23,000.00	433.33	0.23	2.93	1,700	5,000
86	130,000.00	681.82	0.08	2.93	318,800	0
87	16,300.00	583.33	0.02	2.93	12,000	0
88	31,720.00	500.00	0.13	2.93	25,500	0
89	59,400.00	2,416.67	0.30	2.93	48,000	0
90	37,000.00	625.00	0.23	2.93	4,000	11,000
91	117,300.00	600.00	0.18	2.93	72,000	0
92	61,900.00	438.60	0.18	2.93	38,000	0
93	43,700.00	488.89	0.19	2.93	30,000	0
94	7,825.00	123.08	0.42	2.93	4,000	0
95	4,590.00	625.00	0.15	2.93	3,000	0
96	13,579.00	676.00	0.22	2.93	150	108
97	334,300.00	511.11	0.12	2.93	215,000	0

98	105,636.00	339.62	0.24	2.93	0	26,400
99	274,200.00	387.10	0.29	2.93	185,000	0
100	54,500.00	204.55	0.22	2.93	22,500	0
101	438.00	50.00	0.27	2.93	13	20
102	9,505.00	266.67	0.30	2.93	1,200	200
103	14,240.00	250.00	0.08	2.93	18,000	0
104	63,350.00	952.38	0.25	2.93	42,000	0
105	35,000.00	769.23	0.22	2.93	20,000	0
106	97,000.00	500.00	0.17	2.93	51,000	0
107	28,000.00	625.00	0.16	2.93	18,000	0
108	125,000.00	444.44	0.12	2.93	120,000	0
109	14,000.00	300.00	0.10	2.93	57,000	0
110	34,267.00	425.00	0.33	2.93	20,000	0
111	4,800.00	280.00	0.10	2.93	5,000	0
112	22,560.00	276.92	0.25	2.93	0	4,800
113	6,700.00	500.00	0.15	2.93	3,000	0
114	6,720.00	310.67	0.02	2.93	5,616	0
115	680.00	200.00	0.14	2.93	0	100
116	3,800.00	900.00	0.15	2.93	100	300
117	2,329.00	300.00	1.24	2.93	50	56
118	65,260.00	714.29	0.38	2.93	0	30,000
119	4,570.00	366.67	0.27	2.93	300	600
120	9,692.00	250.00	0.20	2.93	0	1,200
121	650.00	300.00	0.10	2.93	125	0
122	7,520.00	500.00	1.20	2.93	0	520
123	8,550.00	416.67	0.79	2.93	208	600
124	1,262.00	362.00	0.11	2.93	0	200
125	1,151.00	150.00	0.25	2.93	12	153
126	2,538.00	200.00	1.40	2.93	125	100
127	2,530.00	424.00	0.16	2.93	104	260
128	3,500.00	380.00	0.17	2.93	650	0
129	705.00	50.00	0.69	2.93	80	80
130	846.00	300.00	0.45	2.93	103	0
131	11,420.00	480.00	0.39	2.93	1,500	800
132	2,250.00	400.00	0.37	2.93	500	250
133	3,460.00	550.00	0.54	2.93	60	360
134	1,830.00	400.00	0.20	2.93	50	200
135	6,550.00	500.00	0.15	2.93	25	430
136	62,000.00	652.17	0.21	2.93	33,000	8,000
137	21,000.00	1,000.00	0.30	2.93	5,750	2,800
138	1,450.00	350.00	0.33	2.93	200	0
139	1,600.00	400.00	0.77	2.93	50	75
140	1,042.00	500.00	0.19	2.93	32	150
141	650.00	300.00	0.10	2.93	125	0
142	2,100.00	300.00	0.06	2.93	200	260
143	3,590.00	475.00	0.27	2.93	60	250
144	1,080.00	200.00	0.10	2.93	240	0
145	8,500.00	900.00	0.05	2.93	800	1,000
146	950.00	350.00	0.06	2.93	150	0
147	1,510.00	500.00	0.67	2.93	90	150
148	5,800.00	333.33	0.98	2.93	30	500
149	3,400.00	333.33	0.33	2.93	0	200
150	1,276.00	400.00	0.30	2.93	0	100

151	2,910.00	400.00	0.12	2.93	50	400
152	1,172.00	250.00	0.46	2.93	50	100
153	1,834.00	200.00	0.68	2.93	70	100
154	788.00	130.00	0.26	2.93	15	80
155	892.00	25.00	0.08	2.93	125	180
156	805.00	5.00	0.83	2.93	75	20
157	2,009.00	250.00	0.63	2.93	200	100
158	1,800.00	400.00	0.06	2.93	100	125
159	2,082.00	300.00	0.72	2.93	150	100
160	666.00	25.00	0.21	2.93	30	100
161	700.00	20.00	0.12	2.93	150	150
162	1,203.00	400.00	0.12	2.93	50	120
163	1,918.00	416.00	0.55	2.93	208	0
164	4,385.00	676.00	0.52	2.93	0	260
165	3,772.00	800.00	1.79	2.93	0	140
166	28,500.00	666.67	0.23	2.93	10,000	0
167	2,000.00	300.00	0.36	2.93	0	190
168	1,580.00	500.00	0.39	2.93	20	80
169	1,910.00	180.00	0.51	2.93	50	175
170	730.00	100.00	0.50	2.93	30	50
171	2,350.00	300.00	0.41	2.93	0	300
172	1,060.00	250.00	0.23	2.93	75	100
173	1,616.00	416.00	0.50	2.93	150	100
174	1,025.00	300.00	0.55	2.93	45	80
175	555.00	37.50	0.09	2.93	25	200
176	1,170.00	150.00	0.24	2.93	0	110
177	2,500.00	300.00	0.21	2.93	0	350
178	3,190.00	500.00	0.14	2.93	0	864
Mean	13,771.08	358.93	0.34	2.93	8,103.15	727.81
S.D.	38,266.12	264.38	0.30	0.00	34,217.90	3,177.90

1.(d.) 1880

Shoes	**1880**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Shoes (prs.)	Quantity of Boots (prs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	2,300.00	300.00	0.16	2.85	1,412	451
2	2,120.00	120.00	1.76	2.85	490	156
3	885.00	225.00	1.19	2.85	242	77
4	92.00	12.00	0.03	2.85	314	100
5	1,400.00	250.00	0.18	2.85	1,288	411
6	750.00	100.00	0.21	2.85	692	221
7	2,150.00	150.00	1.88	2.85	461	147
8	700.00	300.00	0.11	2.85	519	166
9	845.00	310.00	0.18	2.85	576	184
10	950.00	25.00	0.43	2.85	536	171
11	775.00	100.00	0.32	2.85	403	129

12	625.00	175.00	0.27	2.85	317	101
13	950.00	75.00	0.62	2.85	375	120
14	700.00	400.00	0.20	2.85	582	186
15	2,425.00	225.00	0.78	2.85	1,037	331
16	1,000.00	200.00	0.40	2.85	576	184
17	2,900.00	200.00	1.67	2.85	692	221
18	78,800.00	333.33	0.39	2.85	36,593	11,678
19	1,000.00	200.00	0.20	2.85	864	276
20	7,150.00	450.00	0.03	2.85	4,437	1,416
21	4,400.00	150.00	0.08	2.85	2,881	920
22	350.00	100.00	0.24	2.85	360	115
23	3,600.00	500.00	0.50	2.85	2,305	736
24	1,012.00	72.00	0.08	2.85	726	232
25	3,210.00	520.00	0.05	2.85	2,161	690
26	910.00	110.00	0.11	2.85	519	166
27	453.00	128.00	0.03	2.85	576	184
28	4,132.00	533.33	0.28	2.85	2,081	664
29	1,750.00	350.00	0.31	2.85	922	294
30	14,500.00	300.00	0.60	2.85	5,763	1,839
31	1,192.00	248.00	0.02	2.85	1,556	497
32	912.00	312.00	0.31	2.85	562	179
33	2,520.00	520.00	0.32	2.85	1,441	460
34	2,100.00	360.00	0.27	2.85	1,268	405
35	1,426.00	626.00	0.23	2.85	749	239
36	1,700.00	350.00	0.20	2.85	1,153	368
37	1,700.00	350.00	0.20	2.85	1,153	368
38	750.00	300.00	0.09	2.85	634	202
39	2,350.00	450.00	0.17	2.85	864	276
40	740.00	37.50	0.05	2.85	802	256
41	1,950.00	200.00	0.19	2.85	1,052	336
42	850.00	150.00	0.45	2.85	634	202
43	3,100.00	300.00	0.27	2.85	2,161	690
44	2,874.00	396.00	0.06	2.85	2,888	922
45	1,300.00	150.00	0.36	2.85	807	257
46	605.00	50.00	0.16	2.85	461	147
47	5,300.00	320.00	0.25	2.85	3,515	1,122
48	299.00	0.33	0.35	2.85	164	52
49	365.00	100.00	0.15	2.85	389	124
50	1,428.00	250.00	0.12	2.85	936	299
51	430.00	35.00	0.05	2.85	300	96
52	2,550.00	375.00	0.39	2.85	1,335	426
53	750.00	25.00	1.00	2.85	288	92
54	1,250.00	250.00	0.37	2.85	778	248
55	3,000.00	400.00	0.11	2.85	2,556	816
56	900.00	400.00	0.08	2.85	1,383	441
57	4,750.00	250.00	0.33	2.85	3,458	1,103
58	700.00	150.00	0.35	2.85	490	156
59	500.00	125.00	0.10	2.85	864	276
60	525.00	150.00	0.17	2.85	429	137
61	900.00	100.00	0.24	2.85	706	225
62	1,084.00	50.00	0.24	2.85	836	267
63	900.00	200.00	0.20	2.85	576	184
64	2,300.00	500.00	0.12	2.85	1,498	478

65	5,150.00	375.00	0.53	2.85	2,161	690
66	1,154.00	0.33	1.03	2.85	447	143
67	310.00	150.00	0.01	2.85	403	129
68	632.00	125.00	0.03	2.85	447	143
69	431.00	160.00	0.05	2.85	369	118
70	600.00	100.00	0.24	2.85	490	156
71	374.00	0.33	0.20	2.85	363	116
72	1,259.00	133.33	0.57	2.85	516	165
73	1,500.00	125.00	0.06	2.85	922	294
74	775.00	87.50	0.06	2.85	735	234
75	5,250.00	360.00	0.08	2.85	3,227	1,030
76	625.00	100.00	0.19	2.85	449	143
77	350.00	50.00	0.08	2.85	357	114
78	800.00	37.50	0.26	2.85	547	175
79	850.00	200.00	1.08	2.85	294	94
80	599.00	0.33	0.04	2.85	703	224
81	1,500.00	400.00	0.18	2.85	817	261
82	1,150.00	300.00	0.44	2.85	657	210
83	2,000.00	300.00	0.47	2.85	980	313
84	2,300.00	200.00	0.12	2.85	1,412	451
85	675.00	300.00	0.12	2.85	375	120
86	2,250.00	150.00	0.82	2.85	838	268
87	700.00	150.00	0.11	2.85	519	166
88	51,700.00	430.00	0.16	2.85	29,390	9,379
89	3,000.00	533.33	0.06	2.85	1,844	589
90	950.00	300.00	0.15	2.85	576	184
91	30,000.00	560.00	0.20	2.85	17,288	5,517
92	2,100.00	450.00	0.16	2.85	1,441	460
93	1,400.00	300.00	0.29	2.85	807	257
94	1,800.00	300.00	0.11	2.85	1,008	322
95	1,050.00	250.00	0.30	2.85	576	184
96	4,400.00	500.00	0.13	2.85	2,766	883
97	2,005.00	150.00	0.13	2.85	1,369	437
98	1,450.00	300.00	1.00	2.85	519	166
99	600.00	300.00	0.20	2.85	288	92
100	550.00	200.00	0.14	2.85	421	134
101	700.00	100.00	0.11	2.85	519	166
102	1,100.00	300.00	0.15	2.85	1,153	368
103	6,250.00	450.00	3.33	2.85	864	276
104	2,037.00	520.00	0.13	2.85	1,798	574
105	1,570.00	100.00	0.05	2.85	1,694	541
106	1,874.00	300.00	0.54	2.85	860	275
107	2,668.00	100.00	1.24	2.85	697	223
108	1,113.00	450.00	0.19	2.85	892	285
109	3,339.00	313.00	0.40	2.85	1,729	552
110	1,500.00	300.00	0.31	2.85	922	294
111	1,805.00	233.33	0.09	2.85	1,465	468
112	1,500.00	600.00	0.15	2.85	1,153	368
113	191,466.00	167.53	0.42	2.85	138,443	44,182
114	249.00	0.33	0.09	2.85	317	101
115	1,250.00	450.00	0.25	2.85	807	257
116	1,400.00	200.00	0.27	2.85	864	276
117	401.00	0.33	0.07	2.85	622	199

118	1,275.00	208.33	0.03	2.85	864	276
119	2,700.00	140.00	0.83	2.85	1,037	331
120	1,014.00	0.33	0.44	2.85	659	210
121	522.00	0.33	0.63	2.85	228	73
122	399.00	0.33	0.20	2.85	288	92
123	427.00	25.00	0.05	2.85	569	182
124	599.00	0.33	0.26	2.85	553	177
125	1,035.00	150.00	0.08	2.85	1,037	331
126	2,100.00	200.00	0.85	2.85	818	261
127	850.00	100.00	0.92	2.85	346	110
128	4,450.00	337.50	0.34	2.85	2,737	874
129	3,090.00	466.67	0.18	2.85	1,642	524
130	1,250.00	200.00	0.50	2.85	922	294
131	1,050.00	400.00	0.21	2.85	403	129
132	849.00	0.33	0.16	2.85	547	175
133	449.00	0.33	0.15	2.85	576	184
134	1,950.00	450.00	0.56	2.85	1,037	331
135	1,499.00	0.33	0.43	2.85	795	254
136	5,930.00	350.00	3.33	2.85	864	276
137	549.00	0.33	0.50	2.85	346	110
138	5,200.00	300.00	1.96	2.85	1,173	374
139	1,700.00	500.00	0.20	2.85	1,729	552
140	1,100.00	500.00	0.25	2.85	692	221
141	850.00	25.00	0.18	2.85	547	175
142	1,000.00	200.00	0.20	2.85	864	276
143	1,068.00	418.00	0.19	2.85	599	191
144	680.00	40.00	0.09	2.85	634	202
145	3,264.00	364.00	1.53	2.85	864	276
146	3,400.00	500.00	1.67	2.85	864	276
147	1,159.00	0.33	0.42	2.85	692	221
148	4,000.00	500.00	0.67	2.85	1,729	552
149	4,000.00	400.00	0.74	2.85	1,566	500
150	1,100.00	200.00	1.27	2.85	317	101
151	2,775.00	525.00	0.79	2.85	1,199	383
152	1,905.00	530.00	0.17	2.85	1,112	355
153	870.00	300.00	0.33	2.85	519	166
154	2,728.00	390.00	0.24	2.85	2,120	676
155	2,150.00	350.00	0.36	2.85	951	303
156	1,150.00	225.00	0.27	2.85	634	202
157	1,550.00	600.00	0.14	2.85	1,210	386
158	3,200.00	500.00	0.28	2.85	2,046	653
159	1,050.00	350.00	0.33	2.85	864	276
160	2,800.00	550.00	0.10	2.85	1,762	562
161	705.00	500.00	0.07	2.85	622	199
162	1,970.00	200.00	0.55	2.85	1,049	335
163	1,445.00	190.00	0.22	2.85	918	293
164	1,570.00	235.00	0.65	2.85	535	171
165	7,000.00	666.67	0.60	2.85	3,659	1,168
166	1,420.00	780.00	0.29	2.85	634	202
167	3,350.00	250.00	0.71	2.85	1,302	416
168	2,700.00	200.00	2.75	2.85	461	147
169	4,419.00	375.00	4.42	2.85	496	158
170	2,500.00	400.00	0.06	2.85	1,786	570

171	1,850.00	600.00	0.09	2.85	1,297	414
172	2,150.00	133.33	0.56	2.85	1,037	331
173	2,811.00	316.67	0.08	2.85	1,809	577
174	1,200.00	450.00	0.16	2.85	908	290
175	970.00	150.00	0.09	2.85	663	211
176	2,800.00	250.00	0.22	2.85	2,132	680
177	2,100.00	200.00	0.20	2.85	1,441	460
178	1,600.00	800.00	0.53	2.85	432	138
179	6,900.00	466.67	0.94	2.85	2,449	782
180	3,600.00	400.00	1.00	2.85	1,153	368
181	3,600.00	400.00	1.00	2.85	1,153	368
182	2,960.00	480.00	0.40	2.85	1,441	460
183	1,025.00	250.00	0.34	2.85	677	216
184	1,900.00	300.00	0.47	2.85	980	313
185	3,600.00	300.00	1.00	2.85	1,153	368
186	2,950.00	475.00	0.41	2.85	1,412	451
187	1,400.00	400.00	0.42	2.85	692	221
188	3,350.00	550.00	0.05	2.85	2,732	872
189	5,850.00	716.67	0.24	2.85	3,025	966
190	870.00	60.00	0.19	2.85	540	172
191	1,124.00	324.00	0.33	2.85	864	276
192	5,550.00	650.00	0.08	2.85	3,746	1,195
193	505.00	400.00	0.14	2.85	300	96
194	860.00	300.00	0.28	2.85	415	132
195	300.00	50.00	0.14	2.85	602	192
196	925.00	500.00	0.15	2.85	792	253
197	748.00	468.00	0.16	2.85	541	173
198	11,700.00	200.00	1.94	2.85	2,375	758
199	1,385.00	350.00	0.92	2.85	498	159
200	1,250.00	300.00	1.60	2.85	288	92
201	1,480.00	680.00	0.20	2.85	864	276
202	4,600.00	300.00	0.33	2.85	2,593	828
203	4,025.00	600.00	0.62	2.85	1,671	533
204	1,593.00	150.00	1.35	2.85	383	122
205	84,329.00	300.76	2.23	2.85	15,535	4,958
206	2,050.00	500.00	0.02	2.85	1,325	423
207	1,675.00	141.67	0.24	2.85	1,210	386
208	2,500.00	350.00	0.43	2.85	1,325	423
209	2,600.00	500.00	1.50	2.85	692	221
210	2,600.00	500.00	1.50	2.85	692	221
211	2,900.00	300.00	0.47	2.85	1,236	394
212	1,500.00	200.00	0.33	2.85	864	276
213	1,100.00	133.33	0.33	2.85	517	165
214	1,630.00	322.50	0.19	2.85	893	285
215	4,730.00	626.67	0.07	2.85	4,178	1,333
216	399.00	0.33	0.34	2.85	334	107
217	950.00	66.67	0.17	2.85	692	221
218	2,200.00	125.00	0.19	2.85	1,556	497
219	490.00	250.00	0.10	2.85	346	110
220	756.00	456.00	0.13	2.85	461	147
221	2,600.00	233.33	0.03	2.85	2,075	662
222	20,500.00	181.82	0.33	2.85	10,373	3,310
223	1,062.00	312.00	0.08	2.85	720	230

224	1,676.00	338.00	0.08	2.85	1,702	543
225	2,050.00	375.00	0.21	2.85	1,383	441
226	670.00	250.00	0.06	2.85	461	147
227	2,336.00	468.00	0.12	2.85	1,865	595
228	912.00	462.00	0.13	2.85	864	276
229	1,750.00	450.00	0.67	2.85	864	276
230	800.00	200.00	0.50	2.85	346	110
231	1,514.00	432.00	0.04	2.85	1,544	493
232	135.00	60.00	0.05	2.85	317	101
233	1,050.00	350.00	0.25	2.85	692	221
234	42,590.00	200.46	0.46	2.85	16,764	5,350
235	2,220.00	350.00	0.67	2.85	864	276
236	4,062.00	592.00	0.62	2.85	1,775	566
237	1,625.00	325.00	0.38	2.85	922	294
238	1,550.00	350.00	0.29	2.85	1,498	478
239	500.00	100.00	0.43	2.85	403	129
240	1,550.00	25.00	1.25	2.85	461	147
241	1,525.00	675.00	0.08	2.85	1,060	338
242	4,500.00	666.67	0.11	2.85	2,593	828
243	2,200.00	500.00	0.07	2.85	1,614	515
244	6,065.00	266.67	0.44	2.85	2,625	838
245	1,300.00	450.00	0.10	2.85	836	267
246	420.00	100.00	0.40	2.85	288	92
247	420.00	100.00	0.40	2.85	288	92
248	2,925.00	137.50	1.88	2.85	692	221
249	475.00	100.00	0.09	2.85	461	147
250	1,525.00	225.00	0.85	2.85	576	184
251	868.00	25.00	0.72	2.85	419	134
252	3,950.00	283.33	0.64	2.85	1,446	462
253	4,300.00	250.00	0.20	2.85	2,305	736
254	841.00	154.00	0.19	2.85	545	174
255	1,875.00	300.00	0.25	2.85	922	294
256	1,716.00	375.00	0.02	2.85	1,680	536
257	4,250.00	525.00	0.10	2.85	2,363	754
258	1,550.00	300.00	0.36	2.85	810	258
259	635.00	60.00	0.17	2.85	692	221
260	2,800.00	400.00	0.58	2.85	1,001	319
261	2,800.00	400.00	0.58	2.85	1,001	319
262	761.00	111.00	0.32	2.85	447	143
263	700.00	50.00	0.15	2.85	576	184
264	3,890.00	410.00	3.45	2.85	518	165
265	700.00	200.00	0.27	2.85	432	138
266	1,230.00	400.00	0.18	2.85	809	258
267	1,028.00	40.00	0.26	2.85	677	216
268	1,100.00	100.00	0.63	2.85	461	147
269	955.00	0.33	0.84	2.85	416	133
270	2,050.00	425.00	0.28	2.85	1,037	331
271	5,150.00	466.67	0.54	2.85	1,614	515
272	1,150.00	150.00	0.18	2.85	974	311
273	1,150.00	150.00	0.18	2.85	974	311
274	1,550.00	250.00	0.15	2.85	951	303
275	813.00	300.00	0.15	2.85	792	253
276	2,580.00	450.00	0.56	2.85	1,037	331

277	6,000.00	300.00	0.31	2.85	1,879	600
278	1,130.00	300.00	0.58	2.85	496	158
279	625.00	75.00	0.19	2.85	461	147
280	1,300.00	200.00	0.42	2.85	692	221
281	1,500.00	300.00	0.30	2.85	951	303
282	2,400.00	133.33	0.50	2.85	1,154	368
283	807.00	280.00	0.07	2.85	824	263
284	1,270.00	520.00	0.08	2.85	1,037	331
285	2,000.00	500.00	0.14	2.85	1,614	515
286	1,200.00	300.00	0.50	2.85	576	184
287	2,800.00	450.00	0.17	2.85	1,729	552
288	1,790.00	250.00	0.34	2.85	772	246
289	4,867.00	118.75	1.73	2.85	997	318
290	1,500.00	100.00	0.33	2.85	692	221
291	1,800.00	100.00	0.91	2.85	634	202
292	126,700.00	331.03	0.12	2.85	72,034	22,989
293	1,830.00	50.00	0.25	2.85	1,176	375
294	1,200.00	300.00	0.25	2.85	922	294
295	4,500.00	333.33	0.67	2.85	1,729	552
296	4,540.00	220.00	1.20	2.85	1,441	460
297	9,000.00	235.00	0.16	2.85	7,203	2,299
298	1,170.00	137.50	0.48	2.85	719	230
299	120,000.00	304.00	0.36	2.85	63,390	20,230
300	10,900.00	266.67	0.01	2.85	8,661	2,764
301	5,750.00	466.67	0.34	2.85	3,342	1,067
302	30,000.00	278.57	0.22	2.85	15,559	4,966
303	2,350.00	300.00	0.25	2.85	1,153	368
304	14,050.00	125.00	0.25	2.85	6,915	2,207
305	1,175.00	250.00	0.17	2.85	696	222
306	5,000.00	250.00	0.09	2.85	3,227	1,030
307	450.00	50.00	0.33	2.85	346	110
308	1,285.00	400.00	0.20	2.85	591	189
309	21,537.00	373.70	0.74	2.85	7,780	2,483
310	12,000.00	500.00	0.78	2.85	5,186	1,655
311	26,000.00	437.50	0.08	2.85	17,980	5,738
312	16,970.00	282.69	0.18	2.85	9,797	3,126
313	183,500.00	616.44	0.30	2.85	86,441	27,586
314	96,000.00	394.74	0.06	2.85	57,742	18,428
315	38,000.00	476.19	0.14	2.85	21,322	6,805
316	112,000.00	114.29	0.27	2.85	53,017	16,920
317	18,600.00	437.50	0.03	2.85	11,669	3,724
318	58,000.00	600.00	0.09	2.85	31,695	10,115
319	234,264.00	609.14	0.34	2.85	102,864	32,828
320	340,000.00	347.22	0.34	2.85	170,000	54,253
321	73,000.00	323.08	0.14	2.85	40,339	12,874
322	170,000.00	375.00	0.17	2.85	100,847	32,184
323	17,200.00	400.00	0.10	2.85	11,525	3,678
324	13,214.00	190.48	0.21	2.85	6,768	2,160
325	2,207.00	172.80	0.21	2.85	1,348	430
326	850.00	50.00	0.20	2.85	864	276
327	1,850.00	250.00	0.19	2.85	893	285
328	75,000.00	750.00	0.23	2.85	37,458	11,954
329	1,120.00	400.00	0.34	2.85	836	267

330	18,000.00	235.29	0.26	2.85	8,990	2,869
331	3,010.00	150.00	0.23	2.85	1,614	515
332	80,985.00	318.56	0.08	2.85	45,041	14,374
333	186,600.00	520.00	0.25	2.85	92,203	29,425
334	21,800.00	200.00	0.04	2.85	13,254	4,230
335	1,113.00	208.00	0.10	2.85	1,153	368
336	12,713.00	209.00	3.05	2.85	1,891	603
337	264,088.00	462.68	0.14	2.85	146,912	46,885
338	329,700.00	428.57	0.15	2.85	197,440	63,010
339	6,715.00	312.50	0.19	2.85	3,602	1,149
340	78,000.00	441.18	0.92	2.85	25,068	8,000
341	19,270.00	288.46	0.36	2.85	9,544	3,046
342	4,100.00	125.00	0.50	2.85	1,729	552
343	1,805.00	166.67	0.14	2.85	936	299
344	16,895.00	412.27	0.18	2.85	9,543	3,046
345	6,500.00	300.00	0.72	2.85	2,409	769
346	36,000.00	400.00	0.18	2.85	19,017	6,069
347	58,653.00	351.09	0.11	2.85	35,530	11,339
348	17,650.00	617.86	0.22	2.85	10,373	3,310
349	142,915.00	378.49	0.24	2.85	72,034	22,989
350	41,000.00	333.33	0.22	2.85	23,068	7,362
351	118,850.00	426.92	0.31	2.85	55,322	17,655
352	112,500.00	442.31	0.18	2.85	62,523	19,953
353	3,050.00	107.50	0.43	2.85	1,325	423
354	1,910.00	150.00	0.01	2.85	1,138	363
355	944,000.00	374.03	1.00	2.85	288,136	91,954
356	2,000.00	500.00	0.05	2.85	1,153	368
357	2,025.00	375.00	0.22	2.85	980	313
358	1,750.00	250.00	0.11	2.85	1,325	423
359	430.00	70.00	0.11	2.85	303	97
360	429.00	0.33	0.07	2.85	415	132
361	690.00	200.00	0.05	2.85	558	178
362	600.00	200.00	0.29	2.85	403	129
363	5,850.00	297.14	0.01	2.85	4,034	1,287
364	101,300.00	365.08	0.14	2.85	61,315	19,568
365	1,150.00	500.00	0.21	2.85	692	221
366	1,000.00	300.00	0.15	2.85	749	239
367	650.00	200.00	0.17	2.85	692	221
368	800.00	350.00	0.19	2.85	461	147
369	400.00	300.00	0.10	2.85	288	92
370	23,000.00	371.43	0.05	2.85	13,542	4,322
371	1,375.00	375.00	0.60	2.85	576	184
372	1,318.00	256.00	0.06	2.85	951	303
373	1,900.00	450.00	0.18	2.85	954	304
374	1,825.00	287.50	0.34	2.85	879	280
375	3,100.00	350.00	1.25	2.85	922	294
376	750.00	300.00	0.33	2.85	519	166
377	500.00	50.00	0.25	2.85	461	147
378	1,650.00	250.00	0.48	2.85	836	267
379	6,600.00	120.00	1.05	2.85	2,190	699
380	747.00	234.00	0.20	2.85	576	184
381	1,650.00	175.00	0.28	2.85	836	267
382	1,476.00	400.00	0.73	2.85	475	152

383	345.00	75.00	0.12	2.85	346	110
384	3,925.00	450.00	1.10	2.85	1,311	418
385	2,295.00	225.00	1.00	2.85	864	276
386	3,800.00	433.33	0.67	2.85	1,729	552
387	3,200.00	400.00	1.43	2.85	807	257
388	2,300.00	100.00	0.50	2.85	1,153	368
389	5,640.00	520.00	0.24	2.85	2,916	931
390	1,425.00	375.00	0.67	2.85	692	221
391	3,600.00	300.00	0.25	2.85	2,305	736
392	4,900.00	233.33	1.03	2.85	1,671	533
393	9,700.00	525.00	0.05	2.85	6,339	2,023
394	7,923.00	427.00	4.75	2.85	850	271
395	1,100.00	75.00	0.76	2.85	418	133
396	900.00	300.00	0.15	2.85	749	239
397	1,000.00	390.00	0.80	2.85	288	92
398	2,450.00	216.67	0.83	2.85	1,037	331
399	1,640.00	513.00	0.04	2.85	1,348	430
400	1,985.00	150.00	0.92	2.85	692	221
401	1,575.00	225.00	0.24	2.85	951	303
402	867.00	0.33	0.60	2.85	482	154
403	1,386.00	300.00	0.17	2.85	999	319
404	13,839.00	404.80	0.24	2.85	7,198	2,297
405	908.00	208.00	0.06	2.85	934	298
406	337.00	0.33	0.10	2.85	599	191
407	324.00	0.33	0.08	2.85	346	110
408	1,054.00	0.33	1.17	2.85	454	145
409	1,757.00	468.00	0.04	2.85	1,370	437
410	827.00	260.00	0.09	2.85	764	244
411	2,950.00	900.00	0.78	2.85	1,109	354
412	531.00	312.00	0.10	2.85	415	132
413	499.00	0.33	0.24	2.85	490	156
414	282.00	0.33	0.10	2.85	420	134
415	5,676.00	468.00	0.03	2.85	3,896	1,243
416	409.00	0.33	0.04	2.85	761	243
417	434.00	0.33	0.12	2.85	599	191
418	185.00	0.33	0.06	2.85	288	92
419	180.00	0.33	0.04	2.85	360	115
420	1,366.00	416.00	0.05	2.85	1,049	335
421	4,560.00	312.00	0.25	2.85	2,305	736
422	3,780.00	280.00	2.84	2.85	610	195
423	1,550.00	250.00	0.32	2.85	720	230
424	899.00	0.33	0.38	2.85	461	147
425	205.00	0.33	0.09	2.85	330	105
426	3,960.00	260.00	0.20	2.85	2,881	920
427	3,116.00	383.67	0.31	2.85	1,822	582
428	3,435.00	336.00	0.31	2.85	1,848	590
429	724.00	0.33	0.57	2.85	403	129
430	4,225.00	575.00	0.20	2.85	2,840	906
431	1,150.00	400.00	0.40	2.85	576	184
432	2,376.00	576.00	0.31	2.85	1,484	474
433	2,016.00	516.00	0.22	2.85	1,542	492
434	515.00	0.33	0.13	2.85	449	143
435	517.00	0.33	0.05	2.85	629	201

436	722.00	0.33	0.62	2.85	371	118
437	4,500.00	466.67	0.39	2.85	2,219	708
438	1,264.00	364.00	0.40	2.85	864	276
439	1,530.00	450.00	0.17	2.85	1,037	331
440	499.00	0.33	0.17	2.85	346	110
441	2,180.00	180.00	0.50	2.85	1,153	368
442	359.00	0.33	0.17	2.85	332	106
443	1,650.00	200.00	0.95	2.85	605	193
444	2,016.00	468.00	0.12	2.85	1,498	478
445	413.00	0.33	0.07	2.85	432	138
446	1,100.00	300.00	0.11	2.85	1,095	349
447	1,200.00	500.00	0.13	2.85	864	276
448	4,974.00	648.00	0.19	2.85	3,009	960
449	20,895.00	626.92	0.24	2.85	8,488	2,709
450	57,358.00	437.64	0.37	2.85	31,119	9,931
451	206,364.00	426.36	0.23	2.85	123,175	39,309
452	12,705.00	642.86	0.11	2.85	7,520	2,400
453	4,350.00	450.00	0.23	2.85	2,536	809
454	3,053.00	313.00	1.29	2.85	893	285
455	822.00	278.00	0.12	2.85	377	120
456	800.00	100.00	0.08	2.85	692	221
457	4,620.00	480.00	0.02	2.85	5,186	1,655
458	3,125.00	500.00	0.15	2.85	5,809	1,854
459	3,784.00	375.00	0.63	2.85	1,369	437
460	675.00	75.00	0.56	2.85	409	131
461	1,175.00	400.00	0.50	2.85	576	184
462	1,850.00	300.00	0.08	2.85	1,729	552
463	905.00	300.00	0.10	2.85	583	186
464	2,500.00	100.00	1.80	2.85	576	184
465	3,700.00	1,000.00	0.60	2.85	1,441	460
466	1,278.00	390.00	0.09	2.85	1,007	321
467	3,000.00	400.00	1.18	2.85	980	313
468	1,100.00	150.00	1.37	2.85	294	94
469	1,075.00	275.00	0.49	2.85	588	188
470	5,000.00	250.00	2.15	2.85	936	299
471	862.00	400.00	0.22	2.85	531	170
472	2,128.00	182.00	0.67	2.85	864	276
473	1,100.00	200.00	0.07	2.85	864	276
474	950.00	250.00	0.42	2.85	692	221
475	1,790.00	470.00	0.25	2.85	1,153	368
476	675.00	75.00	0.36	2.85	317	101
477	925.00	112.50	0.18	2.85	634	202
478	420.00	10.00	0.16	2.85	360	115
479	1,075.00	125.00	0.56	2.85	461	147
480	1,470.00	210.00	1.68	2.85	343	109
481	464.00	0.33	0.37	2.85	311	99
482	2,240.00	340.00	1.50	2.85	576	184
483	3,064.00	288.00	0.72	2.85	1,608	513
484	1,135.00	125.00	0.97	2.85	357	114
485	3,295.00	75.00	0.70	2.85	1,049	335
486	1,750.00	150.00	0.53	2.85	864	276
487	1,870.00	500.00	0.08	2.85	1,098	351
488	975.00	87.50	0.67	2.85	432	138

489	3,000.00	375.00	0.33	2.85	1,749	558
490	555.00	5.00	0.18	2.85	317	101
491	449.00	0.33	0.35	2.85	409	131
492	329.00	0.33	0.24	2.85	303	97
493	752.00	26.00	0.24	2.85	490	156
494	1,150.00	100.00	1.45	2.85	317	101
495	675.00	87.50	0.21	2.85	547	175
496	680.00	280.00	0.12	2.85	965	308
497	770.00	62.50	0.10	2.85	706	225
498	1,075.00	75.00	0.25	2.85	692	221
499	159.00	0.33	0.10	2.85	288	92
500	2,809.00	450.00	0.58	2.85	994	317
501	2,411.00	350.00	0.21	2.85	1,619	517
502	5,967.00	467.00	2.25	2.85	1,153	368
503	16,378.00	450.00	12.47	2.85	705	225
504	699.00	0.33	0.12	2.85	490	156
505	399.00	0.33	0.23	2.85	507	162
506	1,299.00	0.33	6.67	2.85	86	28
507	1,160.00	60.00	0.56	2.85	516	165
508	1,101.00	141.67	0.18	2.85	648	207
509	1,225.00	75.00	0.56	2.85	519	166
510	2,350.00	150.00	1.33	2.85	692	221
511	2,032.00	275.00	0.26	2.85	1,095	349
512	11,750.00	312.50	0.80	2.85	4,034	1,287
513	1,750.00	100.00	0.93	2.85	617	197
514	11,376.00	275.00	0.50	2.85	4,651	1,484
515	3,600.00	350.00	0.15	2.85	2,245	716
516	1,485.00	150.00	0.06	2.85	954	304
517	2,300.00	375.00	0.36	2.85	807	257
518	900.00	500.00	0.08	2.85	749	239
519	3,042.00	42.00	1.43	2.85	864	276
520	2,425.00	162.50	1.20	2.85	722	230
521	959.00	0.33	0.27	2.85	645	206
522	1,252.00	233.33	0.07	2.85	864	276
523	48,520.00	208.40	0.87	2.85	15,434	4,925
524	1,860.00	270.00	0.68	2.85	847	270
525	1,178.00	226.00	0.67	2.85	692	221
526	1,178.00	226.00	0.67	2.85	692	221
527	349.00	0.33	0.20	2.85	288	92
528	5,596.00	499.20	0.09	2.85	3,746	1,195
529	8,500.00	314.29	0.46	2.85	3,746	1,195
530	1,700.00	325.00	0.18	2.85	1,210	386
531	8,100.00	344.44	0.12	2.85	4,682	1,494
532	240,000.00	244.44	0.16	2.85	129,661	41,379
533	720.00	300.00	0.31	2.85	375	120
534	5,020.00	624.00	0.28	2.85	2,305	736
535	550.00	110.00	0.18	2.85	473	151
536	1,099.00	0.33	0.17	2.85	1,037	331
537	800.00	300.00	0.33	2.85	432	138
538	6,799.00	0.33	6.50	2.85	576	184
539	5,200.00	150.00	0.86	2.85	2,017	644
540	6,750.00	650.00	2.75	2.85	1,153	368
541	1,800.00	266.67	0.25	2.85	1,153	368

542	1,700.00	300.00	0.28	2.85	1,037	331
543	1,630.00	500.00	0.34	2.85	850	271
544	740.00	20.00	0.19	2.85	447	143
545	3,750.00	280.00	0.22	2.85	2,651	846
546	670.00	130.00	0.17	2.85	504	161
547	1,600.00	300.00	0.73	2.85	634	202
548	1,460.00	360.00	0.60	2.85	576	184
549	2,180.00	76.67	1.54	2.85	562	179
550	899.00	0.33	1.20	2.85	288	92
551	513.00	0.33	0.50	2.85	346	110
552	4,545.00	125.00	0.08	2.85	2,635	841
553	3,350.00	175.00	2.00	2.85	720	230
554	1,000.00	350.00	0.17	2.85	692	221
555	2,300.00	250.00	0.50	2.85	1,153	368
556	2,100.00	500.00	0.12	2.85	1,441	460
557	19,860.00	272.73	0.08	2.85	15,271	4,874
558	9,305.00	323.75	0.06	2.85	5,959	1,902
559	2,694.00	27.30	0.98	2.85	885	282
560	1,400.00	500.00	0.42	2.85	692	221
561	1,050.00	300.00	0.08	2.85	1,037	331
562	625.00	225.00	0.14	2.85	418	133
563	1,150.00	470.00	0.09	2.85	864	276
564	1,050.00	225.00	0.18	2.85	985	314
565	665.00	40.00	0.75	2.85	387	123
566	47,500.00	666.67	0.22	2.85	25,932	8,276
Mean	11,766.57	275.05	0.48	2.85	5,861	1,871
S.D.	52,863.65	179.51	0.83	0.00	22,652	7,229

Table A.6.2. Flour

A.6.2. (a.) 1850

Flour	**1850**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Wheat Flour (bbl.)	Quantity of Corn meal (bu.)
n	C	w_1	w_2	w_3	y_1	y_2
1	720.00	120.00	0.18	0.72	0	1,125
2	5,240.00	240.00	0.83	0.72	600	0
3	1,904.00	144.00	2.87	0.72	0	600
4	4,788.00	144.00	0.09	0.72	0	11,000
5	16,620.00	264.00	0.72	0.72	2,000	0
6	6,864.00	432.00	0.77	0.72	500	2,000
7	2,280.00	120.00	0.32	0.72	240	1,200
8	86,840.00	426.67	0.12	0.72	20,000	0
9	890.00	120.00	0.25	0.72	0	2,000
10	12,840.00	120.00	2.71	0.72	550	3,000
11	996.00	96.00	0.19	0.72	0	1,500
12	2,716.00	216.00	0.56	0.72	0	3,000
13	9,354.00	204.00	0.42	0.72	720	5,000
14	5,192.00	192.00	0.57	0.72	675	0
15	9,480.00	240.00	0.10	0.72	1,900	0
16	7,980.00	240.00	0.50	0.72	1,000	0
17	4,960.00	180.00	0.46	0.72	700	0
18	7,360.00	180.00	1.14	0.72	300	3,000
19	5,716.00	216.00	0.48	0.72	0	4,000
20	9,920.00	210.00	0.39	0.72	1,100	3,300
21	1,096.00	96.00	0.83	0.72	0	1,000
22	54,100.00	200.00	0.20	0.72	9,332	0
23	6,940.00	120.00	0.46	0.72	145	3,720
24	3,908.00	108.00	0.94	0.72	200	2,000
25	5,744.00	144.00	0.44	0.72	600	3,000
26	1,920.00	120.00	0.18	0.72	0	3,300
27	7,816.00	108.00	0.59	0.72	100	0
28	10,250.00	120.00	0.27	0.72	1,000	0
29	5,246.00	96.00	0.22	0.72	800	0
30	1,720.00	120.00	1.43	0.72	0	1,500
31	1,832.00	72.00	0.67	0.72	0	2,400
32	960.00	60.00	0.72	0.72	17	1,000
33	3,220.00	120.00	1.72	0.72	133	1,000
34	10,870.00	120.00	0.86	0.72	833	4,000
35	9,380.00	180.00	0.48	0.72	800	4,000
36	2,320.00	120.00	0.08	0.72	0	5,000
37	10,180.00	180.00	0.48	0.72	666	4,000
38	10,240.00	120.00	0.41	0.72	666	6,000
39	1,580.00	180.00	0.35	0.72	0	3,600
40	590.00	180.00	0.30	0.72	0	1,200
41	2,152.00	192.00	0.09	0.72	100	4,000

42	1,179.00	204.00	0.37	0.72	16	2,000
43	4,932.00	132.00	0.20	0.72	450	9,000
44	5,970.00	120.00	1.60	0.72	200	5,000
45	2,120.00	120.00	0.67	0.72	0	5,000
46	2,342.00	192.00	0.44	0.72	0	4,500
47	3,370.00	120.00	0.53	0.72	0	6,500
48	5,340.00	180.00	0.80	0.72	0	5,000
49	12,863.00	240.00	0.21	0.72	0	18,750
50	8,360.00	480.00	0.13	0.72	0	10,000
51	970.00	120.00	0.60	0.72	0	1,500
52	7,440.00	240.00	1.56	0.72	0	4,000
53	10,840.00	180.00	0.23	0.72	1,000	15,000
54	18,080.00	420.00	0.44	0.72	0	16,800
55	13,360.00	180.00	0.30	0.72	2,000	0
56	20,932.00	216.00	0.38	0.72	3,330	2,220
57	8,084.00	192.00	1.00	0.72	800	0
58	23,480.00	240.00	0.67	0.72	3,000	0
59	5,746.00	96.00	0.97	0.72	42	4,800
60	10,864.00	264.00	0.83	0.72	1,500	0
61	8,939.00	132.00	0.23	0.72	1,500	2,600
62	6,840.00	300.00	0.56	0.72	1,000	0
63	7,280.00	240.00	0.60	0.72	1,200	0
64	9,894.00	216.00	2.73	0.72	140	0
65	28,480.00	240.00	0.33	0.72	3,555	1,150
66	4,140.00	240.00	1.60	0.72	100	0
67	15,840.00	120.00	0.30	0.72	2,650	5,700
68	1,970.00	120.00	1.10	0.72	150	0
69	8,240.00	240.00	0.30	0.72	1,500	0
70	6,790.00	120.00	0.33	0.72	1,330	0
71	6,860.00	180.00	0.14	0.72	1,400	0
72	16,360.00	180.00	0.31	0.72	3,000	0
73	1,610.00	360.00	0.50	0.72	0	3,000
74	28,720.00	240.00	0.36	0.72	4,400	0
75	14,240.00	240.00	0.40	0.72	2,022	0
76	62,360.00	180.00	1.17	0.72	6,600	0
77	6,530.00	180.00	3.13	0.72	330	0
78	7,409.00	126.00	0.10	0.72	0	20,400
79	3,230.00	180.00	0.24	0.72	0	1,000
80	8,960.00	180.00	0.89	0.72	0	168
81	48,224.00	408.00	0.17	0.72	15,000	0
82	31,700.00	300.00	0.26	0.72	27,000	0
83	40,770.00	266.67	0.30	0.72	7,000	0
84	151,256.00	336.00	0.14	0.72	25,000	0
85	6,240.00	240.00	0.38	0.72	980	0
86	33,600.00	200.00	0.10	0.72	5,000	60,000
87	5,944.00	492.00	2.50	0.72	400	0
88	7,740.00	240.00	3.33	0.72	600	0
89	8,300.00	240.00	0.03	0.72	9,000	300
90	6,412.00	312.00	0.30	0.72	1,200	2,250
91	3,305.00	180.00	1.54	0.72	200	2,000
92	1,500.00	120.00	0.30	0.72	780	0
93	14,245.00	240.00	0.10	0.72	3,000	8,438
94	74,200.00	240.00	0.12	0.72	20,000	0

95	25,080.00	360.00	1.25	0.72	3,000	0
96	3,970.00	240.00	1.00	0.72	500	0
97	12,200.00	300.00	0.40	0.72	3,000	0
98	106,400.00	300.00	0.11	0.72	37,000	0
99	19,480.00	240.00	0.95	0.72	2,100	0
100	9,408.00	204.00	1.50	0.72	1,000	0
101	15,480.00	240.00	0.53	0.72	2,400	4,800
102	28,460.00	492.00	0.16	0.72	8,000	0
103	34,720.00	480.00	0.53	0.72	3,500	0
104	30,425.00	300.00	0.12	0.72	5,400	0
105	32,028.00	264.00	0.04	0.72	0	5,000
106	4,690.00	240.00	5.33	0.72	500	300
107	6,300.00	300.00	0.45	0.72	0	2,000
108	11,250.00	300.00	0.04	0.72	2,250	0
109	21,674.00	312.00	0.20	0.72	3,200	0
110	48,720.00	240.00	0.15	0.72	2,900	0
111	7,300.00	300.00	0.40	0.72	1,000	0
112	14,720.00	360.00	0.89	0.72	400	0
113	16,100.00	300.00	0.38	0.72	1,100	0
114	64,580.00	360.00	0.41	0.72	9,000	0
115	13,124.00	312.00	1.54	0.72	850	0
116	2,204.00	204.00	0.31	0.72	33,100	2,100
117	10,890.00	360.00	1.18	0.72	800	550
118	1,316.00	216.00	0.23	0.72	14,000	2,000
119	8,908.00	144.00	0.34	0.72	1,000	7,500
120	5,865.00	240.00	1.33	0.72	300	1,500
121	135,290.00	420.00	0.07	0.72	30,000	0
122	2,090.00	240.00	0.29	0.72	0	7,000
123	8,263.00	240.00	0.53	0.72	840	1,000
124	12,432.00	216.00	0.09	0.72	2,400	5,000
125	11,040.00	240.00	0.85	0.72	1,200	1,000
126	20,676.00	240.00	0.30	0.72	3,600	1,000
127	6,640.00	240.00	0.16	0.72	1,200	0
128	13,720.00	360.00	1.84	0.72	1,400	200
129	6,055.00	180.00	0.13	0.72	5,300	8,000
130	28,600.00	200.00	0.15	0.72	7,000	0
131	15,532.00	216.00	0.17	0.72	3,600	0
132	25,150.00	300.00	0.80	0.72	2,800	0
133	4,966.00	216.00	0.56	0.72	1,800	0
134	4,648.00	216.00	0.81	0.72	400	0
135	23,720.00	240.00	1.50	0.72	2,000	0
136	7,300.00	150.00	1.72	0.72	500	0
137	11,856.00	228.00	0.48	0.72	1,799	0
138	19,364.00	198.00	0.66	0.72	2,500	0
139	6,851.00	240.00	2.65	0.72	444	0
140	34,020.00	240.00	0.50	0.72	5,000	0
141	6,240.00	240.00	0.42	0.72	1,200	0
142	3,790.00	300.00	0.54	0.72	1,400	0
143	12,182.00	216.00	0.18	0.72	2,400	0
144	8,720.00	360.00	0.80	0.72	1,000	0
145	36,080.00	360.00	0.63	0.72	6,000	0
146	11,740.00	240.00	0.43	0.72	2,000	0
147	19,000.00	300.00	0.62	0.72	2,600	0

148	2,340.00	240.00	1.94	0.72	100	500
149	13,027.00	240.00	0.61	0.72	1,866	0
150	5,625.00	300.00	0.42	0.72	1,000	0
151	15,220.00	240.00	0.14	0.72	3,640	0
152	7,574.00	312.00	0.64	0.72	1,000	0
153	1,425.00	240.00	0.76	0.72	100	550
154	23,720.00	240.00	1.50	0.72	2,000	0
155	3,884.00	384.00	0.83	0.72	600	0
156	13,600.00	300.00	0.21	0.72	4,000	0
157	81,288.00	396.00	0.18	0.72	19,000	0
158	33,530.00	300.00	0.13	0.72	9,000	0
159	22,900.00	300.00	0.08	0.72	5,000	0
160	22,420.00	210.00	0.21	0.72	0	30,000
161	1,656.00	96.00	0.84	0.72	0	1,200
162	5,880.00	240.00	0.20	0.72	900	0
163	23,900.00	300.00	0.24	0.72	2,500	0
164	6,214.00	264.00	0.94	0.72	200	0
165	4,765.00	240.00	0.46	0.72	106	0
166	4,440.00	240.00	0.29	0.72	0	6,400
167	13,440.00	480.00	0.26	0.72	0	5,000
168	1,912.00	312.00	0.40	0.72	0	1,400
169	2,180.00	180.00	0.29	0.72	0	2,000
170	6,560.00	240.00	0.42	0.72	0	6,000
171	17,600.00	300.00	1.28	0.72	0	15,000
172	3,416.00	216.00	0.15	0.72	0	3,000
173	15,520.00	360.00	0.24	0.72	0	15,000
174	4,640.00	240.00	0.67	0.72	0	3,000
175	12,250.00	300.00	0.22	0.72	800	0
176	15,027.00	300.00	0.35	0.72	775	0
177	18,300.00	300.00	0.45	0.72	1,700	0
178	7,208.00	204.00	1.50	0.72	700	0
179	19,805.00	360.00	0.32	0.72	2,817	0
180	14,180.00	180.00	0.24	0.72	2,000	0
181	11,350.00	300.00	0.75	0.72	400	0
182	18,080.00	360.00	0.75	0.72	2,000	0
183	23,311.00	312.00	0.40	0.72	2,999	0
184	6,450.00	300.00	0.82	0.72	300	0
185	25,480.00	840.00	0.49	0.72	1,400	0
186	14,822.00	180.00	0.34	0.72	1,000	0
187	9,784.00	384.00	0.39	0.72	400	4,000
188	11,716.00	360.00	1.19	0.72	0	25
189	12,155.00	240.00	0.91	0.72	1,364	0
190	11,960.00	240.00	0.77	0.72	800	0
191	1,965.00	240.00	1.60	0.72	100	0
192	37,329.00	312.00	0.17	0.72	5,760	8,250
193	141,145.00	360.00	0.31	0.72	20,000	0
194	275,800.00	400.00	0.43	0.72	43,000	0
195	14,312.00	312.00	0.52	0.72	1,250	0
196	31,867.00	228.00	0.20	0.72	5,000	0
197	119,680.00	336.00	0.18	0.72	20,000	0
198	144,300.00	300.00	0.16	0.72	25,000	0
199	23,311.00	312.00	0.40	0.72	2,999	0
200	9,960.00	360.00	0.47	0.72	7,300	0

201	22,300.00	300.00	0.76	0.72	3,750	0
202	9,480.00	240.00	0.43	0.72	3,000	0
203	5,312.00	312.00	0.62	0.72	400	0
204	3,240.00	240.00	0.44	0.72	444	550
205	5,228.00	144.00	0.54	0.72	675	0
206	8,830.00	180.00	0.10	0.72	1,700	0
207	4,845.00	240.00	0.46	0.72	400	0
208	12,985.00	300.00	0.64	0.72	500	0
209	21,148.00	216.00	0.95	0.72	2,220	0
210	12,540.00	144.00	0.56	0.72	1,800	0
211	24,628.00	264.00	0.88	0.72	1,800	8,000
212	5,744.00	144.00	1.99	0.72	445	0
213	12,740.00	150.00	1.14	0.72	1,000	0
214	4,192.00	192.00	3.00	0.72	100	0
215	11,295.00	240.00	0.71	0.72	650	0
216	3,082.00	192.00	0.09	0.72	225	0
217	8,240.00	240.00	0.50	0.72	666	1,000
218	7,493.00	144.00	0.45	0.72	880	2,400
219	3,780.00	180.00	0.91	0.72	400	0
220	15,818.00	144.00	0.30	0.72	3,000	0
221	8,660.00	180.00	0.23	0.72	2,000	0
222	21,280.00	360.00	0.25	0.72	4,000	0
223	3,190.00	240.00	0.17	0.72	720	0
224	4,740.00	240.00	0.31	0.72	775	0
225	18,212.00	156.00	0.34	0.72	2,200	0
226	10,100.00	300.00	0.30	0.72	1,000	0
227	3,694.00	144.00	0.35	0.72	66	0
228	7,355.00	240.00	0.45	0.72	1,100	0
229	3,320.00	120.00	0.57	0.72	440	0
230	6,550.00	240.00	0.43	0.72	392	0
231	2,468.00	204.00	0.11	0.72	275	0
232	4,166.00	228.00	2.91	0.72	105	900
233	13,740.00	240.00	0.38	0.72	1,400	0
234	26,790.00	240.00	1.04	0.72	1,550	0
235	12,760.00	300.00	0.73	0.72	1,000	0
236	12,520.00	240.00	0.56	0.72	840	5,500
237	7,932.00	216.00	1.00	0.72	1,000	0
238	25,480.00	240.00	0.31	0.72	4,000	0
239	30,371.00	212.00	0.14	0.72	5,500	0
240	18,573.00	216.00	0.27	0.72	2,222	0
241	6,049.00	144.00	0.85	0.72	500	0
242	7,215.00	540.00	0.26	0.72	913	0
243	14,314.00	204.00	0.48	0.72	940	0
244	9,766.00	216.00	0.32	0.72	1,200	0
245	6,080.00	240.00	0.56	0.72	1,000	0
246	10,440.00	240.00	0.61	0.72	444	0
247	6,940.00	240.00	0.67	0.72	600	0
248	15,520.00	210.00	0.32	0.72	2,000	0
249	6,630.00	360.00	2.56	0.72	200	300
250	11,776.00	396.00	0.35	0.72	690	4,400
251	23,480.00	240.00	0.09	0.72	1,500	0
252	13,180.00	480.00	0.33	0.72	400	0
253	9,240.00	240.00	0.43	0.72	230	0

254	14,880.00	240.00	0.66	0.72	311	0
255	10,300.00	300.00	0.83	0.72	1,800	0
256	27,390.00	420.00	0.52	0.72	2,000	0
257	8,220.00	240.00	0.53	0.72	1,000	0
258	53,340.00	300.00	0.66	0.72	5,800	0
259	4,932.00	312.00	0.74	0.72	200	0
260	14,300.00	180.00	0.14	0.72	3,000	0
261	22,360.00	360.00	0.35	0.72	4,320	0
262	10,220.00	240.00	0.23	0.72	1,800	0
263	21,720.00	360.00	0.37	0.72	0	20,000
Mean	16,820.22	244.35	0.64	0.72	2,726.61	1,908.16
S.D.	27,379.16	94.76	0.66	0.00	5,868.62	5,228.48

A.6.2. (b.) 1860

Flour	**1860**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Wheat Flour (bbl.)	Quantity of Corn meal (bu.)
n	C	w_1	w_2	w_3	y_1	y_2
1	9,784.00	192.00	0.67	0.88	0	5,000
2	4,760.00	360.00	0.45	0.88	120	2,250
3	18,740.00	120.00	0.56	0.88	0	12,000
4	3,210.00	360.00	0.14	0.88	0	2,500
5	4,444.00	144.00	0.05	0.88	0	5,625
6	13,836.00	168.00	0.25	0.88	1,400	7,000
7	9,980.00	240.00	0.32	0.88	1,400	0
8	3,538.00	144.00	0.36	0.88	200	2,500
9	3,360.00	360.00	1.33	0.88	0	2,000
10	26,520.00	360.00	0.29	0.88	0	11,000
11	31,200.00	300.00	0.45	0.88	4,000	0
12	32,730.00	240.00	0.26	0.88	6,000	5,000
13	1,090.00	240.00	1.00	0.88	0	1,000
14	5,900.00	300.00	1.94	0.88	200	1,350
15	22,080.00	360.00	0.04	0.88	4,000	0
16	6,600.00	300.00	0.22	0.88	0	9,000
17	32,480.00	240.00	0.47	0.88	4,000	0
18	11,200.00	300.00	0.27	0.88	0	15,000
19	3,350.00	300.00	1.54	0.88	150	600
20	8,352.00	276.00	0.33	0.88	200	10,000
21	11,600.00	300.00	0.30	0.88	1,000	0
22	5,012.00	312.00	0.39	0.88	400	0
23	25,380.00	240.00	0.12	0.88	3,000	15,000
24	22,240.00	240.00	0.31	0.88	2,400	8,002
25	3,212.00	312.00	0.50	0.88	0	4,400
26	2,040.00	240.00	0.17	0.88	0	2,500
27	15,360.00	180.00	0.13	0.88	1,600	12,000
28	2,880.00	240.00	0.09	0.88	0	4,680

29	4,540.00	240.00	0.26	0.88	60	3,500
30	1,890.00	240.00	0.26	0.88	0	2,500
31	31,900.00	300.00	0.46	0.88	4,000	0
32	2,040.00	240.00	0.32	0.88	0	2,000
33	19,300.00	300.00	0.38	0.88	2,600	5,000
34	4,688.00	144.00	1.88	0.88	0	2,000
35	63,200.00	400.00	0.16	0.88	9,200	0
36	5,500.00	240.00	1.37	0.88	220	0
37	8,764.00	264.00	0.18	0.88	950	0
38	26,920.00	240.00	0.50	0.88	2,666	1,100
39	7,845.00	360.00	0.29	0.88	21	0
40	5,700.00	300.00	0.18	0.88	0	2,000
41	37,980.00	240.00	0.05	0.88	8,000	0
42	16,625.00	240.00	0.04	0.88	0	7,845
43	2,686.00	336.00	0.46	0.88	0	407
44	3,240.00	240.00	1.60	0.88	0	1,000
45	5,480.00	240.00	2.86	0.88	0	300
46	4,144.00	144.00	0.83	0.88	200	1,000
47	19,800.00	300.00	0.43	0.88	800	0
48	2,212.00	192.00	0.08	0.88	360	660
49	20,720.00	360.00	0.16	0.88	3,400	0
50	1,580.00	180.00	2.00	0.88	0	500
51	1,030.00	180.00	0.79	0.88	0	506
52	3,390.00	240.00	0.17	0.88	0	2,925
53	11,740.00	240.00	0.68	0.88	600	3,800
54	7,300.00	300.00	0.33	0.88	1,000	0
55	8,880.00	180.00	0.15	0.88	800	3,500
56	9,640.00	240.00	0.80	0.88	0	4,000
57	1,495.00	120.00	0.13	0.88	100	700
58	15,220.00	120.00	0.59	0.88	0	9,350
59	2,772.00	72.00	1.00	0.88	0	1,500
60	4,788.00	144.00	1.20	0.88	0	2,000
61	14,360.00	360.00	0.29	0.88	2,000	0
62	3,406.00	156.00	0.39	0.88	130	2,000
63	14,710.00	240.00	0.19	0.88	1,800	3,300
64	9,900.00	300.00	0.35	0.88	1,000	2,000
65	9,220.00	120.00	0.19	0.88	1,020	0
66	5,880.00	180.00	0.21	0.88	612	0
67	6,760.00	360.00	2.69	0.88	120	900
68	6,144.00	144.00	0.44	0.88	0	4,000
69	4,096.00	96.00	0.12	0.88	0	4,083
70	5,680.00	180.00	0.31	0.88	400	2,200
71	1,320.00	120.00	0.43	0.88	0	800
72	3,144.00	144.00	1.67	0.88	0	1,200
73	5,680.00	180.00	0.49	0.88	400	2,000
74	3,470.00	360.00	0.14	0.88	0	4,680
75	6,480.00	240.00	0.38	0.88	0	8,000
76	6,490.00	240.00	1.43	0.88	450	0
77	13,400.00	450.00	0.24	0.88	2,000	3,000
78	31,540.00	180.00	0.12	0.88	4,000	11,666
79	8,180.00	180.00	0.55	0.88	900	1,500
80	11,180.00	180.00	1.07	0.88	800	3,000
81	32,065.00	288.00	0.31	0.88	4,400	0

82	3,890.00	120.00	3.33	0.88	100	300
83	4,300.00	300.00	1.25	0.88	400	0
84	12,860.00	180.00	1.03	0.88	1,200	0
85	15,970.00	360.00	0.24	0.88	2,000	3,275
86	26,140.00	360.00	0.57	0.88	3,000	1,100
87	15,050.00	300.00	0.36	0.88	1,000	10,000
88	83,312.00	301.09	0.30	0.88	12,000	0
89	43,480.00	240.00	6.33	0.88	1,000	0
90	9,180.00	180.00	0.51	0.88	900	2,500
91	4,080.00	240.00	0.22	0.88	4,000	800
92	17,960.00	240.00	0.11	0.88	0	17,500
93	19,720.00	240.00	0.15	0.88	0	17,500
94	13,120.00	180.00	0.40	0.88	0	13,346
95	6,780.00	480.00	0.42	0.88	520	800
96	13,480.00	480.00	0.15	0.88	0	20,000
97	2,640.00	240.00	2.56	0.88	0	780
98	147,000.00	480.00	0.19	0.88	6,000	0
99	5,393.00	168.00	0.21	0.88	45	4,500
100	18,952.00	276.00	0.32	0.88	1,760	6,500
101	3,740.00	240.00	1.07	0.88	300	0
102	17,104.00	312.00	0.36	0.88	1,555	5,000
103	2,232.00	120.00	0.53	0.88	0	2,100
104	294,900.00	300.00	0.25	0.88	30,000	0
105	5,244.00	144.00	0.35	0.88	0	4,800
106	3,969.00	240.00	0.35	0.88	0	4,178
107	356,600.00	300.00	0.23	0.88	45,000	0
108	5,144.00	144.00	1.14	0.88	400	0
109	226,200.00	420.00	0.15	0.88	40,000	0
110	5,780.00	180.00	0.94	0.88	100	2,000
111	1,725.00	180.00	0.80	0.88	0	600
112	3,070.00	240.00	0.50	0.88	160	1,000
113	8,550.00	300.00	0.66	0.88	660	0
114	23,145.00	300.00	0.26	0.88	3,330	500
115	38,680.00	180.00	0.21	0.88	6,155	0
116	3,180.00	180.00	0.44	0.88	0	2,250
117	11,496.00	96.00	0.31	0.88	80	10,000
118	5,504.00	504.00	1.30	0.88	200	1,000
119	690.00	120.00	0.25	0.88	0	600
120	13,180.00	280.00	0.35	0.88	800	4,800
121	3,580.00	180.00	0.50	0.88	200	1,100
122	8,240.00	240.00	0.21	0.88	600	4,000
123	18,480.00	240.00	0.43	0.88	1,000	6,000
124	6,420.00	120.00	0.28	0.88	0	6,000
125	8,494.00	144.00	0.38	0.88	140	6,000
126	9,680.00	180.00	0.24	0.88	1,330	0
127	43,524.00	204.00	0.46	0.88	3,450	7,187
128	7,332.00	312.00	0.67	0.88	200	3,695
129	20,080.00	240.00	0.40	0.88	2,000	2,000
130	6,590.00	240.00	0.37	0.88	650	0
131	21,740.00	240.00	0.49	0.88	1,600	8,000
132	16,642.00	192.00	0.29	0.88	60	0
133	2,240.00	240.00	0.28	0.88	200	1,000
134	162,600.00	360.00	0.28	0.88	20,000	0

135	31,520.00	240.00	0.31	0.88	4,000	0
136	63,940.00	360.00	0.12	0.88	12,000	17,000
137	42,285.00	480.00	0.86	0.88	4,000	0
138	23,600.00	300.00	0.48	0.88	3,000	0
139	60,700.00	400.00	0.49	0.88	8,000	0
140	12,205.00	240.00	4.44	0.88	450	0
141	85,630.00	360.00	1.64	0.88	6,000	0
142	26,470.00	450.00	0.29	0.88	3,600	0
143	8,468.00	240.00	2.28	0.88	333	0
144	55,300.00	360.00	0.24	0.88	10,000	0
145	32,840.00	360.00	0.20	0.88	6,000	0
146	71,800.00	360.00	0.23	0.88	12,000	0
147	53,900.00	525.00	0.20	0.88	9,000	0
148	36,560.00	390.00	0.39	0.88	6,000	0
149	27,900.00	300.00	0.29	0.88	4,000	0
150	25,450.00	240.00	0.82	0.88	1,600	10,000
151	35,365.00	360.00	0.17	0.88	6,000	2,500
152	122,505.00	360.00	0.24	0.88	19,000	0
153	61,880.00	360.00	0.10	0.88	10,000	13,000
154	10,720.00	240.00	0.67	0.88	1,200	0
155	7,570.00	300.00	0.60	0.88	800	300
156	9,540.00	360.00	0.63	0.88	1,000	0
157	17,580.00	360.00	0.48	0.88	2,297	2,250
158	16,750.00	300.00	0.39	0.88	2,250	4,500
159	21,220.00	240.00	0.33	0.88	3,000	0
160	12,230.00	240.00	0.92	0.88	1,000	600
161	42,960.00	240.00	0.50	0.88	6,000	0
162	2,290.00	240.00	0.52	0.88	300	0
163	14,600.00	300.00	0.36	0.88	2,000	0
164	28,000.00	300.00	0.19	0.88	4,000	4,000
165	108,850.00	300.00	1.04	0.88	10,000	0
166	6,900.00	300.00	0.40	0.88	800	4,000
167	24,360.00	240.00	0.32	0.88	3,000	5,000
168	22,590.00	360.00	0.40	0.88	3,333	6,000
169	16,580.00	240.00	0.49	0.88	202	6,000
170	33,020.00	240.00	0.23	0.88	5,222	1,000
171	14,480.00	480.00	0.22	0.88	2,080	2,300
172	9,435.00	300.00	0.66	0.88	1,000	250
173	46,920.00	360.00	0.16	0.88	6,700	1,200
174	9,650.00	360.00	1.21	0.88	750	0
175	24,400.00	400.00	0.59	0.88	4,000	0
176	4,980.00	180.00	0.19	0.88	800	10,000
177	5,960.00	360.00	1.18	0.88	613	0
178	4,620.00	120.00	1.25	0.88	450	0
179	27,620.00	405.00	0.30	0.88	7,200	0
180	41,600.00	360.00	0.48	0.88	5,200	0
181	21,730.00	240.00	0.39	0.88	3,400	0
182	20,960.00	480.00	0.32	0.88	4,400	4,570
183	86,840.00	320.00	0.63	0.88	10,000	0
184	8,775.00	300.00	0.66	0.88	1,800	0
185	7,220.00	240.00	0.45	0.88	800	0
186	14,145.00	420.00	3.21	0.88	440	0
187	18,090.00	360.00	0.18	0.88	800	0

188	34,920.00	480.00	0.64	0.88	3,500	0
189	66,920.00	480.00	0.23	0.88	12,000	0
190	36,200.00	400.00	0.60	0.88	5,000	0
191	38,840.00	420.00	0.23	0.88	7,000	0
192	6,980.00	480.00	1.30	0.88	450	550
193	21,674.00	312.00	0.20	0.88	3,200	0
194	49,200.00	300.00	0.18	0.88	8,000	0
195	13,924.00	312.00	0.52	0.88	1,700	0
196	26,860.00	320.00	0.45	0.88	700	16,000
197	12,380.00	240.00	0.22	0.88	1,200	0
198	16,780.00	480.00	0.48	0.88	2,000	0
199	25,100.00	300.00	0.14	0.88	3,780	0
200	16,294.00	240.00	0.18	0.88	4,380	0
201	56,100.00	300.00	0.30	0.88	6,600	0
202	5,200.00	300.00	1.75	0.88	400	0
203	6,240.00	240.00	0.63	0.88	800	0
204	30,200.00	400.00	0.29	0.88	600	0
205	35,900.00	300.00	0.33	0.88	3,750	0
206	18,312.00	156.00	0.77	0.88	0	7,300
207	2,620.00	120.00	0.23	0.88	0	8,000
208	110,460.00	360.00	0.09	0.88	12,000	35,000
209	6,140.00	240.00	0.65	0.88	500	500
210	20,470.00	360.00	0.24	0.88	3,000	0
211	187,160.00	360.00	0.06	0.88	30,000	0
212	6,060.00	360.00	0.83	0.88	200	0
213	2,000.00	480.00	0.20	0.88	340	0
214	9,360.00	360.00	1.50	0.88	800	0
215	30,720.00	360.00	0.17	0.88	5,000	0
216	7,860.00	360.00	0.42	0.88	1,000	0
217	30,946.00	348.00	0.45	0.88	4,000	0
218	9,810.00	360.00	0.05	0.88	888	0
219	32,755.00	282.00	0.35	0.88	430	0
220	8,812.00	312.00	0.64	0.88	900	0
221	27,824.00	312.00	0.14	0.88	5,000	0
222	22,280.00	480.00	0.19	0.88	3,333	0
223	3,740.00	240.00	1.08	0.88	500	0
224	8,800.00	300.00	0.38	0.88	1,600	0
225	22,395.00	360.00	0.20	0.88	30,000	1,500
226	4,662.00	300.00	0.44	0.88	500	1,000
227	7,480.00	240.00	1.75	0.88	350	500
228	11,660.00	11.61	0.32	0.88	1,733	2,632
229	41,650.00	300.00	0.17	0.88	6,500	0
230	68,720.00	480.00	0.40	0.88	8,000	2,000
231	60,553.00	300.00	0.10	0.88	8,000	0
232	35,900.00	300.00	0.42	0.88	5,000	0
233	16,600.00	300.00	0.28	0.88	2,400	0
234	9,360.00	360.00	0.67	0.88	1,020	0
235	9,600.00	300.00	1.04	0.88	800	0
236	11,685.00	360.00	1.03	0.88	666	0
237	59,036.00	372.00	0.15	0.88	8,320	0
238	14,100.00	300.00	0.66	0.88	1,250	0
239	32,220.00	360.00	0.37	0.88	3,120	0
240	12,800.00	300.00	1.08	0.88	1,100	0

241	9,030.00	240.00	0.54	0.88	300	5,000
242	64,400.00	300.00	0.26	0.88	18,000	0
243	16,600.00	300.00	0.90	0.88	1,600	0
244	15,240.00	240.00	3.64	0.88	600	0
245	28,900.00	300.00	0.68	0.88	3,550	0
246	7,944.00	144.00	0.60	0.88	700	0
247	9,360.00	360.00	0.73	0.88	1,000	0
248	23,280.00	240.00	0.54	0.88	2,200	6,000
249	6,280.00	240.00	1.00	0.88	600	0
250	8,915.00	420.00	0.38	0.88	1,920	0
251	20,600.00	300.00	0.25	0.88	3,500	0
252	43,500.00	375.00	0.30	0.88	6,666	0
253	16,800.00	300.00	0.33	0.88	3,000	0
254	192,940.00	420.00	0.22	0.88	30,000	0
255	31,960.00	480.00	0.34	0.88	8,000	0
256	51,050.00	300.00	0.10	0.88	7,600	0
257	10,622.00	336.00	0.87	0.88	1,200	1,000
258	54,160.00	432.00	0.26	0.88	8,000	0
259	21,360.00	360.00	0.32	0.88	4,000	0
260	28,660.00	360.00	0.52	0.88	4,695	0
261	142,325.00	360.00	0.11	0.88	25,100	0
262	27,300.00	450.00	0.38	0.88	4,000	0
263	18,280.00	480.00	0.05	0.88	0	20,000
264	33,700.00	240.00	0.16	0.88	2,000	20,000
265	2,380.00	420.00	0.20	0.88	180	700
266	12,220.00	360.00	0.06	0.88	1,100	7,000
267	17,600.00	300.00	0.36	0.88	1,840	0
268	6,040.00	240.00	0.31	0.88	400	3,000
269	4,712.00	312.00	0.18	0.88	0	6,000
270	2,912.00	312.00	0.69	0.88	125	600
271	60,773.00	510.00	0.04	0.88	5,300	17,500
272	31,888.00	360.00	0.40	0.88	0	21,600
273	33,700.00	360.00	0.21	0.88	400	0
274	52,900.00	300.00	0.27	0.88	0	50,000
275	9,400.00	300.00	0.08	0.88	0	10,000
276	13,360.00	360.00	0.08	0.88	0	16,000
277	4,225.00	300.00	0.36	0.88	200	500
278	5,542.00	192.00	0.21	0.88	0	3,000
279	13,260.00	360.00	0.42	0.88	0	8,000
280	68,470.00	420.00	0.15	0.88	600	60,000
281	4,415.00	240.00	0.92	0.88	0	2,000
282	19,009.00	300.00	0.18	0.88	1,175	10,000
283	32,270.00	420.00	0.55	0.88	1,600	9,000
284	54,200.00	300.00	0.24	0.88	0	10,000
285	28,810.00	240.00	0.18	0.88	7,900	0
286	9,160.00	360.00	0.13	0.88	430	0
287	27,250.00	300.00	0.72	0.88	1,050	0
288	15,275.00	300.00	1.49	0.88	400	0
289	14,240.00	240.00	0.50	0.88	2,000	0
290	20,525.00	300.00	0.42	0.88	1,400	0
291	10,367.00	240.00	2.13	0.88	250	0
292	57,935.00	300.00	0.19	0.88	5,000	0
293	7,900.00	300.00	0.14	0.88	400	0

294	10,925.00	300.00	0.65	0.88	700	1,000
295	6,950.00	300.00	0.52	0.88	450	2,000
296	5,630.00	240.00	2.25	0.88	130	0
297	7,940.00	240.00	0.23	0.88	800	0
298	26,520.00	480.00	0.45	0.88	1,400	0
299	2,220.00	330.00	2.14	0.88	50	0
300	8,600.00	300.00	0.24	0.88	750	0
301	12,220.00	360.00	4.46	0.88	160	0
302	20,095.00	360.00	1.08	0.88	1,410	0
303	21,657.00	360.00	0.51	0.88	1,112	5,000
304	35,488.00	360.00	0.32	0.88	3,992	0
305	208,000.00	428.57	0.26	0.88	25,000	0
306	27,020.00	360.00	0.65	0.88	2,500	0
307	10,347.00	408.00	0.75	0.88	333	0
308	17,914.00	300.00	0.40	0.88	1,400	0
309	13,360.00	240.00	1.88	0.88	175	0
310	7,700.00	150.00	0.08	0.88	300	0
311	202,400.00	480.00	0.10	0.88	26,250	0
312	35,000.00	300.00	0.24	0.88	5,000	0
313	9,680.00	240.00	0.87	0.88	660	0
314	22,550.00	400.00	2.39	0.88	900	0
315	28,172.00	222.00	0.51	0.88	2,960	0
316	30,480.00	160.00	1.08	0.88	2,000	0
317	13,630.00	240.00	0.61	0.88	900	0
318	1,450.00	150.00	0.20	0.88	6,000	0
319	15,060.00	420.00	1.75	0.88	444	800
320	11,810.00	360.00	0.78	0.88	1,250	0
321	4,033.00	240.00	0.89	0.88	0	400
322	5,862.00	312.00	0.98	0.88	150	0
323	6,667.00	180.00	0.54	0.88	700	0
324	32,100.00	150.00	0.56	0.88	3,500	0
325	23,600.00	300.00	1.33	0.88	2,000	0
326	7,240.00	240.00	0.23	0.88	0	2,200
327	36,300.00	150.00	0.32	0.88	6,000	0
328	31,400.00	150.00	0.44	0.88	4,500	0
329	10,760.00	360.00	1.18	0.88	850	0
330	35,444.00	222.00	0.50	0.88	5,000	0
331	6,130.00	240.00	1.00	0.88	300	0
332	15,700.00	180.00	1.56	0.88	600	0
333	16,095.00	180.00	2.09	0.88	500	0
334	19,770.00	360.00	0.27	0.88	2,222	0
335	12,999.00	312.00	0.57	0.88	1,366	0
336	707,200.00	400.00	0.16	0.88	105,840	0
337	5,360.00	360.00	0.56	0.88	400	0
338	10,860.00	180.00	0.61	0.88	1,100	0
339	8,465.00	240.00	0.69	0.88	820	0
340	15,480.00	240.00	0.78	0.88	140	0
341	9,200.00	300.00	0.65	0.88	444	0
342	6,940.00	240.00	0.30	0.88	500	0
343	8,336.00	336.00	0.27	0.88	430	0
344	35,980.00	240.00	0.52	0.88	4,500	0
345	7,462.00	312.00	0.65	0.88	445	2,200
346	48,700.00	300.00	0.43	0.88	5,500	0

347	40,340.00	360.00	0.28	0.88	5,000	0
348	18,400.00	300.00	0.89	0.88	1,200	0
349	22,230.00	240.00	0.27	0.88	2,500	0
350	93,004.00	252.00	0.35	0.88	12,000	0
351	48,470.00	360.00	0.18	0.88	4,000	19,800
352	14,920.00	360.00	1.47	0.88	800	0
353	11,076.00	288.00	0.25	0.88	1,500	0
354	20,762.00	240.00	0.28	0.88	2,400	0
355	21,676.00	180.00	0.24	0.88	3,000	0
356	19,920.00	240.00	0.51	0.88	2,640	0
357	10,990.00	240.00	0.40	0.88	1,500	0
358	5,662.00	312.00	1.09	0.88	4,000	700
359	6,440.00	240.00	0.57	0.88	450	0
360	31,284.00	192.00	0.22	0.88	3,200	0
361	21,600.00	300.00	0.43	0.88	1,950	0
362	11,560.00	360.00	0.53	0.88	700	0
363	46,480.00	240.00	0.65	0.88	4,500	0
364	45,235.00	150.00	0.36	0.88	5,414	0
365	29,410.00	240.00	1.11	0.88	2,200	0
366	10,268.00	156.00	3.38	0.88	223	0
367	7,298.00	228.00	0.47	0.88	210	0
368	18,580.00	180.00	0.96	0.88	550	0
369	61,240.00	270.00	1.27	0.88	2,450	0
370	26,124.00	308.00	0.56	0.88	2,000	0
371	11,440.00	240.00	1.36	0.88	1,022	0
372	43,600.00	720.00	0.50	0.88	15,000	0
373	2,197.00	240.00	2.70	0.88	45	0
374	1,287.00	312.00	0.82	0.88	60	0
375	8,550.00	300.00	1.32	0.88	450	0
376	14,395.00	180.00	0.52	0.88	2,149	0
377	2,140.00	240.00	0.97	0.88	180	0
378	4,079.00	180.00	2.68	0.88	60	0
379	34,860.00	300.00	1.02	0.88	2,000	0
380	2,912.00	312.00	0.50	0.88	400	0
381	16,840.00	420.00	0.58	0.88	2,400	0
382	9,880.00	480.00	0.25	0.88	0	7,600
383	31,600.00	300.00	0.23	0.88	0	24,000
384	37,900.00	800.00	0.56	0.88	1,600	200
385	7,980.00	960.00	0.21	0.88	1,400	0
386	5,180.00	780.00	0.39	0.88	600	0
387	44,160.00	1,080.00	0.71	0.88	4,444	0
Mean	26,430.63	294.58	0.62	0.88	3,140.35	2,469.75
S.D.	50,886.16	112.85	0.70	0.00	7,530.96	5,898.15

A.6.2.(c.) 1870

Flour	**1870**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Wheat Flour (bbl.)	Quantity of Corn meal (bu.)
n	C	w_1	w_2	w_3	y_1	y_2
1	12,096.00	332.00	0.65	1.12	375	2,190
2	1,611.00	48.00	0.41	1.12	0	956
3	9,825.00	300.00	0.04	1.12	0	9,125
4	24,296.00	259.20	0.12	1.12	0	18,000
5	13,000.00	250.00	0.47	1.12	400	5,500
6	2,460.00	160.00	0.16	1.12	0	2,500
7	1,250.00	150.00	0.33	1.12	0	1,000
8	11,200.00	100.00	2.07	1.12	0	1,930
9	2,740.00	60.00	0.20	1.12	0	2,500
10	3,775.00	33.33	1.79	1.12	0	1,000
11	5,460.00	200.00	0.11	1.12	136	368
12	6,010.00	175.00	1.58	1.12	100	500
13	3,080.00	40.00	0.19	1.12	0	1,664
14	3,136.00	318.00	0.51	1.12	0	18,000
15	1,625.00	125.00	0.36	1.12	0	1,200
16	6,468.00	133.33	1.95	1.12	134	734
17	17,363.00	400.00	0.43	1.12	0	1,200
18	12,650.00	300.00	0.32	1.12	800	4,000
19	950.00	50.00	1.00	1.12	0	300
20	30,600.00	300.00	0.28	1.12	0	8,000
21	1,275.00	100.00	0.56	1.12	0	300
22	1,575.00	175.00	0.84	1.12	50	300
23	3,050.00	250.00	0.20	1.12	0	10,000
24	14,180.00	90.00	0.49	1.12	600	6,000
25	6,900.00	200.00	0.40	1.12	400	1,000
26	1,575.00	75.00	0.40	1.12	0	1,000
27	750.00	50.00	0.28	1.12	0	525
28	5,900.00	100.00	0.46	1.12	0	1,200
29	10,100.00	100.00	0.24	1.12	660	2,220
30	5,200.00	200.00	0.17	1.12	0	4,000
31	1,540.00	40.00	1.72	1.12	0	500
32	12,750.00	250.00	0.16	1.12	0	5,478
33	3,700.00	150.00	0.21	1.12	0	1,000
34	1,975.00	75.00	1.43	1.12	0	600
35	16,700.00	100.00	0.09	1.12	0	800
36	1,800.00	200.00	1.56	1.12	0	400
37	11,652.00	252.00	0.31	1.12	0	3,600
38	2,948.00	198.00	0.23	1.12	0	1,000
39	11,504.00	250.67	0.48	1.12	1,200	0
40	12,150.00	150.00	0.19	1.12	0	10,500
41	3,200.00	50.00	0.75	1.12	0	3,300
42	6,650.00	150.00	0.44	1.12	0	4,500
43	15,250.00	250.00	0.25	1.12	0	5,000

44	240,940.00	255.00	0.04	1.12	28,566	56,000
45	4,550.00	400.00	0.57	1.12	371	0
46	8,830.00	150.00	0.23	1.12	550	1,620
47	61,325.00	241.67	0.23	1.12	8,000	0
48	4,100.00	100.00	0.30	1.12	660	0
49	2,280.00	100.00	0.27	1.12	0	1,500
50	2,900.00	100.00	0.37	1.12	0	2,000
51	15,500.00	175.00	0.07	1.12	1,200	8,000
52	21,125.00	525.00	0.29	1.12	0	10,000
53	32,800.00	400.00	0.40	1.12	2,550	8,480
54	19,800.00	133.33	0.30	1.12	1,600	6,650
55	1,330.00	50.00	0.56	1.12	0	1,000
56	30,006.00	200.00	0.43	1.12	3,000	2,000
57	7,150.00	150.00	0.60	1.12	0	4,800
58	65,223.00	525.00	0.27	1.12	7,642	0
59	5,060.00	250.00	0.27	1.12	400	300
60	31,700.00	250.00	0.31	1.12	0	4,000
61	27,920.00	375.00	0.62	1.12	3,000	0
62	51,500.00	600.00	0.47	1.12	1,000	0
63	43,875.00	666.67	0.80	1.12	0	533
64	9,110.00	360.00	0.15	1.12	666	333
65	60,450.00	425.00	0.25	1.12	4,600	0
66	160,000.00	454.55	0.12	1.12	23,000	0
67	27,150.00	150.00	0.32	1.12	2,700	0
68	10,200.00	700.00	0.45	1.12	2,327	0
69	48,800.00	475.00	0.91	1.12	6,100	0
70	121,030.00	600.00	0.37	1.12	15,000	500
71	288,000.00	1,000.00	0.09	1.12	40,000	0
72	112,400.00	777.78	0.09	1.12	18,000	0
73	26,450.00	250.00	0.71	1.12	1,500	0
74	13,060.00	150.00	0.33	1.12	1,200	100,000
75	20,660.00	400.00	0.11	1.12	2,000	0
76	12,325.00	150.00	0.08	1.12	60	0
77	20,800.00	500.00	0.50	1.12	2,400	0
78	21,850.00	425.00	0.26	1.12	1,600	0
79	15,285.00	300.00	0.69	1.12	1,200	0
80	38,220.00	300.00	0.20	1.12	5,000	1,300
81	60,160.00	450.00	0.24	1.12	8,000	4,600
82	445,000.00	750.00	0.12	1.12	66,000	0
83	7,100.00	500.00	2.59	1.12	272	0
84	17,830.00	65.00	4.60	1.12	300	0
85	17,160.00	500.00	0.48	1.12	1,600	0
86	7,050.00	400.00	0.79	1.12	637	0
87	21,055.00	300.00	0.36	1.12	2,400	0
88	27,720.00	1,200.00	0.38	1.12	0	13,440
89	13,600.00	75.00	1.17	1.12	0	4,000
90	236,230.00	625.00	0.25	1.12	0	30,575
91	62,000.00	600.00	0.08	1.12	6,000	0
92	4,200.00	200.00	0.29	1.12	0	3,500
93	39,600.00	600.00	0.17	1.12	0	33,600
94	3,600.00	200.00	0.12	1.12	0	3,000
95	6,850.00	150.00	0.31	1.12	0	4,000
96	27,350.00	550.00	0.19	1.12	0	6,600

97	34,000.00	250.00	0.08	1.12	800	0
98	89,000.00	500.00	0.40	1.12	2,250	0
99	45,305.00	700.00	0.21	1.12	1,809	0
100	113,500.00	500.00	2.29	1.12	0	5,211
101	80,500.00	625.00	0.24	1.12	8,000	0
102	58,900.00	233.33	0.72	1.12	0	4,400
103	44,331.00	500.00	0.77	1.12	1,600	0
104	473,650.00	777.78	0.32	1.12	38,700	0
105	25,005.00	350.00	0.50	1.12	174	1,650
106	5,125.00	75.00	1.32	1.12	240	0
107	27,904.00	600.00	0.49	1.12	840	0
108	501,400.00	545.45	0.28	1.12	60,000	0
109	14,500.00	250.00	0.32	1.12	1,035	0
110	8,980.00	600.00	0.29	1.12	60	0
111	24,250.00	600.00	0.40	1.12	995	0
112	31,450.00	450.00	0.36	1.12	1,800	0
113	29,445.00	400.00	2.05	1.12	0	2,500
114	18,400.00	400.00	3.47	1.12	800	0
115	46,990.00	250.00	0.54	1.12	1,980	0
116	21,700.00	800.00	0.26	1.12	400	0
117	5,550.00	233.33	0.24	1.12	220	0
118	41,300.00	500.00	0.20	1.12	0	10,000
119	49,700.00	216.67	0.61	1.12	4,000	1,500
120	14,800.00	300.00	0.42	1.12	800	0
121	7,650.00	600.00	0.39	1.12	200	0
122	22,792.00	700.00	0.81	1.12	909	0
123	34,070.00	500.00	0.87	1.12	1,111	0
124	18,050.00	150.00	0.56	1.12	1,100	0
125	16,340.00	540.00	0.26	1.12	4,250	0
126	10,300.00	150.00	1.25	1.12	800	0
Mean	39,023.93	323.14	0.56	1.12	3,260.55	3,821.29
S.D.	81,312.06	223.74	0.66	0.00	9,843.75	11,098.62

2.(d.) 1880

Flour	**1880**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Wheat Flour (bbl.)	Quantity of Corn meal (bu.)
n	C	w_1	w_2	w_3	y_1	y_2
1	6,520.00	80.00	0.77	0.83	165	4,365
2	5,725.00	150.00	0.67	0.83	182	4,802
3	4,550.00	300.00	0.45	0.83	143	3,788
4	7,350.00	175.00	0.83	0.83	181	4,774
5	810.00	60.00	0.19	0.83	33	868
6	5,160.00	160.00	0.22	0.83	195	5,158
7	14,875.00	187.50	0.32	0.83	538	14,204
8	3,385.00	260.00	0.12	0.83	149	3,945

9	1,450.00	33.33	1.07	0.83	32	845
10	6,400.00	66.67	0.80	0.83	160	4,216
11	12,700.00	100.00	0.12	0.83	538	14,204
12	11,650.00	225.00	0.38	0.83	366	9,672
13	5,300.00	75.00	0.43	0.83	199	5,264
14	9,506.00	273.00	0.58	0.83	256	6,764
15	6,300.00	100.00	0.57	0.83	187	4,937
16	15,200.00	266.67	0.22	0.83	573	15,128
17	2,470.00	140.00	0.08	0.83	107	2,818
18	16,578.00	114.00	0.12	0.83	699	18,459
19	8,700.00	450.00	0.12	0.83	361	9,525
20	5,405.00	30.00	2.38	0.83	72	1,894
21	1,215.00	37.50	0.17	0.83	56	1,465
22	2,276.00	78.00	0.51	0.83	67	1,759
23	8,890.00	300.00	0.24	0.83	356	9,390
24	4,237.00	56.00	0.02	0.83	192	5,073
25	2,530.00	125.00	0.60	0.83	72	1,894
26	4,700.00	50.00	0.44	0.83	145	3,833
27	10,875.00	300.00	0.39	0.83	440	11,611
28	6,000.00	250.00	0.26	0.83	243	6,425
29	6,806.00	306.00	0.36	0.83	235	6,200
30	2,417.00	10.00	0.43	0.83	79	2,096
31	4,110.00	100.00	0.71	0.83	120	3,156
32	8,470.00	145.00	0.29	0.83	368	9,725
33	2,890.00	183.33	0.37	0.83	114	3,021
34	1,394.00	75.00	2.00	0.83	21	564
35	3,325.00	112.50	0.33	0.83	128	3,382
36	9,450.00	150.00	1.00	0.83	213	5,636
37	7,635.00	85.00	0.06	0.83	360	9,492
38	10,060.00	125.00	0.30	0.83	359	9,469
39	9,059.00	200.00	0.26	0.83	331	8,736
40	77,350.00	228.57	0.07	0.83	3,448	91,027
41	1,700.00	100.00	0.32	0.83	67	1,781
42	12,195.00	175.00	0.11	0.83	592	15,624
43	1,850.00	100.00	0.38	0.83	67	1,759
44	8,235.00	175.00	0.28	0.83	320	8,455
45	9,525.00	200.00	0.43	0.83	301	7,947
46	6,638.00	78.00	0.07	0.83	295	7,801
47	1,160.00	150.00	0.75	0.83	34	902
48	8,525.00	200.00	1.03	0.83	207	5,456
49	2,130.00	130.00	0.83	0.83	51	1,353
50	7,166.00	125.00	0.63	0.83	205	5,411
51	5,770.00	175.00	0.17	0.83	253	6,668
52	1,275.00	125.00	0.33	0.83	64	1,691
53	1,700.00	75.00	2.40	0.83	21	564
54	4,172.00	100.00	2.00	0.83	64	1,691
55	7,425.00	150.00	0.32	0.83	269	7,102
56	3,655.00	150.00	0.87	0.83	98	2,593
57	1,075.00	125.00	0.19	0.83	45	1,197
58	7,784.00	150.00	0.18	0.83	354	9,356
59	24,100.00	83.33	0.08	0.83	1,029	27,167
60	11,997.00	257.33	0.30	0.83	423	11,155
61	11,997.00	257.33	0.30	0.83	423	11,155

62	166,500.00	312.50	0.25	0.83	5,978	157,818
63	3,800.00	250.00	0.33	0.83	128	3,371
64	4,300.00	150.00	0.81	0.83	111	2,931
65	4,250.00	200.00	0.71	0.83	120	3,156
66	21,090.00	300.00	0.56	0.83	615	16,232
67	51,600.00	400.00	0.53	0.83	1,600	42,245
68	16,400.00	250.00	0.19	0.83	692	18,262
69	5,170.00	70.00	0.38	0.83	171	4,509
70	30,200.00	300.00	0.18	0.83	1,204	31,789
71	2,710.00	66.67	0.17	0.83	124	3,269
72	3,750.00	75.00	0.27	0.83	155	4,103
73	2,200.00	150.00	1.42	0.83	45	1,195
74	8,000.00	125.00	1.40	0.83	152	4,024
75	216,000.00	500.00	0.52	0.83	6,136	161,989
76	17,900.00	342.86	1.19	0.83	358	9,447
77	587.00	25.00	0.60	0.83	21	564
78	2,410.00	28.57	0.19	0.83	115	3,044
79	4,325.00	30.00	0.39	0.83	142	3,750
80	12,100.00	25.00	0.51	0.83	418	11,038
81	9,530.00	96.00	0.61	0.83	286	7,539
82	5,195.00	17.50	0.18	0.83	284	7,508
83	17,600.00	400.00	0.64	0.83	484	12,772
84	105,650.00	150.00	0.04	0.83	4,654	122,873
85	3,170.00	60.00	0.45	0.83	142	3,752
86	29,900.00	400.00	0.28	0.83	1,238	32,691
87	600.00	25.00	1.50	0.83	9	225
88	13,200.00	300.00	0.55	0.83	389	10,258
89	184,800.00	463.16	0.16	0.83	7,771	205,164
90	13,558.00	258.33	2.50	0.83	171	4,509
91	6,990.00	240.00	0.63	0.83	204	5,394
92	3,600.00	100.00	0.11	0.83	162	4,284
93	20,600.00	300.00	0.67	0.83	640	16,909
94	23,100.00	300.00	0.59	0.83	709	18,724
95	9,900.00	100.00	1.33	0.83	192	5,073
96	4,945.00	87.50	1.15	0.83	111	2,931
97	8,000.00	50.00	0.06	0.83	388	10,238
98	6,388.00	210.00	0.10	0.83	264	6,981
99	4,675.00	425.00	3.33	0.83	51	1,353
100	5,195.00	87.50	0.24	0.83	180	4,745
101	2,928.00	205.00	0.37	0.83	115	3,044
102	1,525.00	50.00	0.54	0.83	51	1,353
103	3,650.00	78.00	0.60	0.83	107	2,818
104	4,650.00	150.00	0.44	0.83	154	4,058
105	6,330.00	150.00	0.30	0.83	213	5,636
106	2,060.00	150.00	0.53	0.83	64	1,691
107	2,330.00	200.00	0.36	0.83	94	2,480
108	2,790.00	125.00	0.51	0.83	85	2,232
109	2,700.00	50.00	0.92	0.83	70	1,837
110	3,600.00	50.00	0.31	0.83	139	3,664
111	2,500.00	75.00	0.22	0.83	96	2,536
112	3,375.00	150.00	0.54	0.83	120	3,156
113	3,075.00	60.00	0.29	0.83	120	3,156
114	2,220.00	30.00	1.60	0.83	40	1,060

115	2,115.00	100.00	0.30	0.83	99	2,615
116	2,317.00	50.00	0.61	0.83	70	1,855
117	7,100.00	142.86	0.61	0.83	210	5,546
118	2,900.00	300.00	0.17	0.83	128	3,382
119	4,400.00	150.00	2.92	0.83	51	1,353
120	6,150.00	250.00	1.67	0.83	102	2,705
121	3,825.00	125.00	0.31	0.83	137	3,607
122	6,925.00	250.00	1.26	0.83	136	3,578
123	5,254.00	200.00	0.60	0.83	143	3,787
124	5,949.00	525.00	0.91	0.83	141	3,720
125	8,640.00	240.00	0.47	0.83	274	7,233
126	9,188.00	156.50	0.48	0.83	268	7,074
127	18,363.00	313.00	0.10	0.83	854	22,545
128	31,800.00	150.00	0.06	0.83	1,397	36,873
129	2,355.00	100.00	0.48	0.83	90	2,367
130	8,668.00	156.00	0.12	0.83	360	9,507
131	4,560.00	150.00	0.14	0.83	186	4,924
132	38,500.00	233.33	0.19	0.83	1,573	41,540
133	8,100.00	150.00	0.21	0.83	299	7,891
134	3,400.00	250.00	2.23	0.83	48	1,263
135	7,925.00	150.00	0.32	0.83	306	8,083
136	9,000.00	197.50	0.44	0.83	292	7,705
137	6,350.00	50.00	0.41	0.83	209	5,518
138	6,060.00	235.00	0.56	0.83	191	5,041
139	13,150.00	125.00	0.16	0.83	529	13,978
140	2,015.00	53.75	0.96	0.83	44	1,172
141	7,300.00	250.00	1.13	0.83	171	4,509
142	6,450.00	200.00	0.13	0.83	321	8,477
143	10,500.00	150.00	0.08	0.83	510	13,471
144	1,550.00	150.00	0.21	0.83	62	1,635
145	4,600.00	100.00	0.67	0.83	128	3,382
146	3,580.00	300.00	1.00	0.83	85	2,255
147	4,900.00	133.33	1.34	0.83	96	2,525
148	69,150.00	300.00	1.31	0.83	1,304	34,440
149	10,350.00	66.67	0.19	0.83	402	10,602
150	3,500.00	212.50	0.18	0.83	141	3,731
151	1,750.00	100.00	0.09	0.83	92	2,435
152	18,274.00	470.00	0.26	0.83	662	17,473
153	7,130.00	100.00	1.11	0.83	154	4,058
154	8,200.00	250.00	0.13	0.83	327	8,624
155	8,900.00	300.00	0.39	0.83	324	8,567
156	1,850.00	250.00	0.33	0.83	64	1,691
157	4,187.00	275.00	0.67	0.83	128	3,382
158	6,250.00	200.00	0.16	0.83	265	6,989
159	5,725.00	225.00	0.32	0.83	199	5,242
160	11,300.00	150.00	0.71	0.83	302	7,964
161	5,850.00	75.00	2.11	0.83	81	2,142
162	5,400.00	250.00	0.11	0.83	235	6,200
163	11,025.00	325.00	0.48	0.83	357	9,424
164	11,300.00	150.00	0.75	0.83	342	9,018
165	5,200.00	150.00	0.33	0.83	192	5,073
166	11,400.00	150.00	0.36	0.83	418	11,047
167	1,270.00	40.00	0.34	0.83	64	1,680

168	15,300.00	350.00	0.45	0.83	474	12,513
169	3,750.00	100.00	0.46	0.83	139	3,675
170	1,400.00	83.33	0.11	0.83	79	2,085
171	21,300.00	300.00	0.02	0.83	956	25,251
172	1,974.00	0.33	1.05	0.83	41	1,071
173	5,245.00	150.00	0.21	0.83	199	5,258
174	1,200.00	175.00	0.13	0.83	171	4,509
175	4,500.00	800.00	0.67	0.83	128	3,382
176	3,100.00	50.00	0.40	0.83	107	2,818
177	4,310.00	120.00	0.30	0.83	140	3,697
178	5,350.00	50.00	0.26	0.83	199	5,242
179	11,650.00	250.00	1.17	0.83	219	5,772
180	2,929.00	0.33	1.82	0.83	47	1,240
181	4,570.00	60.00	0.14	0.83	187	4,943
182	3,900.00	50.00	0.17	0.83	205	5,411
183	37,100.00	200.00	0.17	0.83	1,477	39,004
184	20,270.00	175.00	0.16	0.83	799	21,103
185	5,810.00	16.67	0.69	0.83	154	4,058
186	2,175.00	125.00	0.28	0.83	77	2,046
187	2,450.00	62.50	0.38	0.83	90	2,367
188	4,092.00	322.00	0.66	0.83	97	2,559
189	14,425.00	150.00	0.14	0.83	608	16,064
190	1,355.00	50.00	0.26	0.83	49	1,296
191	4,670.00	90.00	0.25	0.83	173	4,565
192	18,000.00	250.00	0.54	0.83	635	16,774
193	32,250.00	225.00	0.33	0.83	1,110	29,309
194	30,000.00	416.67	0.13	0.83	1,318	34,805
195	2,140.00	50.00	0.86	0.83	50	1,316
196	11,900.00	250.00	0.47	0.83	367	9,695
197	7,095.00	271.00	0.53	0.83	209	5,524
198	6,350.00	200.00	0.80	0.83	160	4,216
199	14,600.00	400.00	0.31	0.83	546	14,418
200	11,970.00	400.00	0.81	0.83	314	8,299
201	9,650.00	250.00	0.33	0.83	320	8,455
202	5,525.00	120.00	0.15	0.83	213	5,636
203	4,002.00	60.00	1.37	0.83	75	1,976
204	3,450.00	40.00	0.53	0.83	96	2,542
205	3,500.00	100.00	0.19	0.83	135	3,562
206	5,000.00	200.00	0.63	0.83	135	3,573
207	980.00	25.00	0.81	0.83	26	699
208	8,400.00	150.00	0.24	0.83	363	9,582
209	4,775.00	450.00	0.41	0.83	155	4,090
210	3,030.00	180.00	0.10	0.83	128	3,382
211	50,800.00	62.50	0.08	0.83	2,562	67,636
212	3,540.00	175.00	0.10	0.83	149	3,945
213	2,326.00	38.00	0.15	0.83	97	2,562
214	13,600.00	250.00	0.09	0.83	598	15,782
215	2,506.00	39.00	0.59	0.83	72	1,902
216	6,645.00	62.50	0.75	0.83	171	4,509
217	1,884.00	80.00	0.67	0.83	51	1,353
218	1,790.00	50.00	1.11	0.83	38	1,015
219	17,900.00	50.00	0.23	0.83	640	16,909
220	2,750.00	50.00	0.53	0.83	81	2,126

221	41,181.00	250.00	0.17	0.83	2,040	53,863
222	3,550.00	83.33	1.98	0.83	54	1,420
223	18,500.00	300.00	0.40	0.83	640	16,909
224	15,100.00	125.00	1.07	0.83	320	8,438
225	8,285.00	60.00	0.47	0.83	260	6,876
226	1,050.00	25.00	0.18	0.83	48	1,274
227	27,050.00	312.50	0.26	0.83	1,003	26,491
228	4,300.00	83.33	0.77	0.83	110	2,916
229	33,120.00	360.00	0.69	0.83	932	24,609
230	8,900.00	50.00	0.77	0.83	222	5,862
231	4,170.00	150.00	2.00	0.83	64	1,691
232	10,400.00	66.67	0.53	0.83	320	8,455
233	4,775.00	66.67	0.42	0.83	154	4,060
234	2,040.00	200.00	0.64	0.83	67	1,759
235	120,000.00	400.00	0.08	0.83	6,191	163,455
236	60,900.00	150.00	0.21	0.83	2,391	63,127
237	5,475.00	20.83	8.77	0.83	24	643
238	43,000.00	166.67	0.10	0.83	1,745	46,077
239	3,320.00	50.00	0.46	0.83	112	2,958
240	6,850.00	62.50	0.68	0.83	188	4,960
241	6,725.00	66.67	0.26	0.83	244	6,448
242	2,892.00	36.00	0.33	0.83	107	2,818
243	13,500.00	75.00	0.57	0.83	374	9,864
244	1,130.00	150.00	0.18	0.83	60	1,578
245	6,975.00	237.50	0.36	0.83	239	6,313
246	13,800.00	200.00	2.22	0.83	192	5,073
247	9,792.00	342.00	0.16	0.83	384	10,145
248	5,860.00	175.00	1.48	0.83	101	2,660
249	11,830.00	200.00	2.00	0.83	171	4,509
250	9,620.00	200.00	0.54	0.83	285	7,536
251	175,000.00	200.00	0.28	0.83	6,020	158,945
252	11,265.00	250.00	0.74	0.83	288	7,609
253	3,025.00	300.00	0.81	0.83	74	1,958
254	5,190.00	62.50	0.41	0.83	168	4,437
255	37,475.00	175.00	0.19	0.83	1,350	35,650
256	11,300.00	50.00	5.62	0.83	76	2,005
257	71,012.00	337.33	0.24	0.83	2,626	69,327
258	4,890.00	125.00	0.30	0.83	171	4,509
259	4,053.00	313.00	0.30	0.83	171	4,512
260	9,100.00	166.67	0.36	0.83	293	7,735
261	33,850.00	166.67	0.12	0.83	1,665	43,964
262	4,500.00	300.00	0.20	0.83	170	4,481
263	1,950.00	200.00	1.00	0.83	43	1,127
264	7,325.00	100.00	0.24	0.83	269	7,102
265	18,250.00	125.00	0.33	0.83	640	16,909
266	10,400.00	150.00	0.31	0.83	342	9,018
267	16,500.00	187.50	0.16	0.83	654	17,279
268	4,940.00	130.00	3.33	0.83	51	1,353
269	8,372.00	172.00	0.80	0.83	213	5,636
270	7,800.00	75.00	0.57	0.83	299	7,891
271	17,410.00	100.00	0.26	0.83	645	17,022
272	10,000.00	270.00	1.06	0.83	201	5,298
273	1,160.00	150.00	0.60	0.83	36	947

274	2,196.00	91.00	2.50	0.83	26	676
275	2,650.00	75.00	0.32	0.83	107	2,818
276	2,289.00	0.33	0.44	0.83	77	2,029
277	20,800.00	100.00	0.16	0.83	811	21,418
278	3,475.00	225.00	0.37	0.83	116	3,068
279	5,270.00	250.00	0.44	0.83	192	5,073
280	1,925.00	75.00	0.77	0.83	56	1,465
281	2,755.00	135.00	0.07	0.83	115	3,027
282	4,400.00	400.00	0.74	0.83	115	3,044
283	16,750.00	175.00	0.27	0.83	639	16,869
284	23,850.00	50.00	11.00	0.83	85	2,255
285	14,870.00	106.67	0.20	0.83	628	16,582
286	13,390.00	166.67	0.25	0.83	512	13,527
287	17,405.00	202.50	0.41	0.83	619	16,345
288	8,450.00	125.00	0.40	0.83	320	8,455
289	14,650.00	116.67	0.39	0.83	497	13,133
290	4,530.00	500.00	0.26	0.83	167	4,396
291	13,510.00	250.00	0.47	0.83	450	11,893
292	8,250.00	100.00	0.13	0.83	363	9,582
293	111,460.00	727.27	0.49	0.83	3,487	92,070
294	263,237.00	583.33	0.17	0.83	10,176	268,663
295	8,120.00	210.00	0.57	0.83	241	6,363
296	48,000.00	480.00	0.67	0.83	1,281	33,818
297	5,750.00	375.00	0.56	0.83	152	4,002
298	60,400.00	350.00	0.22	0.83	2,174	57,401
299	5,030.00	325.00	2.47	0.83	69	1,826
300	48,150.00	150.00	0.06	0.83	2,775	73,273
301	48,000.00	500.00	0.43	0.83	1,494	39,455
302	28,800.00	416.67	0.75	0.83	854	22,545
303	2,280.00	60.00	0.83	0.83	56	1,488
304	51,410.00	360.00	0.79	0.83	1,243	32,815
305	4,220.00	60.00	0.02	0.83	235	6,200
306	6,680.00	26.67	0.30	0.83	288	7,609
307	125,500.00	200.00	0.29	0.83	4,485	118,420
308	605,000.00	444.44	0.23	0.83	23,483	620,000
309	4,600.00	300.00	0.61	0.83	140	3,692
310	26,800.00	250.00	0.43	0.83	993	26,209
311	159,900.00	218.18	0.25	0.83	6,065	160,129
312	61,500.00	333.33	0.63	0.83	1,708	45,091
313	21,650.00	150.00	0.24	0.83	880	23,243
314	22,800.00	200.00	0.92	0.83	512	13,527
315	35,950.00	450.00	0.11	0.83	1,520	40,131
316	87,000.00	444.44	0.27	0.83	3,147	83,080
317	397,133.00	650.00	0.33	0.83	13,039	344,256
318	21,950.00	666.67	0.71	0.83	598	15,782
319	49,900.00	300.00	0.40	0.83	1,598	42,188
320	21,900.00	300.00	0.25	0.83	854	22,545
321	55,420.00	242.86	0.16	0.83	2,170	57,295
322	11,230.00	300.00	4.17	0.83	96	2,548
323	18,850.00	166.67	0.24	0.83	878	23,188
324	401,350.00	457.14	0.19	0.83	17,079	450,909
325	323,500.00	727.27	0.10	0.83	12,937	341,564
326	6,370.00	200.00	0.32	0.83	268	7,087

327	29,760.00	300.00	0.19	0.83	1,134	29,940
328	11,900.00	200.00	0.67	0.83	320	8,455
329	16,550.00	200.00	0.30	0.83	567	14,965
330	17,119.00	272.80	1.17	0.83	365	9,649
331	11,500.00	225.00	0.15	0.83	854	22,545
332	256,000.00	266.67	0.57	0.83	7,472	197,273
333	21,400.00	200.00	0.57	0.83	596	15,725
334	71,300.00	583.33	0.26	0.83	2,493	65,833
335	8,852.00	234.00	0.17	0.83	354	9,356
336	271,000.00	333.33	0.21	0.83	10,034	264,909
337	15,000.00	500.00	0.70	0.83	427	11,273
338	23,400.00	375.00	1.54	0.83	417	11,002
339	4,640.00	100.00	0.71	0.83	121	3,190
340	5,752.00	17.33	0.09	0.83	342	9,018
341	6,025.00	300.00	0.41	0.83	206	5,445
342	89,375.00	563.33	0.23	0.83	3,192	84,286
343	25,512.00	237.33	0.24	0.83	1,084	28,633
344	12,900.00	200.00	0.58	0.83	371	9,796
345	15,524.00	208.00	0.32	0.83	541	14,287
346	8,510.00	50.00	0.30	0.83	317	8,382
347	6,500.00	200.00	0.56	0.83	192	5,073
348	17,700.00	150.00	0.42	0.83	608	16,047
349	12,850.00	250.00	0.75	0.83	342	9,018
350	17,100.00	200.00	0.21	0.83	619	16,345
351	10,985.00	135.00	2.68	0.83	127	3,366
352	8,325.00	400.00	0.09	0.83	384	10,145
353	133,330.00	395.00	0.12	0.83	5,558	146,729
354	17,610.00	300.00	0.51	0.83	503	13,279
355	23,875.00	625.00	0.29	0.83	808	21,334
356	25,224.00	242.80	0.61	0.83	710	18,753
357	18,850.00	400.00	0.35	0.83	734	19,389
358	133,000.00	750.00	0.36	0.83	4,697	124,000
359	30,340.00	340.00	0.30	0.83	1,409	37,200
360	19,600.00	266.67	0.31	0.83	686	18,104
361	20,492.00	40.00	0.37	0.83	686	18,120
362	35,600.00	500.00	0.35	0.83	1,448	38,243
363	21,030.00	300.00	1.76	0.83	365	9,633
364	24,350.00	300.00	0.25	0.83	1,017	26,852
365	7,900.00	300.00	1.51	0.83	142	3,743
366	65,200.00	166.67	0.22	0.83	2,952	77,951
367	18,386.00	349.00	0.24	0.83	721	19,041
368	7,650.00	150.00	0.39	0.83	328	8,652
369	35,003.00	275.00	0.43	0.83	1,184	31,254
370	50,250.00	250.00	0.23	0.83	1,890	49,910
371	17,725.00	300.00	0.29	0.83	742	19,581
372	156,020.00	503.33	0.10	0.83	6,151	162,395
373	27,700.00	450.00	0.38	0.83	1,110	29,309
374	25,825.00	250.00	0.12	0.83	1,212	32,009
375	12,871.00	224.67	0.75	0.83	340	8,984
376	39,150.00	500.00	0.43	0.83	1,388	36,636
377	109,000.00	500.00	0.24	0.83	4,440	117,236
378	33,370.00	225.00	1.33	0.83	674	17,783
379	11,373.00	83.33	0.49	0.83	346	9,142

380	31,950.00	750.00	0.40	0.83	1,067	28,182
381	38,400.00	333.33	0.70	0.83	1,099	29,027
382	93,500.00	428.57	0.35	0.83	3,437	90,745
383	207,400.00	540.00	0.20	0.83	7,621	201,218
384	62,045.00	848.57	0.22	0.83	2,374	62,676
385	30,200.00	400.00	1.14	0.83	749	19,784
386	72,880.00	326.00	0.43	0.83	2,275	60,059
387	13,050.00	120.00	9.20	0.83	56	1,471
388	46,500.00	500.00	0.06	0.83	2,135	56,364
389	90,000.00	500.00	0.21	0.83	4,035	106,527
390	103,500.00	500.00	0.16	0.83	4,056	107,091
391	20,481.00	203.00	0.36	0.83	714	18,859
392	16,884.00	450.00	0.41	0.83	619	16,338
393	95,030.00	375.00	0.25	0.83	3,423	90,385
394	10,650.00	325.00	0.40	0.83	427	11,273
395	12,900.00	333.33	1.33	0.83	256	6,764
396	63,226.00	508.50	0.11	0.83	2,641	69,720
397	31,650.00	375.00	0.19	0.83	1,345	35,509
398	54,500.00	375.00	0.21	0.83	2,417	63,804
399	13,673.00	300.00	0.72	0.83	354	9,359
400	27,674.00	360.00	0.53	0.83	967	25,521
401	26,750.00	375.00	0.14	0.83	1,249	32,984
402	16,200.00	162.50	0.40	0.83	538	14,204
403	36,189.00	564.00	0.12	0.83	1,489	39,319
404	11,380.00	375.00	0.61	0.83	350	9,244
405	36,000.00	150.00	0.33	0.83	1,298	34,269
406	9,300.00	333.33	0.17	0.83	376	9,920
407	20,360.00	900.00	0.28	0.83	1,057	27,907
408	22,269.00	400.00	0.43	0.83	795	20,989
409	13,025.00	425.00	0.40	0.83	427	11,273
410	58,850.00	350.00	0.19	0.83	2,412	63,691
411	38,300.00	266.67	0.38	0.83	1,337	35,292
412	54,625.00	300.00	0.29	0.83	2,049	54,109
413	70,000.00	500.00	0.16	0.83	2,635	69,576
414	326,000.00	642.86	0.27	0.83	11,742	310,000
415	37,700.00	550.00	0.18	0.83	1,579	41,698
416	15,288.00	269.00	0.13	0.83	651	17,198
417	44,760.00	225.00	0.79	0.83	1,358	35,855
418	18,050.00	425.00	0.16	0.83	786	20,742
419	27,290.00	330.00	0.45	0.83	855	22,579
420	33,500.00	500.00	0.40	0.83	1,067	28,182
421	59,009.00	471.80	0.34	0.83	1,904	50,276
422	108,200.00	500.00	0.28	0.83	3,843	101,455
423	103,542.00	354.20	0.22	0.83	3,924	103,592
424	41,300.00	600.00	0.63	0.83	1,355	35,763
425	128,800.00	471.43	0.72	0.83	3,262	86,124
426	23,290.00	695.00	0.44	0.83	769	20,291
427	19,190.00	350.00	0.35	0.83	742	19,593
428	505,500.00	590.91	0.24	0.83	17,471	461,274
429	26,144.00	552.00	1.05	0.83	570	15,058
430	8,000.00	300.00	0.89	0.83	192	5,073
431	7,700.00	233.33	0.24	0.83	279	7,366
432	26,575.00	265.00	0.71	0.83	726	19,164

433	36,500.00	642.86	2.50	0.83	427	11,273
434	5,200.00	325.00	0.48	0.83	179	4,735
435	131,786.00	436.36	0.16	0.83	5,212	137,599
436	15,460.00	360.00	0.19	0.83	672	17,739
437	32,951.00	545.00	0.34	0.83	1,208	31,891
438	63,700.00	350.00	0.13	0.83	3,416	90,182
439	3,672.00	225.00	0.35	0.83	122	3,212
440	15,500.00	166.67	0.29	0.83	598	15,782
441	25,055.00	235.00	0.04	0.83	1,184	31,258
442	53,400.00	400.00	0.12	0.83	2,135	56,364
443	18,484.00	333.33	0.18	0.83	727	19,200
444	8,200.00	100.00	0.10	0.83	413	10,901
445	7,730.00	160.00	0.22	0.83	290	7,665
446	36,250.00	333.33	0.17	0.83	1,494	39,455
447	20,350.00	225.00	0.20	0.83	744	19,648
448	25,280.00	226.67	1.33	0.83	483	12,747
449	27,100.00	250.00	0.72	0.83	709	18,724
450	25,948.00	312.00	0.59	0.83	726	19,164
451	1,665.00	75.00	0.17	0.83	64	1,702
452	12,783.00	354.00	0.50	0.83	384	10,145
453	4,205.00	19.38	1.33	0.83	80	2,119
454	9,500.00	200.00	0.42	0.83	308	8,122
455	28,800.00	250.00	0.32	0.83	1,067	28,182
456	2,500.00	75.00	0.75	0.83	85	2,255
457	31,800.00	266.67	0.40	0.83	1,067	28,182
458	4,144.00	92.00	0.26	0.83	184	4,847
459	957,600.00	666.67	0.17	0.83	38,427	1,014,545
460	1,720,500.00	714.29	0.09	0.83	69,083	1,823,927
461	31,910.00	370.00	0.19	0.83	1,200	31,676
462	16,600.00	133.33	0.28	0.83	606	16,007
463	57,980.00	420.00	0.35	0.83	1,964	51,855
464	26,400.00	600.00	0.16	0.83	1,052	27,776
465	13,692.00	357.14	0.40	0.83	427	11,273
466	18,975.00	150.00	0.79	0.83	544	14,356
467	8,850.00	500.00	1.50	0.83	171	4,509
468	11,500.00	150.00	1.95	0.83	175	4,622
469	21,300.00	150.00	0.24	0.83	874	23,075
470	31,855.00	214.29	1.00	0.83	726	19,164
471	24,008.00	166.67	0.20	0.83	854	22,545
472	37,550.00	325.00	0.35	0.83	1,276	33,694
473	14,600.00	300.00	0.20	0.83	536	14,159
474	21,376.00	225.00	0.10	0.83	898	23,716
475	9,855.00	225.00	0.67	0.83	256	6,764
476	10,400.00	50.00	0.38	0.83	342	9,018
477	7,840.00	450.00	1.85	0.83	116	3,054
478	17,200.00	200.00	0.33	0.83	640	16,909
479	5,990.00	100.00	1.36	0.83	113	2,974
480	13,750.00	83.33	0.16	0.83	546	14,411
481	47,750.00	400.00	0.32	0.83	1,599	42,216
482	7,050.00	175.00	0.38	0.83	222	5,862
483	3,250.00	83.33	2.20	0.83	43	1,127
484	14,700.00	250.00	0.31	0.83	555	14,655
485	15,050.00	600.00	0.31	0.83	555	14,655

486	41,500.00	400.00	0.54	0.83	1,191	31,451
487	33,916.00	450.00	0.83	0.83	825	21,790
488	7,600.00	266.67	0.58	0.83	222	5,862
489	14,094.00	337.50	0.53	0.83	406	10,709
490	9,870.00	350.00	0.56	0.83	384	10,145
491	15,100.00	366.67	0.77	0.83	555	14,655
492	2,900.00	80.00	1.00	0.83	64	1,691
493	5,150.00	100.00	0.54	0.83	143	3,782
494	19,100.00	266.67	0.06	0.83	841	22,196
495	10,892.00	156.00	0.74	0.83	287	7,589
496	9,290.00	450.00	2.99	0.83	100	2,643
497	14,200.00	500.00	0.33	0.83	512	13,527
498	27,580.00	325.00	0.52	0.83	828	21,869
499	22,890.00	18.00	1.04	0.83	512	13,527
500	18,250.00	333.33	0.47	0.83	540	14,266
501	30,300.00	300.00	0.75	0.83	1,025	27,055
502	15,950.00	300.00	0.13	0.83	650	17,163
503	15,296.00	450.00	1.25	0.83	273	7,215
504	24,700.00	100.00	0.39	0.83	871	22,996
505	6,650.00	150.00	0.55	0.83	196	5,163
506	12,210.00	203.00	0.85	0.83	301	7,936
507	111,808.00	441.60	0.15	0.83	4,337	114,498
508	12,161.00	100.00	0.63	0.83	340	8,973
509	100,300.00	416.67	0.17	0.83	3,959	104,532
510	12,950.00	200.00	0.58	0.83	367	9,695
511	2,100.00	50.00	1.21	0.83	42	1,116
512	24,300.00	350.00	0.64	0.83	670	17,698
513	110,100.00	160.00	0.21	0.83	4,122	108,838
514	65,555.00	200.00	0.68	0.83	1,770	46,725
515	28,554.00	273.33	0.47	0.83	901	23,778
516	9,620.00	200.00	0.64	0.83	269	7,093
517	45,700.00	433.33	1.24	0.83	897	23,673
518	20,800.00	425.00	0.31	0.83	683	18,036
519	30,440.00	313.33	0.19	0.83	1,153	30,436
520	63,300.00	333.33	0.67	0.83	1,665	43,964
521	46,000.00	500.00	0.29	0.83	1,751	46,218
522	141,100.00	260.00	0.09	0.83	5,764	152,182
523	22,650.00	75.00	0.72	0.83	594	15,686
524	42,360.00	150.00	0.51	0.83	1,252	33,063
525	44,850.00	283.33	0.22	0.83	1,921	50,727
526	5,750.00	200.00	0.20	0.83	215	5,670
527	4,350.00	25.00	0.12	0.83	181	4,774
528	208,550.00	61.11	0.22	0.83	7,685	202,909
529	5,087.00	250.00	0.20	0.83	213	5,636
530	2,202.00	300.00	0.67	0.83	64	1,691
531	7,600.00	300.00	0.12	0.83	350	9,244
532	36,750.00	583.33	0.63	0.83	1,025	27,055
533	70,950.00	450.00	0.15	0.83	2,863	75,578
534	23,600.00	250.00	0.35	0.83	854	22,545
535	11,170.00	270.00	0.11	0.83	470	12,400
536	6,060.00	150.00	1.23	0.83	122	3,213
537	20,000.00	366.67	0.20	0.83	769	20,291
538	10,800.00	333.33	0.20	0.83	384	10,145

539	8,000.00	400.00	0.22	0.83	287	7,575
540	6,480.00	150.00	0.17	0.83	256	6,759
541	13,406.00	256.00	0.40	0.83	427	11,273
542	11,077.00	187.00	0.17	0.83	430	11,361
543	28,525.00	250.00	0.50	0.83	854	22,545
544	90,780.00	250.00	4.42	0.83	725	19,149
545	44,880.00	591.00	0.29	0.83	1,498	39,539
546	12,550.00	450.00	0.18	0.83	478	12,625
547	30,650.00	500.00	0.21	0.83	1,119	29,535
548	3,510.00	150.00	0.10	0.83	149	3,945
549	2,855.00	90.00	0.18	0.83	118	3,111
550	4,445.00	145.00	0.43	0.83	149	3,945
551	2,999.00	0.33	0.45	0.83	94	2,480
552	11,350.00	33.33	1.27	0.83	235	6,200
553	6,950.00	100.00	0.50	0.83	213	5,636
554	60,600.00	290.00	0.31	0.83	2,220	58,618
555	6,450.00	300.00	0.27	0.83	239	6,313
556	15,392.00	392.00	0.17	0.83	619	16,345
557	18,320.00	120.00	1.08	0.83	394	10,399
558	72,600.00	450.00	0.46	0.83	2,306	60,873
559	37,600.00	450.00	0.89	0.83	961	25,364
560	18,000.00	400.00	0.62	0.83	555	14,655
561	3,860.00	200.00	0.04	0.83	213	5,636
562	2,325.00	200.00	0.22	0.83	96	2,536
563	37,677.00	520.00	1.82	0.83	585	15,444
564	5,330.00	250.00	3.33	0.83	51	1,353
565	16,000.00	300.00	1.47	0.83	291	7,681
566	14,100.00	400.00	1.14	0.83	299	7,891
567	120,100.00	350.00	0.38	0.83	3,971	104,836
568	28,800.00	266.67	0.31	0.83	1,117	29,484
569	4,010.00	10.00	0.55	0.83	117	3,100
570	11,050.00	100.00	1.57	0.83	190	5,022
571	22,205.00	333.33	16.67	0.83	51	1,353
572	314,000.00	500.00	0.78	0.83	8,240	217,564
573	12,925.00	550.00	0.35	0.83	423	11,160
574	47,625.00	200.00	0.31	0.83	1,664	43,946
575	26,650.00	600.00	0.40	0.83	854	22,545
576	23,565.00	25.00	0.04	0.83	1,025	27,055
577	16,875.00	112.50	0.69	0.83	430	11,357
578	13,460.00	52.00	0.36	0.83	470	12,400
579	6,175.00	87.50	0.59	0.83	216	5,704
580	6,190.00	8.57	0.69	0.83	154	4,058
581	79,400.00	350.00	0.13	0.83	3,259	86,056
582	14,200.00	66.67	0.40	0.83	427	11,273
583	30,350.00	283.33	0.40	0.83	1,067	28,182
584	43,500.00	166.67	0.06	0.83	1,879	49,600
585	31,830.00	500.00	0.75	0.83	854	22,545
586	15,599.00	0.33	0.03	0.83	670	17,698
587	19,300.00	200.00	0.67	0.83	445	11,746
588	2,300.00	150.00	0.17	0.83	128	3,382
589	31,800.00	433.33	0.60	0.83	854	22,545
590	18,410.00	180.00	1.04	0.83	410	10,822
591	159,744.00	527.11	0.10	0.83	6,618	174,727

592	18,498.00	448.00	0.48	0.83	533	14,085
593	13,950.00	100.00	0.36	0.83	470	12,400
594	7,400.00	400.00	0.50	0.83	213	5,636
595	14,250.00	50.00	0.42	0.83	512	13,527
596	228,500.00	583.33	0.25	0.83	8,539	225,455
597	108,674.00	353.00	0.22	0.83	4,387	115,827
598	15,900.00	125.00	0.37	0.83	525	13,865
599	84,540.00	390.00	0.43	0.83	2,476	65,382
600	38,547.00	319.50	0.43	0.83	1,347	35,570
601	85,500.00	437.50	0.05	0.83	3,885	102,582
602	14,650.00	116.67	0.48	0.83	442	11,679
603	106,600.00	666.67	0.57	0.83	3,014	79,585
604	12,792.00	64.00	0.30	0.83	427	11,273
605	35,854.00	317.33	0.21	0.83	1,393	36,776
606	15,320.00	50.00	1.71	0.83	250	6,597
607	10,450.00	450.00	0.91	0.83	235	6,200
608	102,875.00	500.00	0.25	0.83	3,757	99,200
609	19,325.00	166.67	0.95	0.83	448	11,836
610	75,500.00	150.00	0.21	0.83	2,669	70,455
611	75,250.00	250.00	0.59	0.83	3,629	95,818
612	44,100.00	200.00	0.47	0.83	1,281	33,818
613	8,000.00	100.00	0.31	0.83	276	7,293
614	14,325.00	150.00	0.04	0.83	640	16,909
615	7,670.00	100.00	0.42	0.83	256	6,764
616	279,112.00	790.22	0.54	0.83	7,952	209,951
617	24,950.00	150.00	0.66	0.83	645	17,039
618	4,400.00	300.00	0.38	0.83	168	4,430
619	111,000.00	485.71	0.75	0.83	2,837	74,899
620	26,060.00	60.00	0.03	0.83	1,662	43,887
621	35,075.00	25.00	0.71	0.83	897	23,673
622	31,055.00	512.50	0.77	0.83	773	20,412
623	8,788.00	156.50	0.81	0.83	238	6,290
624	32,950.00	425.00	0.23	0.83	1,217	32,127
625	8,275.00	50.00	0.41	0.83	368	9,723
626	43,250.00	333.33	0.15	0.83	1,749	46,190
627	20,900.00	300.00	0.54	0.83	555	14,655
628	12,585.00	250.00	0.34	0.83	441	11,650
629	6,071.00	350.00	2.00	0.83	64	1,691
630	32,375.00	350.00	0.30	0.83	1,152	30,408
631	15,050.00	400.00	0.19	0.83	564	14,880
632	8,075.00	166.67	1.07	0.83	159	4,207
633	85,700.00	550.00	0.37	0.83	2,861	75,527
634	12,930.00	550.00	0.37	0.83	427	11,273
635	28,000.00	550.00	0.45	0.83	854	22,545
636	8,800.00	500.00	0.57	0.83	299	7,891
637	8,500.00	166.67	0.48	0.83	265	6,989
638	33,800.00	375.00	0.50	0.83	1,114	29,422
639	10,510.00	60.00	0.29	0.83	374	9,864
640	13,530.00	15.00	0.33	0.83	257	6,785
641	11,446.00	246.00	0.64	0.83	332	8,769
642	11,175.00	337.50	0.33	0.83	385	10,168
643	60,800.00	366.67	0.63	0.83	1,681	44,392
644	12,069.00	300.00	1.19	0.83	251	6,637

645	33,900.00	400.00	0.44	0.83	1,176	31,045
646	5,490.00	600.00	1.23	0.83	104	2,751
647	17,295.00	50.00	0.71	0.83	448	11,836
648	7,212.00	120.00	2.01	0.83	106	2,802
649	11,780.00	120.00	0.47	0.83	361	9,539
650	10,350.00	400.00	0.83	0.83	256	6,764
651	9,695.00	17.50	1.13	0.83	203	5,366
652	42,524.00	512.67	0.29	0.83	1,469	38,775
653	14,743.00	50.00	0.50	0.83	427	11,268
654	11,458.00	50.00	0.46	0.83	368	9,706
655	11,260.00	75.00	0.94	0.83	263	6,933
656	15,600.00	75.00	0.88	0.83	388	10,236
657	5,857.00	11.67	0.89	0.83	144	3,792
658	16,770.00	500.00	0.27	0.83	640	16,909
659	15,390.00	50.00	0.22	0.83	577	15,240
660	7,325.00	225.00	0.06	0.83	342	9,041
661	3,724.00	0.33	0.80	0.83	107	2,818
662	15,425.00	312.50	0.45	0.83	478	12,625
663	6,359.00	0.33	1.43	0.83	120	3,156
664	28,925.00	200.00	1.31	0.83	556	14,683
665	5,000.00	200.00	0.43	0.83	149	3,945
666	11,190.00	50.00	0.39	0.83	380	10,033
667	15,850.00	300.00	1.11	0.83	327	8,644
668	29,534.00	265.00	0.55	0.83	811	21,418
669	3,212.00	62.00	0.81	0.83	83	2,204
670	3,975.00	120.00	0.14	0.83	148	3,921
671	23,500.00	250.00	0.67	0.83	634	16,740
672	16,775.00	150.00	0.38	0.83	558	14,742
673	34,300.00	625.00	0.12	0.83	2,135	56,364
674	52,200.00	600.00	0.37	0.83	1,747	46,128
675	12,800.00	50.00	0.05	0.83	606	16,007
676	14,165.00	200.00	1.53	0.83	279	7,355
677	414,000.00	300.00	0.14	0.83	22,753	600,724
678	17,950.00	75.00	0.52	0.83	570	15,049
679	9,480.00	400.00	0.20	0.83	431	11,385
680	12,360.00	75.00	0.77	0.83	332	8,754
681	33,050.00	187.50	0.70	0.83	854	22,545
682	8,600.00	150.00	0.41	0.83	314	8,291
683	2,985.00	225.00	0.05	0.83	179	4,735
684	2,439.00	0.33	0.03	0.83	126	3,314
685	3,880.00	40.00	0.43	0.83	142	3,740
686	35,900.00	300.00	0.23	0.83	1,319	34,833
687	2,625.00	100.00	1.50	0.83	51	1,353
688	25,750.00	375.00	0.29	0.83	897	23,673
689	27,450.00	216.67	0.67	0.83	767	20,246
690	38,517.00	675.00	0.10	0.83	1,640	43,287
691	26,783.00	420.00	0.93	0.83	598	15,782
692	21,550.00	183.33	0.79	0.83	538	14,204
693	10,800.00	250.00	1.38	0.83	208	5,490
694	47,300.00	100.00	0.39	0.83	1,742	45,993
695	56,250.00	83.33	0.21	0.83	2,033	53,681
696	20,460.00	40.00	1.30	0.83	427	11,273
697	11,250.00	200.00	1.00	0.83	256	6,764

698	7,150.00	100.00	1.85	0.83	115	3,044
699	7,150.00	100.00	1.85	0.83	115	3,044
700	15,290.00	225.00	0.33	0.83	519	13,708
701	8,850.00	325.00	1.15	0.83	186	4,904
702	8,035.00	360.00	0.53	0.83	242	6,386
703	11,620.00	400.00	0.55	0.83	388	10,231
704	19,940.00	250.00	0.49	0.83	615	16,233
705	11,246.00	333.33	0.03	0.83	472	12,456
706	68,300.00	166.67	0.45	0.83	2,274	60,027
707	11,455.00	60.00	0.14	0.83	533	14,068
708	24,385.00	91.67	0.73	0.83	617	16,289
709	43,160.00	125.00	0.67	0.83	1,245	32,860
710	6,594.00	175.00	2.44	0.83	84	2,221
711	6,638.00	550.00	0.16	0.83	287	7,575
712	2,546.00	50.00	0.73	0.83	88	2,311
713	8,670.00	30.00	0.10	0.83	342	9,018
714	61,900.00	400.00	0.56	0.83	1,612	42,555
715	29,540.00	300.00	0.67	0.83	769	20,291
716	10,890.00	100.00	0.67	0.83	320	8,455
717	274,252.00	525.20	0.20	0.83	10,678	281,908
718	6,150.00	300.00	0.77	0.83	278	7,327
719	20,600.00	300.00	0.59	0.83	576	15,218
720	22,750.00	250.00	0.19	0.83	889	23,470
721	4,200.00	150.00	0.56	0.83	152	4,002
722	7,868.00	125.00	0.40	0.83	256	6,764
723	9,375.00	100.00	0.62	0.83	275	7,253
724	26,580.00	250.00	0.27	0.83	966	25,512
725	7,645.00	300.00	0.33	0.83	256	6,764
726	14,500.00	450.00	1.21	0.83	282	7,440
727	14,100.00	300.00	0.14	0.83	598	15,782
728	4,895.00	75.00	0.39	0.83	163	4,305
729	7,300.00	100.00	0.60	0.83	213	5,636
730	11,400.00	150.00	5.56	0.83	77	2,029
731	7,720.00	120.00	0.58	0.83	222	5,862
732	17,345.00	420.00	0.41	0.83	579	15,295
733	16,814.00	200.00	0.37	0.83	572	15,105
734	14,525.00	225.00	0.53	0.83	405	10,690
735	23,300.00	300.00	0.22	0.83	987	26,064
736	7,696.00	75.00	0.77	0.83	195	5,156
737	5,471.00	125.00	4.04	0.83	48	1,255
738	5,925.00	312.50	0.88	0.83	146	3,850
739	27,500.00	333.33	0.50	0.83	854	22,545
740	11,750.00	50.00	0.79	0.83	299	7,891
741	12,600.00	75.00	0.29	0.83	448	11,836
742	28,600.00	250.00	0.41	0.83	939	24,800
743	9,320.00	150.00	1.03	0.83	207	5,456
744	1,920.00	150.00	1.00	0.83	43	1,127
745	54,165.00	160.00	2.28	0.83	729	19,254
746	20,580.00	300.00	0.33	0.83	769	20,291
747	40,700.00	350.00	0.23	0.83	1,494	39,455
748	55,725.00	300.00	0.36	0.83	1,804	47,616
Mean	31,960.58	240.98	0.63	0.83	1,141	30,132
S.D.	89,374.97	163.41	1.03	-	3,539	93,423

Table A.6.3. Men's clothing

A.6.3. (a.) 1850

Men's clothing	**1850**	Vector of Input Prices			Vector of Output Quantities		
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Coats (nos.)	Quantity of Pants (prs.)	Quantity of Vests (nos.)
n	C	w_1	w_2	w_3	y_1	y_2	y_3
1	2,855.00	80.00	0.11	1.69	200	0	0
2	5,790.00	300.00	0.11	1.69	300	500	0
3	3,500.00	360.00	0.99	1.69	100	204	0
4	8,212.00	100.36	0.32	1.69	275	364	250
5	1,080.00	240.00	0.02	1.69	25	20	30
6	1,880.00	360.00	0.01	1.69	100	20	20
7	2,150.00	300.00	0.11	1.69	150	150	0
8	2,868.00	256.00	0.34	1.69	75	0	0
9	5,024.00	162.67	0.53	1.69	300	500	150
10	4,400.00	400.00	0.05	1.69	200	250	200
11	1,960.00	240.00	0.12	1.69	84	50	0
12	2,514.00	216.00	0.67	1.69	200	0	0
13	1,680.00	240.00	0.37	1.69	50	100	0
14	1,380.00	240.00	0.49	1.69	40	30	20
15	17,371.00	148.14	0.35	1.69	1,200	0	800
16	3,062.00	258.00	0.28	1.69	104	104	104
17	705.00	180.00	0.11	1.69	50	100	0
18	12,460.00	244.00	0.22	1.69	500	500	600
19	20,840.00	225.60	0.53	1.69	800	800	700
20	10,417.00	221.33	0.30	1.69	400	600	600
21	5,410.00	210.00	0.31	1.69	200	200	0
22	3,964.00	151.20	0.68	1.69	150	120	120
23	2,452.00	276.00	0.04	1.69	100	0	0
24	2,812.00	144.00	0.48	1.69	0	620	0
25	1,490.00	240.00	0.33	1.69	300	0	0
26	1,780.00	120.00	1.25	1.69	75	90	20
27	15,618.00	141.45	0.34	1.69	1,100	2,000	1,500
28	87,000.00	60.00	0.17	1.69	7,200	6,664	12,200
29	7,840.00	120.00	0.00	1.69	200	0	0
30	1,136.00	168.00	0.20	1.69	200	0	0
31	670.00	120.00	0.17	1.69	200	0	0
32	2,940.00	270.00	0.10	1.69	150	100	100
33	1,736.00	240.00	0.09	1.69	100	100	150
34	9,976.00	142.43	0.41	1.69	560	731	500
35	925.00	120.00	0.01	1.69	60	80	70
36	1,461.00	156.00	0.15	1.69	90	130	120
37	11,677.00	274.67	0.85	1.69	300	300	260
38	3,804.00	368.00	0.16	1.69	104	150	150
39	2,742.00	218.40	0.10	1.69	100	100	150

Mean	7,066.18	213.13	0.31	1.69	419.03	401.97	482.41
S.D.	14,024.15	82.40	0.28	0.00	1,145.91	1,091.82	1,949.57

A.6.3. (b.) 1860

Men's clothing	**1860**	Vector of Input Prices			Vector of Output Quantities		
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Coats (nos.)	Quantity of Pants (prs.)	Quantity of Vests (nos.)
n	C	w_1	w_2	w_3	y_1	y_2	y_3
1	39,740.00	478.50	0.48	1.75	500	1,500	4,000
2	38,090.00	246.00	0.34	1.75	3,650	800	1,040
3	2,370.00	180.00	0.26	1.75	125	150	75
4	17,800.00	240.00	0.30	1.75	2,000	5,000	0
5	3,400.00	240.00	0.15	1.75	500	100	0
6	1,780.00	240.00	0.14	1.75	50	100	50
7	6,200.00	171.43	0.29	1.75	600	0	0
8	3,500.00	300.00	0.03	1.75	150	75	75
9	1,130.00	240.00	0.57	1.75	50	40	0
10	1,725.00	300.00	0.07	1.75	30	300	0
11	8,096.00	214.00	0.32	1.75	444	252	180
12	2,400.00	300.00	0.60	1.75	100	400	300
13	4,160.00	180.00	0.71	1.75	100	300	100
14	7,688.00	114.46	1.72	1.75	0	1,200	0
15	5,160.00	320.00	0.17	1.75	200	400	0
16	2,310.00	320.00	0.04	1.75	100	200	100
17	1,101.00	198.00	0.08	1.75	96	220	40
18	1,680.00	240.00	0.12	1.75	200	200	0
19	1,560.00	180.00	0.11	1.75	150	0	0
20	1,140.00	240.00	0.13	1.75	120	150	0
21	1,010.00	360.00	0.21	1.75	80	0	0
22	888.00	288.00	0.06	1.75	175	150	0
23	15,660.00	360.00	0.24	1.75	300	400	400
24	12,868.00	150.86	0.40	1.75	864	4,000	2,000
25	5,982.00	233.14	0.95	1.75	144	576	288
26	2,530.00	240.00	0.78	1.75	100	350	150
27	3,170.00	204.00	0.18	1.75	100	250	200
28	5,246.00	249.00	0.39	1.75	150	450	150
29	2,080.00	240.00	0.31	1.75	60	120	48
30	157,900.00	108.83	0.04	1.75	75,000	0	0
31	4,440.00	280.00	1.32	1.75	100	200	100
32	2,932.00	216.00	0.17	1.75	300	0	0
33	9,313.00	213.00	0.19	1.75	312	620	520
34	4,668.00	67.50	0.16	1.75	1,912	1,300	470
35	7,309.00	213.00	0.35	1.75	200	300	300
36	25,430.00	186.32	0.23	1.75	450	650	475
37	11,640.00	264.00	0.18	1.75	300	800	0

38	6,874.00	248.57	0.27	1.75	216	360	0
39	12,600.00	275.00	0.40	1.75	400	800	500
40	3,840.00	315.00	0.35	1.75	200	200	100
41	7,116.00	183.27	0.50	1.75	300	425	434
42	272,250.00	232.00	0.32	1.75	10,000	20,000	12,000
43	2,404.00	180.00	0.05	1.75	150	200	50
44	9,030.00	207.27	1.21	1.75	300	200	300
45	1,740.00	260.00	0.06	1.75	40	90	150
46	6,720.00	240.00	0.10	1.75	100	600	200
47	1,761.00	232.00	0.89	1.75	25	0	0
48	9,380.00	153.33	0.35	1.75	250	0	400
49	30,004.00	100.08	0.28	1.75	1,250	2,500	2,152
50	29,670.00	118.78	1.08	1.75	1,400	1,400	300
51	2,284.00	192.00	0.18	1.75	0	750	0
52	15,095.00	216.92	0.57	1.75	720	1,040	850
53	7,990.00	340.00	0.16	1.75	200	300	300
54	91,600.00	480.00	0.34	1.75	1,600	1,600	1,900
55	2,900.00	225.00	0.07	1.75	200	350	350
56	96,620.00	188.00	0.57	1.75	5,000	8,000	8,000
57	30,170.00	134.40	0.41	1.75	1,500	3,000	3,000
58	30,004.00	50.04	0.29	1.75	1,250	2,500	2,152
59	898.00	150.00	0.33	1.75	100	30	25
60	6,350.00	240.00	0.06	1.75	1,000	500	500
61	1,600.00	300.00	1.54	1.75	50	50	0
62	3,062.00	300.00	0.38	1.75	100	150	150
63	2,860.00	22.50	0.59	1.75	400	300	300
64	1,184.00	192.00	0.11	1.75	300	0	0
65	15,400.00	270.00	0.24	1.75	1,000	1,500	1,500
66	31,800.00	240.00	0.60	1.75	1,500	1,500	400
67	1,318.00	300.00	0.71	1.75	28	37	27
68	8,878.00	206.40	0.78	1.75	1,000	1,000	500
69	2,360.00	360.00	0.77	1.75	150	150	50
70	3,146.00	20.57	0.04	1.75	1,300	0	0
71	2,780.00	216.00	0.11	1.75	200	150	0
72	4,704.00	156.00	0.41	1.75	350	400	400
73	14,560.00	206.40	0.30	1.75	480	1,000	250
74	7,755.00	316.80	0.25	1.75	180	280	300
75	4,414.00	13.71	0.38	1.75	250	175	0
Mean	16,096.23	225.31	0.38	1.75	1,642.68	974.53	648.01
S.D.	38,299.76	87.71	0.35	0.00	8,691.46	2,545.65	1,747.17

A.6.3. (c.) 1870

Men's clothing	**1870**	Vector of Input Prices			Vector of Output Quantities		
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Coats (nos.)	Quantity of Pants (prs.)	Quantity of Vests (nos.)
n	C	w_1	w_2	w_3	y_1	y_2	y_3
1	7,556.00	250.00	0.63	1.92	156	312	156
2	2,720.00	133.33	0.09	1.92	100	300	300
3	19,500.00	875.00	0.20	1.92	200	400	300
4	2,700.00	200.00	0.11	1.92	100	300	100
5	7,200.00	633.33	0.08	1.92	280	0	260
6	1,850.00	300.00	0.08	1.92	100	300	200
7	11,800.00	450.00	0.08	1.92	600	0	0
8	35,600.00	258.33	1.12	1.92	600	700	800
9	1,555.00	206.67	0.09	1.92	120	200	0
10	16,800.00	138.46	0.39	1.92	0	6,550	0
11	11,000.00	250.00	0.72	1.92	120	150	150
12	23,500.00	500.00	0.24	1.92	416	600	450
13	7,000.00	380.00	0.70	1.92	200	200	120
14	20,000.00	555.56	0.23	1.92	400	150	50
15	1,840.00	400.00	0.97	1.92	50	25	30
16	2,800.00	500.00	0.11	1.92	35	85	35
17	1,800.00	500.00	0.12	1.92	150	0	0
18	6,955.00	475.00	0.34	1.92	210	325	210
19	7,415.00	520.00	1.10	1.92	150	0	0
20	26,000.00	576.92	0.21	1.92	715	850	715
21	3,400.00	800.00	0.05	1.92	200	50	0
22	80,902.00	800.00	0.20	1.92	1,252	2,584	0
23	25,500.00	458.33	0.36	1.92	400	600	500
24	4,343.00	625.00	0.16	1.92	80	128	111
25	9,281.00	389.33	1.21	1.92	100	250	50
26	72,000.00	9.06	0.60	1.92	4,000	4,000	4,000
27	144,700.00	225.00	1.47	1.92	2,000	2,500	1,500
28	3,706.00	208.00	0.09	1.92	156	266	244
29	23,950.00	900.00	0.27	1.92	400	400	400
30	11,900.00	350.00	0.22	1.92	150	250	200
Mean	19,842.43	428.91	0.41	1.92	448.00	749.17	362.70
S.D.	30,209.58	227.61	0.40	0.00	784.95	1,415.01	756.33

Table A.6.4. Millwork

A.6.4. (a.) 1850

Millwork	**1850**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Sashes (nos.)	Quantity of Doors (nos.)
n	C	w_1	w_2	w_3	y_1	y_2
1	8,600.00	360.00	0.49	0.26	31,200	100
2	2,580.00	540.00	0.23	0.26	30	50
3	3,200.00	360.00	0.13	0.26	100	100
4	20,930.00	240.00	0.24	0.26	4,500	0
5	2,180.00	240.00	0.79	0.26	6,000	0
6	702.00	312.00	0.25	0.26	4,000	0
7	1,870.00	240.00	1.08	0.26	2,500	150
8	1,250.00	240.00	1.05	0.26	10,000	0
9	4,705.00	420.00	0.96	0.26	30,000	225
10	5,400.00	300.00	1.14	0.26	16,000	0
11	6,545.00	405.00	0.40	0.26	31,200	1,200
12	1,150.00	600.00	0.24	0.26	30,000	160
13	1,584.00	192.00	1.11	0.26	10,000	0
14	1,530.00	180.00	0.60	0.26	20,000	0
Mean	4,444.71	330.64	0.62	0.26	13,966.43	141.79
S.D.	5,283.91	126.40	0.39	0.00	12,249.13	313.76

A.6.4. (b.) 1860

Millwork	**1860**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Sashes (nos.)	Quantity of Doors (nos.)
n	C	w_1	w_2	w_3	y_1	y_2
1	2,100.00	600.00	0.15	0.27	9,000	1,000
2	3,400.00	375.00	0.16	0.27	0	100
3	124,000.00	400.00	0.70	0.27	94,000	0
4	10,600.00	300.00	5.00	0.27	0	800
5	33,500.00	480.00	1.79	0.27	96,000	1,530
6	12,272.00	378.00	0.17	0.27	7,540	350
7	10,320.00	540.00	0.17	0.27	5,000	300
8	6,995.00	312.00	0.09	0.27	15,000	0
9	1,500.00	300.00	0.91	0.27	800	0
10	3,936.00	282.00	0.49	0.27	100	0
11	4,500.00	300.00	1.38	0.27	2,000	500
12	4,012.00	216.00	1.94	0.27	200,000	0
13	23,040.00	360.00	0.50	0.27	12,000	1,500
14	12,341.00	384.00	0.04	0.27	1,248	1,300
15	4,921.00	360.00	1.33	0.27	800	0

16	1,620.00	240.00	0.40	0.27	10,000	0
17	8,480.00	360.00	0.94	0.27	1,000	800
Mean	15,737.47	363.94	0.95	0.27	26,734.59	481.18
S.D.	29,109.96	100.37	1.21	0.00	53,933.49	564.43

A.6.4.(c.) 1870

Millwork	**1870**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Sashes (nos.)	Quantity of Doors (nos.)
n	C	w_1	w_2	w_3	y_1	y_2
1	6,835.00	500.00	0.18	0.32	120	55
2	22,500.00	285.71	0.50	0.32	400	400
3	85,000.00	662.50	1.03	0.32	2,000	1,200
4	15,525.00	300.00	0.97	0.32	1,500	900
5	39,000.00	500.00	0.80	0.32	2,000	500
6	24,185.00	208.33	1.43	0.32	0	300
Mean	32,174.17	409.42	0.82	0.32	1,003.33	559.17
S.D.	27,978.01	172.15	0.44	0.00	936.41	418.81

Table A.6.5. Furniture

A.6.5. (a.) 1850

Furniture	**1850**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Bureaus (nos.)	Quantity of Bedsteads (nos.)
n	C	w_1	w_2	w_3	y_1	y_2
1	1,241.00	84.00	0.96	0.06	10	25
2	1,366.00	336.00	0.28	0.06	5	0
3	780.00	180.00	0.26	0.06	20	20
4	1,555.00	240.00	0.70	0.06	0	100
5	1,400.00	300.00	0.50	0.06	0	100
6	1,405.00	360.00	0.15	0.06	30	100
7	2,029.00	432.00	1.45	0.06	10	30
8	2,000.00	240.00	0.38	0.06	40	100
9	5,425.00	360.00	0.97	0.06	36	100
10	9,400.00	300.00	0.36	0.06	0	3,000
11	1,430.00	160.00	0.51	0.06	12	0
12	930.00	180.00	0.70	0.06	30	51
13	82,100.00	400.00	0.83	0.06	6,000	0
14	1,120.00	200.00	0.53	0.06	15	0
15	1,400.00	300.00	0.80	0.06	10	10
16	1,374.00	312.00	0.58	0.06	30	0
17	2,036.00	234.00	0.59	0.06	10	0
18	1,325.00	300.00	0.65	0.06	20	0
19	630.00	240.00	0.12	0.06	5	20
20	885.00	360.00	0.78	0.06	0	60
21	2,960.00	480.00	1.33	0.06	0	50
22	3,285.00	300.00	1.33	0.06	0	1,000
23	1,367.00	264.00	1.27	0.06	0	50
24	1,896.00	300.00	0.88	0.06	0	75
25	1,430.00	540.00	1.35	0.06	0	30
26	1,407.00	312.00	1.04	0.06	15	40
27	1,600.00	300.00	0.46	0.06	0	1,200
28	2,406.00	240.00	1.15	0.06	0	40
29	467.00	168.00	0.31	0.06	0	78
30	9,898.00	300.00	0.16	0.06	0	624
31	4,100.00	180.00	1.14	0.06	50	100
32	1,175.00	300.00	0.22	0.06	12	50
33	3,171.00	144.00	1.86	0.06	15	50
34	1,026.00	192.00	0.67	0.06	11	26
35	3,785.00	120.00	0.95	0.06	50	150
36	860.00	180.00	0.16	0.06	15	0
37	2,002.00	300.00	0.51	0.06	24	0
Mean	4,396.38	274.00	0.73	0.06	175.00	196.73
S.D.	13,292.21	97.83	0.43	0.00	984.33	540.45

A.6.5. (b.) 1860

Furniture	**1860**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Bureaus (nos.)	Quantity of Bedsteads (nos.)
n	C	w_1	w_2	w_3	y_1	y_2
1	660.00	360.00	0.20	0.08	2	30
2	2,880.00	400.00	1.32	0.08	18	50
3	1,020.00	360.00	0.19	0.08	24	0
4	7,680.00	300.00	0.48	0.08	0	500
5	6,800.00	300.00	1.00	0.08	100	200
6	1,480.00	480.00	1.13	0.08	0	30
7	1,186.00	360.00	1.19	0.08	0	30
8	2,023.00	360.00	0.36	0.08	0	400
9	3,696.00	79.20	0.61	0.08	50	150
10	1,500.00	300.00	0.63	0.08	0	100
11	5,736.00	309.00	0.33	0.08	50	100
12	4,620.00	375.00	0.40	0.08	0	500
13	3,610.00	360.00	0.28	0.08	0	200
14	1,035.00	420.00	0.91	0.08	6	25
15	548.00	180.00	0.21	0.08	0	50
16	5,260.00	40.00	0.46	0.08	100	300
17	5,176.00	312.00	0.26	0.08	42	200
18	3,150.00	300.00	0.73	0.08	25	0
19	2,318.00	360.00	0.40	0.08	0	50
20	4,370.00	240.00	1.94	0.08	25	100
21	11,530.00	300.00	0.65	0.08	600	0
22	2,620.00	300.00	0.13	0.08	0	1,200
23	784.00	336.00	0.33	0.08	6	40
24	1,460.00	360.00	0.72	0.08	12	20
25	10,284.00	360.00	2.00	0.08	0	300
26	897.00	300.00	0.04	0.08	25	12
27	3,104.00	300.00	0.88	0.08	20	0
28	13,120.00	400.00	0.65	0.08	60	0
29	945.00	150.00	0.78	0.08	6	20
30	14,700.00	480.00	0.24	0.08	416	0
31	4,752.00	288.00	0.56	0.08	100	150
32	4,840.00	360.00	0.97	0.08	288	0
33	1,210.00	180.00	0.40	0.08	9	50
34	13,620.00	432.00	0.86	0.08	0	2,000
Mean	4,371.00	315.92	0.65	0.08	58.35	200.21
S.D.	3,997.52	98.31	0.46	0.00	128.41	394.20

A.6.5. (c.) 1870

Furniture	**1870**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Bureaus (nos.)	Quantity of Bedsteads (nos.)
n	C	w_1	w_2	w_3	y_1	y_2
1	1,254.00	450.00	0.25	0.11	0	50
2	10,000.00	400.00	1.00	0.11	0	1,500
3	4,760.00	100.00	2.36	0.11	24	200
4	70,200.00	250.00	0.85	0.11	0	11,000
5	3,850.00	333.33	0.04	0.11	0	72
6	1,880.00	250.00	0.71	0.11	25	100
7	9,900.00	600.00	1.11	0.11	30	288
8	3,800.00	200.00	0.37	0.11	50	500
9	2,350.00	600.00	0.71	0.11	0	156
10	46,300.00	909.09	0.48	0.11	150	600
Mean	15,429.40	409.24	0.79	0.11	27.90	1,446.60
S.D.	23,455.93	240.43	0.64	0.00	46.33	3,384.58

Table A.6.6. Tobacco*

A.6.6. (a.) 1850

Tobacco*	**1850**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Cigars (nos.)	Quantity of Loose tobacco (lbs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	2,130.00	240.00	0.20	0.20	245,000	0
2	2,072.00	336.00	0.07	0.20	186,000	0
3	1,326.00	288.00	0.67	0.20	50,000	0
4	860.00	240.00	0.17	0.20	160,000	0
5	2,360.00	240.00	0.35	0.20	200,000	0
6	1,696.00	144.00	0.13	0.20	600,000	0
7	760.00	300.00	0.20	0.20	160,000	0
8	610.00	240.00	0.03	0.20	120,000	0
9	2,260.00	480.00	0.14	0.20	192,000	0
10	1,230.00	240.00	0.31	0.20	200,000	0
11	1,152.00	336.00	0.06	0.20	728,000	0
12	1,725.00	360.00	0.29	0.20	256,000	0
13	5,768.00	288.00	0.11	0.20	364,000	0
14	10,434.00	375.00	0.29	0.20	700	0
15	1,160.00	360.00	0.33	0.20	100,000	0
16	3,060.00	240.00	0.17	0.20	610,000	0
17	3,132.00	206.40	0.14	0.20	1,000,000	0
18	2,356.00	139.20	0.26	0.20	600,000	500
19	4,964.00	216.00	0.83	0.20	200,000	0
20	7,980.00	480.00	0.19	0.20	400,000	0
21	890.00	240.00	0.63	0.20	40,000	0
22	1,940.00	360.00	0.05	0.20	150,000	0
23	4,850.00	225.00	0.36	0.20	50,000	0
24	736.00	168.00	0.36	0.20	100,000	0
25	615.00	144.00	0.17	0.20	300,000	0
26	1,190.00	180.00	0.16	0.20	412,000	0
27	21,480.00	240.00	1.38	0.20	139,000	0
28	3,268.00	171.00	0.29	0.20	0	6,000
29	5,286.00	139.64	0.32	0.20	1,000,000	150
30	3,000.00	300.00	0.33	0.20	80,000	0
31	21,634.00	124.80	1.38	0.20	1,440,000	0
32	2,800.00	300.00	0.45	0.20	260,000	0
33	940.00	240.00	0.33	0.20	90,000	0
34	1,716.00	204.00	0.27	0.20	150,000	0
35	1,338.00	288.00	0.67	0.20	120,000	0
36	3,190.00	240.00	0.34	0.20	412,000	0
37	3,412.00	180.00	1.60	0.20	156,000	0
Mean	3,657.30	256.57	0.38	0.20	304,613.51	179.73
S.D.	4,818.95	87.39	0.37	0.00	315,296.99	987.10

A.6.6. (b.) 1860

Tobacco*	**1860**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Cigars (nos.)	Quantity of Loose tobacco (lbs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	28,200.00	377.14	0.13	0.25	2,000,000	0
2	4,360.00	480.00	1.00	0.25	150,000	0
3	9,508.00	67.20	1.29	0.25	0	33,000
4	4,286.00	151.50	0.29	0.25	0	2,500
5	3,320.00	360.00	0.40	0.25	200,000	0
6	31,340.00	174.46	0.11	0.25	0	250,000
7	2,724.00	312.00	2.08	0.25	60,000	0
8	5,200.00	300.00	0.83	0.25	200,000	0
9	1,200.00	300.00	0.16	0.25	25,000	0
10	1,480.00	240.00	0.55	0.25	70,000	0
11	5,320.00	225.00	0.19	0.25	360,000	0
12	2,740.00	144.00	0.24	0.25	500,000	0
13	2,592.00	278.40	0.67	0.25	40,000	0
14	3,360.00	180.00	0.42	0.25	100,000	0
15	3,140.00	420.00	0.33	0.25	150,000	0
16	4,254.00	201.00	0.68	0.25	572,000	0
17	9,140.00	405.00	0.67	0.25	500,000	0
18	6,822.00	436.00	0.41	0.25	520,000	0
19	1,410.00	360.00	0.80	0.25	50,000	0
20	7,112.00	172.80	0.11	0.25	595,000	0
21	7,572.00	468.00	0.33	0.25	300,000	0
22	5,680.00	186.67	0.10	0.25	400,000	0
23	2,220.00	360.00	0.10	0.25	150,000	0
24	7,008.00	504.00	0.18	0.25	500,000	0
25	2,820.00	240.00	0.22	0.25	150,000	0
26	23,770.00	412.80	0.14	0.25	1,080,000	0
27	11,418.00	264.00	0.40	0.25	624,000	0
28	4,265.00	360.00	0.15	0.25	388,000	0
29	1,270.00	360.00	0.14	0.25	109,000	0
30	2,385.00	360.00	0.50	0.25	100,000	0
31	1,620.00	360.00	0.13	0.25	130,000	0
32	3,480.00	216.00	0.24	0.25	150,000	0
33	4,120.00	320.00	0.10	0.25	125,000	0
34	1,920.00	210.00	0.14	0.25	50,000	0
35	1,455.00	600.00	0.42	0.25	62,000	0
36	1,300.00	240.00	0.33	0.25	50,000	0
37	2,160.00	120.00	0.30	0.25	150,000	0
38	12,492.00	349.50	0.17	0.25	780,000	0
39	4,760.00	300.00	0.15	0.25	520,000	0
40	10,720.00	240.00	2.00	0.25	100,000	50,000
41	8,670.00	480.00	0.30	0.25	500,000	0
42	4,820.00	228.00	0.13	0.25	60,000	0
43	1,080.00	96.00	0.05	0.25	350,000	0
44	2,016.00	79.64	0.33	0.25	500,000	0

45	4,300.00	360.00	0.20	0.25	300,000	0
46	4,900.00	360.00	0.19	0.25	2,180,000	0
47	6,800.00	300.00	0.06	0.25	400,000	21,000
48	3,290.00	200.00	0.23	0.25	233,000	0
49	1,280.00	240.00	0.33	0.25	150,000	0
50	2,112.00	300.00	0.33	0.25	364,000	0
51	1,028.00	136.00	0.18	0.25	156,000	0
52	860.00	360.00	0.29	0.25	140,000	0
53	4,528.00	246.86	0.29	0.25	350,000	0
54	4,528.00	192.00	0.36	0.25	340,000	0
55	6,355.00	1,080.00	0.17	0.25	120,000	0
Mean	5,572.91	303.89	0.38	0.25	330,054.55	6,481.82
S.D.	6,105.62	156.53	0.41	0.00	410,973.21	34,487.11

A.6.6.(c.) 1870

Tobacco*	**1870**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Cigars (nos.)	Quantity of Loose tobacco (lbs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	2,200.00	300.00	0.17	0.46	84,000	0
2	1,650.00	225.00	0.06	0.46	100,000	0
3	2,273.00	55.56	0.43	0.46	0	4,000
4	2,080.00	15.00	1.00	0.46	0	300
5	4,500.00	500.00	0.56	0.46	90,000	0
6	9,900.00	700.00	0.83	0.46	200,000	0
7	20,000.00	857.14	0.21	0.46	321,000	0
8	2,900.00	600.00	0.39	0.46	90,000	0
9	9,393.00	413.60	0.65	0.46	155,000	0
10	14,400.00	400.00	0.60	0.46	160,000	0
11	8,100.00	437.50	0.18	0.46	273,600	0
12	2,140.00	700.00	0.08	0.46	120,000	0
13	525.00	110.00	0.10	0.46	48,000	0
14	35,449.00	279.49	0.33	0.46	667,000	0
15	3,001.00	200.00	0.37	0.46	135,000	0
16	11,500.00	333.33	0.04	0.46	36,600	0
17	13,020.00	354.55	0.38	0.46	500,000	0
18	2,316.00	550.00	0.13	0.46	92,000	0
19	1,860.00	350.00	0.17	0.46	60,000	0
20	1,200.00	300.00	0.04	0.46	60,000	0
21	765.00	200.00	0.33	0.46	25,000	0
22	6,700.00	625.00	0.09	0.46	600,000	0
23	10,800.00	311.11	0.20	0.46	150,000	0
24	55,220.00	681.82	0.20	0.46	0	50,000
25	9,752.00	428.57	0.03	0.46	250,000	0
26	5,689.00	312.00	0.50	0.46	0	20,250
27	7,020.00	400.00	0.17	0.46	8,500	0

28	21,000.00	343.75	0.18	0.46	900,000	0
29	2,500.00	250.00	0.37	0.46	45,000	0
30	3,864.00	433.33	0.20	0.46	147,000	0
31	6,780.00	400.00	0.36	0.46	175,000	0
32	13,000.00	406.25	0.24	0.46	210,000	0
33	3,800.00	266.67	0.63	0.46	80,000	0
34	1,485.00	500.00	0.15	0.46	40,000	0
35	4,000.00	675.00	0.16	0.46	175,000	0
36	11,058.00	9.45	0.05	0.46	560,000	0
37	1,975.00	160.00	0.01	0.46	67,000	0
38	7,880.00	375.00	0.85	0.46	88,000	0
39	5,750.00	350.00	0.22	0.46	135,000	0
40	4,650.00	466.67	0.54	0.46	70,000	0
41	5,300.00	375.00	0.40	0.46	109,000	0
42	2,216.00	442.00	0.19	0.46	78,000	0
43	3,300.00	400.00	0.25	0.46	100,000	0
44	3,920.00	233.33	0.25	0.46	80,000	0
45	6,475.00	416.00	0.28	0.46	117,700	0
46	7,300.00	500.00	0.56	0.46	120,000	0
47	2,150.00	900.00	0.14	0.46	35,000	0
48	2,800.00	450.00	0.39	0.46	40,000	0
49	4,643.00	246.60	0.20	0.46	100,000	0
50	2,650.00	750.00	0.03	0.46	135,000	0
51	7,890.00	728.00	0.03	0.46	520,000	0
52	6,340.00	525.00	1.06	0.46	108,000	0
53	5,750.00	350.00	0.22	0.46	135,000	0
54	4,700.00	600.00	0.07	0.46	140,300	0
55	10,000.00	400.00	0.77	0.46	260,000	0
56	290,000.00	365.85	0.10	0.46	4,000,000	0
57	3,620.00	620.00	1.00	0.46	62,000	0
58	3,350.00	500.00	0.13	0.46	40,000	0
59	9,500.00	416.67	0.10	0.46	225,000	0
60	4,800.00	250.00	0.40	0.46	109,000	0
61	7,700.00	600.00	0.22	0.46	258,000	0
62	2,900.00	400.00	1.43	0.46	55,000	0
63	26,786.00	650.00	0.71	0.46	540,000	0
64	3,740.00	240.00	0.57	0.46	80,000	0
65	1,350.00	600.00	0.18	0.46	75,000	0
66	25,385.00	350.00	0.20	0.46	0	58,738
67	1,620.00	133.33	0.13	0.46	2,000	0
68	1,600.00	500.00	0.56	0.46	100,000	0
69	2,300.00	400.00	0.03	0.46	120,000	0
70	2,600.00	225.00	0.33	0.46	100,000	0
71	2,150.00	20.00	0.41	0.46	111,800	0
72	875.00	150.00	0.25	0.46	100,000	0
73	400.00	37.50	0.45	0.46	30,000	0
74	2,025.00	166.67	0.26	0.46	100,000	0
75	2,920.00	520.00	0.34	0.46	100,000	0
76	56,625.00	420.00	0.97	0.46	1,089,000	0
77	1,475.00	133.33	0.04	0.46	196,600	0
78	340.00	97.00	0.15	0.46	32,500	0
79	1,020.00	400.00	0.60	0.46	25,000	0
80	1,212.00	400.00	0.22	0.46	40,000	0

81	4,817.00	1,090.67	0.13	0.46	62,100	0
82	1,460.00	400.00	1.00	0.46	30,000	0
83	2,500.00	500.00	0.40	0.46	150,000	0
84	5,500.00	625.00	0.50	0.46	200,000	0
85	12,000.00	777.78	0.14	0.46	310,000	0
86	9,300.00	600.00	0.17	0.46	240,000	0
87	5,800.00	500.00	1.32	0.46	118,000	0
88	5,324.00	624.00	1.46	0.46	120,000	0
89	11,500.00	400.00	0.50	0.46	220,000	0
90	12,551.00	866.67	0.80	0.46	249,400	0
91	30,200.00	625.00	0.40	0.46	800,000	0
92	42,650.00	1,375.00	0.21	0.46	750,000	0
93	16,000.00	321.43	0.17	0.46	600,000	0
94	26,500.00	186.67	0.04	0.46	1,806,000	0
Mean	11,169.40	426.38	0.36	0.46	236,618.09	1,417.96
S.D.	30,903.50	231.60	0.32	0.00	474,493.91	8,156.60

6.(d.) 1880

Tobacco*	**1880**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Cigars (nos.)	Quantity of Loose tobacco (lbs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	1,218.00	468.00	0.67	0.26	35,748	938
2	446.00	30.00	0.08	0.26	61,009	1,600
3	1,500.00	100.00	0.05	0.26	238,318	6,250
4	16,500.00	333.33	0.42	0.26	905,607	23,750
5	10,000.00	400.00	1.04	0.26	228,785	6,000
6	1,300.00	100.00	0.45	0.26	52,430	1,375
7	1,050.00	50.00	0.48	0.26	50,047	1,313
8	5,400.00	466.67	0.30	0.26	238,318	6,250
9	3,166.00	416.00	0.90	0.26	114,393	3,000
10	10,800.00	80.00	0.83	0.26	285,981	7,500
11	15,500.00	62.50	0.21	0.26	667,290	17,500
12	9,400.00	44.44	0.50	0.26	571,963	15,000
13	5,800.00	266.67	0.75	0.26	190,654	5,000
14	10,425.00	228.33	0.19	0.26	502,136	13,169
15	11,240.00	454.55	0.08	0.26	586,262	15,375
16	3,800.00	450.00	0.89	0.26	107,243	2,813
17	1,850.00	200.00	0.25	0.26	95,327	2,500
18	2,800.00	450.00	0.75	0.26	95,327	2,500
19	2,711.00	312.50	0.23	0.26	142,991	3,750
20	732.00	312.00	0.44	0.26	27,359	718
21	899.00	0.50	1.22	0.26	27,407	719
22	716.00	312.00	0.05	0.26	45,852	1,203

23	4,393.00	383.33	0.67	0.26	142,991	3,750
24	9,000.00	147.06	0.62	0.26	309,813	8,125
25	7,040.00	44.44	1.00	0.26	190,654	5,000
26	16,500.00	68.97	0.50	0.26	810,280	21,250
27	108,500.00	108.33	3.60	0.26	1,191,589	31,250
28	40,900.00	778.57	0.08	0.26	3,098,131	81,250
29	1,300.00	500.00	0.15	0.26	131,075	3,438
30	190.00	75.00	0.58	0.26	6,196	163
31	55,800.00	66.67	0.71	0.26	1,668,224	43,750
32	7,000.00	222.22	0.11	0.26	428,972	11,250
33	404,870.00	175.00	0.31	0.26	15,285,701	400,875
34	2,740.00	310.00	0.15	0.26	124,879	3,275
35	9,200.00	340.00	0.29	0.26	333,645	8,750
36	2,216.00	372.00	0.09	0.26	126,785	3,325
37	6,500.00	625.00	0.40	0.26	238,318	6,250
38	2,175.00	675.00	0.27	0.26	89,369	2,344
39	7,844.00	624.00	0.06	0.26	407,237	10,680
40	1,696.00	461.00	0.28	0.26	68,636	1,800
41	922.00	468.00	0.09	0.26	53,621	1,406
42	1,150.00	150.00	0.27	0.26	52,430	1,375
43	1,250.00	200.00	0.60	0.26	47,664	1,250
44	40,500.00	460.00	0.38	0.26	2,144,860	56,250
45	1,550.00	175.00	1.13	0.26	38,131	1,000
46	4,000.00	300.00	0.45	0.26	157,290	4,125
47	96,000.00	262.50	0.67	0.26	2,859,813	75,000
48	2,100.00	300.00	0.23	0.26	104,860	2,750
49	6,300.00	433.33	1.14	0.26	166,822	4,375
50	500.00	83.33	0.13	0.26	38,131	1,000
51	1,183.00	270.00	0.10	0.26	70,351	1,845
52	585.00	92.50	0.22	0.26	42,897	1,125
53	813.00	313.00	0.50	0.26	23,832	625
54	6,478.00	626.00	0.17	0.26	285,981	7,500
55	2,256.00	142.20	0.30	0.26	112,486	2,950
56	4,260.00	312.00	0.07	0.26	219,252	5,750
57	16,200.00	525.00	0.50	0.26	571,963	15,000
58	5,570.00	467.50	0.12	0.26	285,981	7,500
59	3,600.00	333.33	0.29	0.26	166,822	4,375
60	1,138.00	175.00	0.42	0.26	56,577	1,484
61	8,000.00	500.00	0.12	0.26	390,841	10,250
62	1,800.00	200.00	0.50	0.26	76,262	2,000
63	12,500.00	900.00	0.17	0.26	571,963	15,000
64	8,600.00	450.00	0.46	0.26	309,813	8,125
65	1,100.00	300.00	0.33	0.26	57,196	1,500
66	93,300.00	366.36	0.13	0.26	5,719,626	150,000
67	3,400.00	120.00	0.18	0.26	190,654	5,000
68	20,042.00	399.00	0.25	0.26	1,143,925	30,000
69	4,700.00	500.00	0.22	0.26	428,972	11,250
70	4,540.00	633.33	0.12	0.26	307,430	8,063
71	57,000.00	93.75	1.28	0.26	1,191,589	31,250
72	1,575.00	412.50	0.12	0.26	81,505	2,138
73	1,550.00	125.00	0.83	0.26	57,196	1,500
74	3,100.00	500.00	0.13	0.26	214,486	5,625
75	7,200.00	60.00	0.60	0.26	238,318	6,250

76	7,150.00	525.00	0.29	0.26	333,645	8,750
77	1,575.00	237.50	0.28	0.26	85,794	2,250
78	2,900.00	300.00	0.40	0.26	119,159	3,125
79	3,200.00	450.00	0.09	0.26	166,822	4,375
80	710.00	250.00	0.30	0.26	47,664	1,250
81	4,400.00	600.00	0.50	0.26	190,654	5,000
82	12,200.00	457.14	0.20	0.26	714,953	18,750
83	10,000.00	411.11	0.27	0.26	714,953	18,750
84	4,750.00	450.00	0.40	0.26	238,794	6,263
85	16,000.00	291.67	0.37	0.26	643,458	16,875
86	4,900.00	400.00	0.08	0.26	171,589	4,500
87	3,500.00	333.33	0.15	0.26	162,056	4,250
88	2,176.00	313.00	1.00	0.26	57,196	1,500
89	3,026.00	164.00	0.19	0.26	257,383	6,750
90	4,960.00	500.00	0.75	0.26	190,654	5,000
91	2,280.00	466.67	0.14	0.26	133,458	3,500
92	2,000.00	400.00	0.23	0.26	104,860	2,750
93	21,700.00	600.00	0.21	0.26	1,143,925	30,000
94	2,100.00	187.50	0.11	0.26	109,626	2,875
95	6,570.00	240.00	0.16	0.26	352,710	9,250
96	4,685.00	312.00	0.67	0.26	142,991	3,750
97	2,534.00	300.00	0.25	0.26	142,991	3,750
98	770.00	60.00	0.22	0.26	42,897	1,125
99	357.00	0.33	0.13	0.26	36,129	948
100	10,000.00	500.00	0.56	0.26	428,972	11,250
101	2,450.00	225.00	0.40	0.26	119,159	3,125
102	5,800.00	300.00	0.20	0.26	238,318	6,250
103	26,500.00	153.85	0.10	0.26	1,429,907	37,500
104	1,350.00	150.00	0.28	0.26	95,327	2,500
105	2,085.00	492.50	0.25	0.26	114,393	3,000
106	300.00	75.00	0.08	0.26	28,598	750
107	1,200.00	166.67	0.26	0.26	72,449	1,900
108	1,532.00	166.67	0.25	0.26	76,262	2,000
109	3,665.00	276.75	0.51	0.26	131,075	3,438
110	2,200.00	200.00	0.20	0.26	142,991	3,750
111	7,200.00	500.00	0.09	0.26	381,308	10,000
112	6,040.00	264.50	1.56	0.26	122,019	3,200
113	18,381.00	294.83	0.21	0.26	571,963	15,000
114	2,500.00	166.67	0.33	0.26	142,991	3,750
115	3,600.00	300.00	0.40	0.26	142,991	3,750
116	2,250.00	90.00	0.40	0.26	95,327	2,500
117	11,500.00	500.00	0.41	0.26	524,299	13,750
118	16,200.00	553.85	0.10	0.26	1,000,935	26,250
119	4,000.00	250.00	0.25	0.26	190,654	5,000
120	1,187.00	162.00	0.06	0.26	76,262	2,000
121	2,050.00	300.00	0.19	0.26	114,393	3,000
122	4,776.00	300.00	1.25	0.26	114,631	3,006
123	6,500.00	333.33	0.60	0.26	238,318	6,250
124	8,200.00	379.00	0.11	0.26	432,547	11,344
125	31,000.00	500.00	0.15	0.26	1,429,907	37,500
126	1,700.00	500.00	0.10	0.26	99,140	2,600
127	1,200.00	400.00	0.50	0.26	47,664	1,250
128	1,000.00	300.00	0.04	0.26	119,159	3,125

129	800.00	200.00	0.10	0.26	47,664	1,250
130	24,500.00	312.50	0.20	0.26	1,191,589	31,250
131	10,620.00	424.00	0.20	0.26	476,636	12,500
132	8,000.00	625.00	2.40	0.26	119,159	3,125
133	950.00	250.00	0.14	0.26	66,729	1,750
134	885.00	260.00	0.18	0.26	52,430	1,375
135	9,800.00	500.00	0.15	0.26	476,636	12,500
136	3,400.00	200.00	0.80	0.26	119,159	3,125
137	3,000.00	83.33	0.67	0.26	106,051	2,781
138	8,600.00	680.00	0.22	0.26	428,972	11,250
139	1,945.00	145.00	1.88	0.26	38,131	1,000
140	1,400.00	175.00	0.67	0.26	50,047	1,313
141	3,650.00	175.00	3.87	0.26	36,939	969
142	3,122.00	386.00	0.63	0.26	114,393	3,000
143	6,900.00	415.00	0.36	0.26	398,849	10,460
144	17,390.00	873.33	0.32	0.26	756,421	19,838
145	7,325.00	255.00	0.56	0.26	255,238	6,694
146	8,542.00	636.33	0.05	0.26	503,327	13,200
147	1,051.00	228.00	0.44	0.26	54,336	1,425
148	532.00	159.00	0.30	0.26	31,696	831
149	540.00	42.00	0.59	0.26	24,118	633
150	1,425.00	178.33	0.35	0.26	68,159	1,788
151	934.00	160.00	0.69	0.26	38,131	1,000
152	1,048.00	396.00	0.19	0.26	73,402	1,925
153	1,649.00	490.00	0.47	0.26	71,495	1,875
154	325.00	0.33	0.19	0.26	38,131	1,000
155	884.00	0.33	0.22	0.26	64,346	1,688
156	749.00	0.33	1.00	0.26	23,832	625
157	10,500.00	250.00	0.50	0.26	476,636	12,500
158	9,800.00	337.50	0.14	0.26	514,766	13,500
159	11,463.00	234.00	0.46	0.26	467,103	12,250
160	3,404.00	702.00	0.31	0.26	152,523	4,000
161	2,050.00	550.00	0.36	0.26	133,458	3,500
162	3,367.00	468.00	0.42	0.26	113,106	2,966
163	10,000.00	416.67	0.67	0.26	357,477	9,375
164	1,649.00	0.33	0.46	0.26	72,449	1,900
165	3,286.00	518.00	0.17	0.26	184,458	4,838
166	9,976.00	520.00	0.63	0.26	381,308	10,000
167	951.00	338.00	0.12	0.26	60,771	1,594
168	1,524.00	0.33	1.25	0.26	38,131	1,000
169	873.00	0.33	0.26	0.26	46,472	1,219
170	2,854.00	572.00	0.35	0.26	108,673	2,850
171	469.00	0.33	0.27	0.26	26,692	700
172	3,704.00	338.00	0.25	0.26	188,700	4,949
173	301.00	0.33	0.20	0.26	23,832	625
174	9,200.00	325.00	0.43	0.26	333,645	8,750
175	454.00	0.33	0.18	0.26	26,215	688
176	3,042.00	416.00	1.00	0.26	76,643	2,010
177	799,000.00	433.33	0.21	0.26	33,841,121	887,500
178	470,000.00	500.00	0.03	0.26	28,598,131	750,000
179	140,500.00	175.00	0.60	0.26	4,766,355	125,000
180	16,500.00	138.89	1.00	0.26	476,636	12,500
181	59,500.00	300.00	0.11	0.26	2,859,813	75,000

182	33,000.00	400.00	0.06	0.26	1,668,224	43,750
183	25,300.00	527.27	0.27	0.26	1,057,654	27,738
184	1,200.00	100.00	0.25	0.26	57,196	1,500
185	3,452.00	626.00	0.33	0.26	142,991	3,750
186	863.00	60.00	0.17	0.26	71,495	1,875
187	4,200.00	500.00	0.18	0.26	262,150	6,875
188	2,600.00	333.33	0.28	0.26	119,159	3,125
189	3,500.00	375.00	0.11	0.26	214,486	5,625
190	850.00	16.67	0.13	0.26	71,495	1,875
191	2,400.00	300.00	0.12	0.26	119,159	3,125
192	2,675.00	42.86	0.63	0.26	76,262	2,000
193	5,248.00	416.00	0.71	0.26	166,822	4,375
194	1,299.00	0.33	0.73	0.26	52,430	1,375
195	575.00	37.50	0.67	0.26	28,598	750
196	1,250.00	150.00	0.71	0.26	33,364	875
197	652.00	52.00	0.25	0.26	57,196	1,500
198	2,181.00	195.00	0.16	0.26	174,687	4,581
199	6,532.00	303.20	0.39	0.26	362,243	9,500
200	3,112.00	253.00	0.20	0.26	237,412	6,226
201	1,689.00	56.00	1.08	0.26	47,664	1,250
202	3,500.00	250.00	0.13	0.26	190,654	5,000
203	3,450.00	100.00	0.11	0.26	223,065	5,850
204	23,800.00	300.00	0.09	0.26	1,668,224	43,750
205	27,500.00	34.88	0.21	0.26	1,143,925	30,000
206	1,300.00	300.00	0.88	0.26	38,131	1,000
207	833.00	125.00	0.19	0.26	50,666	1,329
208	2,100.00	160.00	0.24	0.26	119,159	3,125
209	8,400.00	400.00	0.12	0.26	405,140	10,625
210	17,000.00	375.00	1.76	0.26	324,112	8,500
211	7,000.00	312.50	0.31	0.26	381,308	10,000
212	6,900.00	144.00	0.25	0.26	291,701	7,650
213	2,780.00	40.00	6.25	0.26	19,065	500
214	2,450.00	400.00	0.14	0.26	164,439	4,313
215	1,999.00	0.33	2.14	0.26	33,364	875
216	6,500.00	625.00	0.42	0.26	285,981	7,500
217	1,825.00	525.00	0.48	0.26	79,360	2,081
218	900.00	150.00	0.91	0.26	26,215	688
219	2,700.00	600.00	0.14	0.26	166,822	4,375
220	410.00	20.00	0.25	0.26	28,979	760
221	1,410.00	150.00	0.24	0.26	90,561	2,375
222	1,149.00	0.33	0.20	0.26	71,495	1,875
223	18,000.00	300.00	0.33	0.26	714,953	18,750
224	2,064.00	300.00	0.81	0.26	76,262	2,000
225	7,527.00	400.00	1.75	0.26	150,140	3,938
226	1,600.00	450.00	0.15	0.26	95,327	2,500
227	700.00	400.00	0.13	0.26	38,131	1,000
228	2,800.00	100.00	0.60	0.26	119,159	3,125
229	1,084.00	234.00	0.07	0.26	71,495	1,875
230	20,700.00	372.22	0.28	0.26	857,944	22,500
231	360.00	20.00	0.32	0.26	29,790	781
232	1,450.00	42.86	1.06	0.26	40,514	1,063
233	3,200.00	166.67	0.35	0.26	190,654	5,000
234	22,250.00	130.00	0.36	0.26	857,944	22,500

235	40,400.00	520.00	0.50	0.26	1,429,907	37,500
236	7,600.00	625.00	0.42	0.26	285,981	7,500
237	140,601.00	238.49	0.45	0.26	5,326,640	139,694
238	1,925.00	625.00	0.29	0.26	115,822	3,038
239	23,201.00	260.00	0.60	0.26	796,458	20,888
240	10,669.00	237.35	0.21	0.26	461,574	12,105
241	9,424.00	180.00	0.21	0.26	453,757	11,900
Mean	15,713.94	296.08	0.46	0.26	690,520	18,109
S.D.	66,561.99	189.48	0.61	0.00	3,053,558	80,081

Table A.6.7. Foundaries*

A.6.7. (a.) 1850

Foundaries*	**1850**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Castings (tons)	Quantity of Plows (nos.)
n	C	w_1	w_2	w_3	y_1	y_2
1	8,978.00	144.00	0.80	23.50	100	0
2	2,270.00	120.00	0.18	23.50	50	0
3	28,264.00	360.00	0.18	23.50	0	600
4	6,360.00	156.00	0.36	23.50	40	0
5	18,550.00	276.92	0.69	23.50	0	400
6	4,296.00	264.00	1.06	23.50	0	20
7	12,294.00	360.00	0.25	23.50	0	600
8	11,427.00	384.00	0.77	23.50	75	0
9	1,880.00	360.00	0.28	23.50	19	0
10	2,896.00	348.00	0.89	23.50	21	0
11	4,136.00	384.00	0.56	23.50	0	50
12	3,640.00	300.00	1.00	23.50	28	0
13	3,640.00	300.00	1.00	23.50	28	0
14	220,000.00	487.50	0.54	23.50	3,500	0
15	31,287.00	331.43	0.56	23.50	300	0
16	5,510.00	300.00	1.06	23.50	121	0
17	8,962.00	240.00	0.48	23.50	85	0
18	27,460.00	450.00	0.50	23.50	320	0
19	4,729.00	312.00	0.89	23.50	45	0
20	21,480.00	480.00	0.10	23.50	200	0
21	4,709.00	429.00	0.74	23.50	34	0
22	2,004.00	246.00	0.08	23.50	30	0
23	2,400.00	160.00	0.88	23.50	17	0
24	9,550.00	240.00	0.38	23.50	130	0
25	4,249.00	360.00	0.54	23.50	0	150
26	8,040.00	240.00	0.46	23.50	65	0
27	19,560.00	304.00	1.00	23.50	155	0
28	2,970.00	360.00	0.51	23.50	33	0
29	9,240.00	348.00	0.45	23.50	52	0
Mean	16,923.48	311.89	0.59	23.50	187.86	62.76
S.D.	39,968.35	95.07	0.30	0.00	642.43	168.10

A.6.7. (b.) 1860

Foundaries*	**1860**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Castings (tons)	Quantity of Plows (nos.)
n	C	w_1	w_2	w_3	y_1	y_2
1	14,480.00	480.00	0.07	21.42	270	0
2	3,920.00	330.00	0.60	21.42	35	0
3	9,800.00	180.00	0.83	21.42	120	0
4	14,228.00	282.00	4.80	21.42	50,000	0
5	7,887.00	144.00	1.25	21.42	15	0
6	87,209.00	389.87	0.67	21.42	1,000	0
7	295,678.00	1,242.76	0.68	21.42	80	0
8	19,450.00	500.00	0.54	21.42	195	0
9	27,470.00	369.23	0.15	21.42	540	0
10	73,557.00	272.57	0.35	21.42	1,420	0
11	147,500.00	362.79	1.41	21.42	1,600	0
12	50,700.00	522.58	0.40	21.42	1,000	0
13	33,448.00	527.00	0.79	21.42	450	0
14	45,775.00	377.14	0.57	21.42	400	0
15	6,955.00	240.00	0.31	21.42	90	0
16	1,190.00	360.00	0.20	21.42	9	0
17	229,500.00	336.00	0.67	21.42	1,000	0
18	3,480.00	360.00	0.48	21.42	0	80
19	9,878.00	24.00	1.69	21.42	60	0
20	3,534.00	96.00	0.52	21.42	60	100
Mean	54,281.95	369.80	0.85	21.42	2,917.20	9.00
S.D.	80,659.33	246.90	1.02	0.00	11,093.33	27.89

A.6.7.(c.) 1870

Foundaries*	**1870**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Castings (tons)	Quantity of Plows (nos.)
n	C	w_1	w_2	w_3	y_1	y_2
1	25,790.00	600.00	0.48	30.66	150	0
2	17,500.00	76.47	7.50	30.66	20	0
3	31,500.00	750.00	1.25	30.66	91	0
4	2,565.00	175.00	0.75	30.66	4	0
5	27,550.00	937.50	0.50	30.66	200	0
6	6,712.00	250.00	1.32	30.66	0	130
7	13,777.00	408.33	0.50	30.66	450	0
8	13,465.00	120.00	3.33	30.66	38	0
9	165,000.00	400.00	0.40	30.66	1,450	0
10	177,000.00	850.00	1.00	30.66	500	0
11	47,625.00	827.78	0.43	30.66	300	0
12	2,697.00	250.00	0.83	30.66	20	0
13	116,850.00	370.37	1.25	30.66	612	0
14	3,820.00	100.00	0.38	30.66	23	0
15	12,680.00	625.00	1.45	30.66	50	0
16	137,650.00	590.91	0.48	30.66	1,400	0
17	39,254.00	389.47	2.06	30.66	68	0
18	76,300.00	424.24	0.16	30.66	1,350	0
19	64,200.00	500.00	0.68	30.66	300	0
Mean	51,680.79	455.00	1.30	30.66	369.79	6.84
S.D.	56,513.83	263.19	1.68	0.00	492.98	29.82

Table A.6.8. Meat*

A.6.8. (a.) 1850

Meat*	**1850**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Beef (lbs.)	Quantity of Mutton (lbs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	6,353.00	264.00	0.08	11.84	87,500	0
2	8,870.00	360.00	0.15	11.84	160,000	0
3	989.00	240.00	0.28	11.84	21,000	0
4	20,270.00	420.00	0.30	11.84	175	200
5	2,360.00	360.00	0.83	11.84	150	0
6	6,532.00	216.00	0.16	11.84	68,500	6,000
7	6,650.00	300.00	0.10	11.84	79,040	0
8	3,860.00	360.00	0.11	11.84	60,000	0
9	6,330.00	180.00	0.17	11.84	70,000	0
10	5,770.00	360.00	0.72	11.84	48,000	0
Mean	6,798.40	306.00	0.29	11.84	59,436.50	620.00
S.D.	5,264.42	78.03	0.27	0.00	47,274.49	1,891.38

A.6.8. (b.) 1860

Meat*	**1860**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Beef (lbs.)	Quantity of Mutton (lbs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	23,940.00	360.00	0.04	17.63	369	700
2	2,314.00	360.00	0.25	17.63	21,000	0
3	157,592.00	324.00	0.05	17.63	1,750,000	0
4	10,648.00	324.00	0.36	17.63	90,000	0
5	16,970.00	360.00	0.25	17.63	157,000	0
6	2,220.00	480.00	0.30	17.63	26,500	4,800
7	20,660.00	480.00	0.07	17.63	176,200	35,000
8	8,320.00	320.00	0.11	17.63	90,000	12,000
9	35,801.00	360.00	0.26	17.63	364,800	0
10	71,420.00	480.00	0.15	17.63	720,000	0
11	29,460.00	420.00	0.16	17.63	362,400	0
12	7,992.00	492.00	0.27	17.63	93,000	4,500
13	3,820.00	240.00	0.09	17.63	26,700	0
14	15,440.00	240.00	0.06	17.63	185,400	0
15	1,740.00	120.00	0.13	17.63	20,000	8,000
16	6,660.00	360.00	0.03	17.63	93,000	1,200

17	7,536.00	768.00	1.60	17.63	12,000	0
18	1,814.00	264.00	0.33	17.63	16,960	0
Mean	23,574.83	375.11	0.25	17.63	233,629.39	3,677.78
S.D.	37,563.20	138.56	0.35	0.00	419,318.70	8,522.47

A.6.8.(c.) 1870

Meat*	**1870**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Beef (lbs.)	Quantity of Mutton (lbs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	9,468.00	200.00	0.18	13.71	78,720	0
2	21,512.00	360.00	0.33	13.71	10,000	0
Mean	15,490.00	280.00	0.26	13.71	44,360.00	0.00
S.D.	8,516.39	113.14	0.11	0.00	48,592.38	0.00

8.(d.) 1880

Meat*	**1880**	Vector of Input Prices			Vector of Output Quantities	
Obs. No.	Total Cost	Price of Labor	Price of Capital	Price of Materials	Quantity of Beef (lbs.)	Quantity of Mutton (lbs.)
n	C	w_1	w_2	w_3	y_1	y_2
1	13,782.00	328.50	0.03	18.17	41,015	5,736
2	2,867.00	0.33	0.03	18.17	9,292	1,300
3	10,225.00	200.00	0.73	18.17	17,784	2,487
4	3,220.00	400.00	0.05	18.17	9,477	1,325
5	30,565.00	391.25	0.03	18.17	101,239	14,159
6	8,300.00	300.00	0.27	18.17	19,500	2,727
7	407,602.00	684.64	0.67	18.17	780,000	109,091
8	20,600.00	100.00	0.11	18.17	57,070	7,982
9	15,400.00	350.00	0.01	18.17	40,898	5,720
10	3,100.00	250.00	0.11	18.17	18,720	2,618
11	2,705.00	200.00	0.11	18.17	7,615	1,065
12	73,300.00	160.00	0.13	18.17	205,504	28,742
13	4,450.00	300.00	0.02	18.17	17,329	2,424
14	477,500.00	500.00	0.25	18.17	1,027,000	143,636
15	11,250.00	500.00	0.47	18.17	19,500	2,727
16	10,750.00	133.33	0.26	18.17	24,931	3,487
17	4,680.00	100.00	0.45	18.17	8,684	1,215
18	1,325.00	50.00	0.06	18.17	8,320	1,164
19	14,460.00	266.67	0.04	18.17	42,900	6,000

20	5,454.00	159.67	0.19	18.17	13,975	1,955
21	856,000.00	300.00	0.06	18.17	2,210,000	309,091
22	3,600.00	100.00	0.10	18.17	12,480	1,745
23	3,610.00	100.00	0.12	18.17	8,645	1,209
24	9,310.00	55.00	0.04	18.17	29,042	4,062
25	5,777.00	60.00	0.17	18.17	15,002	2,098
26	2,263,150.00	414.71	0.04	18.17	5,928,000	829,091
27	51,460.00	600.00	0.23	18.17	111,722	15,625
28	4,775.00	125.00	0.34	18.17	9,100	1,273
29	4,150.00	75.00	0.15	18.17	12,480	1,745
30	4,350.00	116.67	0.24	18.17	15,990	2,236
31	3,600.00	500.00	0.15	18.17	10,400	1,455
32	11,750.00	166.67	0.55	18.17	23,660	3,309
33	5,350.00	225.00	0.09	18.17	16,900	2,364
34	11,452.00	400.00	0.16	18.17	32,071	4,485
35	2,265,246.00	213.38	0.20	18.17	5,200,000	727,273
36	39,626.00	725.00	0.42	18.17	81,019	11,331
37	19,220.00	666.67	0.42	18.17	37,440	5,236
38	26,500.00	375.00	0.78	18.17	29,900	4,182
39	5,400.00	100.00	0.20	18.17	15,501	2,168
40	560,000.00	171.43	0.09	18.17	1,479,920	206,982
41	6,200.00	175.00	0.08	18.17	16,120	2,255
42	9,030.00	240.00	0.07	18.17	24,284	3,396
43	281,523.00	175.00	0.36	18.17	536,960	75,099
44	9,050.00	200.00	0.04	18.17	30,030	4,200
45	6,227.00	250.00	0.02	18.17	16,120	2,255
46	20,575.00	240.00	0.23	18.17	45,591	6,376
47	9,375.00	125.00	0.27	18.17	47,788	6,684
48	10,715.00	228.00	0.15	18.17	45,687	6,390
49	34,400.00	266.67	1.43	18.17	39,000	5,455
50	3,725.00	200.00	0.30	18.17	26,000	3,636
51	9,825.00	333.33	0.16	18.17	24,302	3,399
52	449,600.00	350.00	0.06	18.17	1,133,600	158,545
53	6,735.00	225.00	0.29	18.17	16,341	2,285
54	15,125.00	200.00	0.04	18.17	54,600	7,636
55	9,400.00	133.33	0.38	18.17	20,800	2,909
56	6,165.00	365.00	0.13	18.17	15,600	2,182
57	25,150.00	400.00	0.09	18.17	60,970	8,527
58	6,903.00	468.00	0.74	18.17	10,530	1,473
59	83,600.00	400.00	0.06	18.17	224,900	31,455
60	7,222.00	330.00	0.14	18.17	18,062	2,526
61	20,050.00	450.00	0.13	18.17	48,360	6,764
62	5,700.00	250.00	0.08	18.17	31,200	4,364
63	8,373.00	466.67	0.11	18.17	24,393	3,412
64	91,850.00	625.00	0.10	18.17	273,650	38,273
65	13,800.00	400.00	0.11	18.17	45,474	6,360
66	111,700.00	357.14	0.20	18.17	260,000	36,364
67	12,590.00	445.00	0.50	18.17	26,104	3,651
68	13,450.00	225.00	0.38	18.17	33,800	4,727
69	11,150.00	250.00	0.03	18.17	31,200	4,364
70	24,150.00	600.00	1.25	18.17	31,200	4,364
71	15,870.00	450.00	0.13	18.17	41,600	5,818
72	3,795.00	250.00	0.36	18.17	9,360	1,309

73	3,800.00	200.00	0.62	18.17	6,305	882
74	10,925.00	275.00	0.02	18.17	28,600	4,000
75	9,175.00	300.00	0.10	18.17	25,771	3,604
76	10,100.00	300.00	0.08	18.17	34,320	4,800
77	7,650.00	500.00	0.13	18.17	20,800	2,909
78	2,740.00	450.00	0.11	18.17	9,724	1,360
79	138,500.00	700.00	0.11	18.17	351,000	49,091
80	3,000.00	500.00	0.02	18.17	10,660	1,491
81	6,600.00	500.00	0.01	18.17	20,800	2,909
82	6,200.00	500.00	0.02	18.17	17,082	2,389
83	4,500.00	450.00	0.06	18.17	12,870	1,800
84	11,225.00	166.67	0.22	18.17	23,205	3,245
85	10,513.00	638.00	0.17	18.17	27,084	3,788
86	7,040.00	420.00	0.07	18.17	18,200	2,545
87	18,975.00	350.00	0.05	18.17	51,805	7,245
88	52,475.00	180.00	0.52	18.17	100,100	14,000
89	6,440.00	240.00	0.07	18.17	19,656	2,749
90	13,500.00	450.00	0.12	18.17	43,789	6,124
91	9,460.00	160.00	0.02	18.17	32,292	4,516
92	6,754.00	780.00	0.02	18.17	19,500	2,727
93	10,100.00	300.00	0.16	18.17	24,128	3,375
94	19,450.00	225.00	0.47	18.17	39,000	5,455
95	210,000.00	500.00	0.72	18.17	358,800	50,182
96	58,500.00	300.00	0.20	18.17	130,000	18,182
97	9,035.00	300.00	0.27	18.17	18,928	2,647
98	3,575.00	25.00	0.33	18.17	7,800	1,091
99	2,951.00	137.50	0.12	18.17	6,630	927
100	10,200.00	350.00	0.05	18.17	31,200	4,364
101	132,500.00	285.71	0.48	18.17	325,000	45,455
102	10,175.00	200.00	0.27	18.17	24,050	3,364
103	13,295.00	425.00	0.04	18.17	41,600	5,818
104	8,000.00	100.00	0.13	18.17	20,800	2,909
105	22,480.00	100.00	1.00	18.17	30,680	4,291
106	6,120.00	300.00	0.18	18.17	14,466	2,023
107	21,325.00	492.50	0.26	18.17	49,400	6,909
108	7,775.00	300.00	0.20	18.17	25,701	3,595
109	5,397.00	362.50	0.09	18.17	15,200	2,126
110	7,580.00	383.33	0.19	18.17	20,150	2,818
111	10,600.00	300.00	0.42	18.17	19,630	2,745
112	8,600.00	200.00	0.06	18.17	27,014	3,778
113	6,365.00	240.00	0.04	18.17	24,931	3,487
114	46,400.00	85.71	1.36	18.17	57,200	8,000
115	14,263.00	436.50	0.28	18.17	37,365	5,226
116	8,350.00	166.67	0.15	18.17	35,100	4,909
117	7,250.00	125.00	0.27	18.17	14,560	2,036
118	21,350.00	300.00	0.04	18.17	117,000	16,364
119	2,144.00	0.33	0.44	18.17	4,680	655
120	3,515.00	315.00	0.27	18.17	7,800	1,091
121	2,985.00	75.00	0.12	18.17	8,580	1,200
122	1,336.00	15.00	0.13	18.17	5,138	719
123	1,278.00	5.00	0.31	18.17	2,548	356
124	8,395.00	225.00	0.04	18.17	31,200	4,364
125	3,550.00	100.00	0.12	18.17	8,921	1,248

126	3,037.00	437.00	0.39	18.17	5,304	742
127	8,200.00	400.00	0.03	18.17	22,360	3,127
128	16,310.00	475.00	0.14	18.17	37,076	5,185
129	20,225.00	625.00	0.05	18.17	48,360	6,764
130	6,250.00	100.00	0.27	18.17	14,300	2,000
131	3,000.00	400.00	0.29	18.17	7,280	1,018
132	969,948.00	540.00	0.10	18.17	2,596,880	363,200
133	1,450.00	50.00	0.70	18.17	2,600	364
134	14,047.00	625.00	0.24	18.17	26,772	3,744
135	11,735.00	116.67	0.14	18.17	28,210	3,945
136	2,619.00	0.33	0.17	18.17	9,048	1,265
137	3,640.00	48.00	0.33	18.17	7,790	1,089
138	8,475.00	300.00	0.14	18.17	18,850	2,636
139	3,277.00	75.00	0.09	18.17	11,544	1,615
140	10,170.00	125.00	0.36	18.17	19,596	2,741
141	65,900.00	600.00	0.05	18.17	169,000	23,636
142	5,750.00	100.00	0.20	18.17	13,000	1,818
143	10,880.00	150.00	0.54	18.17	19,240	2,691
144	2,605.00	145.00	0.20	18.17	6,656	931
145	6,412.00	106.00	0.07	18.17	19,110	2,673
146	10,000.00	500.00	0.09	18.17	27,456	3,840
147	1,562,672.00	596.67	0.05	18.17	3,962,772	554,234
148	662,053.00	290.17	0.33	18.17	1,363,926	190,759
149	38,056.00	450.00	0.64	18.17	60,970	8,527
150	49,359.00	333.33	0.24	18.17	110,133	15,403
151	2,575.00	37.50	0.20	18.17	6,630	927
152	12,365.00	182.50	0.12	18.17	33,800	4,727
153	13,599.00	0.33	0.24	18.17	37,180	5,200
154	4,060.00	20.00	0.08	18.17	12,480	1,745
155	14,800.00	150.00	0.22	18.17	34,840	4,873
156	5,800.00	150.00	0.16	18.17	16,120	2,255
157	5,644.00	150.00	0.43	18.17	10,530	1,473
158	1,538.00	79.00	0.17	18.17	5,473	765
159	19,936.00	312.00	0.15	18.17	52,000	7,273
160	14,005.00	200.00	1.00	18.17	18,200	2,545
161	4,870.00	50.00	0.30	18.17	13,000	1,818
162	11,630.00	83.33	0.28	18.17	23,608	3,302
163	45,804.00	520.00	0.31	18.17	100,690	14,083
164	14,950.00	150.00	0.03	18.17	42,120	5,891
165	15,299.00	350.00	0.30	18.17	34,315	4,799
166	1,283,750.00	750.00	0.05	18.17	3,279,900	458,727
167	147,500.00	562.50	0.10	18.17	455,000	63,636
168	114,200.00	416.67	0.37	18.17	247,000	34,545
169	4,000.00	150.00	0.06	18.17	13,195	1,845
170	5,200.00	33.33	0.13	18.17	11,700	1,636
171	15,455.00	200.00	0.07	18.17	39,088	5,467
172	4,963.00	313.00	0.09	18.17	13,686	1,914
173	19,334.00	400.00	0.19	18.17	57,200	8,000
174	3,750.00	25.00	0.36	18.17	7,280	1,018
175	15,500.00	100.00	0.76	18.17	23,972	3,353
176	3,100.00	300.00	0.29	18.17	9,100	1,273
177	8,160.00	500.00	0.23	18.17	17,316	2,422
178	7,837.00	33.33	0.35	18.17	18,564	2,596

179	13,757.00	450.00	0.08	18.17	33,548	4,692
180	5,756.00	20.00	0.14	18.17	18,200	2,545
181	8,065.00	50.00	0.56	18.17	23,400	3,273
182	5,495.00	166.67	0.29	18.17	12,826	1,794
183	7,475.00	100.00	0.15	18.17	16,783	2,347
184	1,600.00	150.00	0.19	18.17	4,053	567
185	7,620.00	300.00	0.03	18.17	22,685	3,173
186	8,402.00	156.00	0.11	18.17	21,252	2,972
187	12,210.00	454.00	0.10	18.17	37,991	5,313
188	27,565.00	600.00	0.55	18.17	56,277	7,871
189	5,700.00	150.00	0.23	18.17	11,180	1,564
190	14,000.00	250.00	0.11	18.17	36,400	5,091
191	8,400.00	200.00	0.10	18.17	26,000	3,636
192	2,550.00	50.00	0.20	18.17	5,200	727
193	3,100.00	20.00	0.15	18.17	8,793	1,230
194	10,450.00	100.00	0.15	18.17	26,572	3,716
195	4,939.00	0.33	0.02	18.17	15,080	2,109
196	2,750.00	200.00	0.62	18.17	10,556	1,476
197	2,300.00	300.00	0.29	18.17	8,915	1,247
198	80,200.00	200.00	0.07	18.17	199,940	27,964
199	3,524.00	0.33	0.07	18.17	8,759	1,225
200	4,397.00	50.00	0.11	18.17	12,212	1,708
201	5,332.00	166.00	0.28	18.17	5,486	767
202	4,359.00	0.33	0.04	18.17	13,385	1,872
203	7,572.00	0.50	0.42	18.17	15,465	2,163
204	6,949.00	47.50	0.05	18.17	20,345	2,845
205	6,477.00	95.40	0.31	18.17	45,526	6,367
206	7,290.00	375.00	0.22	18.17	18,078	2,528
207	14,300.00	125.00	0.03	18.17	45,552	6,371
208	773,300.00	600.00	0.01	18.17	2,119,000	296,364
209	10,059.00	0.33	0.04	18.17	37,060	5,183
210	19,136.00	568.00	0.17	18.17	45,240	6,327
211	35,680.00	600.00	0.18	18.17	87,558	12,246
212	5,330.00	300.00	0.21	18.17	12,610	1,764
213	128,250.00	450.00	0.01	18.17	395,200	55,273
214	58,280.00	480.00	0.17	18.17	140,400	19,636
215	7,850.00	150.00	0.11	18.17	24,440	3,418
216	1,023.00	100.00	0.09	18.17	2,769	387
217	8,438.00	219.00	0.67	18.17	15,600	2,182
218	5,419.00	1.00	0.08	18.17	16,125	2,255
219	21,116.00	550.00	0.13	18.17	61,880	8,655
220	14,971.00	137.00	0.14	18.17	37,700	5,273
221	4,600.00	200.00	0.17	18.17	31,200	4,364
222	3,860.00	100.00	0.13	18.17	11,700	1,636
223	1,625.00	125.00	0.74	18.17	2,210	309
224	14,078.00	580.00	0.06	18.17	40,167	5,618
225	4,530.00	930.00	0.48	18.17	5,460	764
226	12,500.00	150.00	0.08	18.17	104,000	14,545
227	16,000.00	500.00	0.08	18.17	46,800	6,545
228	8,165.00	400.00	0.48	18.17	13,429	1,878
229	2,150.00	100.00	0.22	18.17	7,150	1,000
Mean	71,737.48	272.91	0.23	18.17	177,960	24,889
S.D.	273,750.80	189.19	0.23	-	682,341	95,432

BIBLIOGRAPHY

Books and Articles

American Iron and Steel Association. *Statistics of the American and Foreign Iron Trades.* Philadelphia: The Association. 1888, 1889.

Atack, Jeremy. *Estimation of Economies of Scale in Nineteenth Century United States Manufacturing*, New York & London: Garland Publishing, Inc. (1985).

-------- "Industrial Structure and the Emergence of the Modern Industrial Corporation." *Explorations in Economic History* 22, 29-52 (1985).

-------- and Fred Bateman. "Nineteenth-Century U.S. Industrial Development through the Eyes of the Census of Manufactures: A New Resource for Historical Research." *Historical Methods*, Fall 1999, Vol. 32, No. 4: 177-88.

Bagwell, Philip S. *The Transport Revolution from 1770*. London, Batsford (1974).

Bain, J. S. *Barriers to New Competition* (Cambridge, Mass.: Harvard University Press, 1956).

Ballin, H. H. *The Organisation of Electricity Supply in Great Britain*. London: Electrical Press, Ltd., 1946.

Beard, Charles, and Mary Beard. *The Rise of American Civilization.* New Edition, Two Volumes in One, Revised and Enlarged. New York: Macmillan, 1934.

Berg, S. V. "The Production of Compatibility: Technical Standards as Collective Goods." *Kyklos*, Vol. 42, FASC 3, 1989: 361-83.

Berndt, Ernst R. *The Practice of Econometrics: Classic and Contemporary*. Addison-Wesley, 1991.

Brady, R. A. *The Rationalization Movement in German Industry: A Study in the Evolution of Economic Planning*. New York: H. Fertig, 1974.

Broadbridge, S.A. "The Sources of Railway Share Capital" in M.C. Reed, (Ed.), *Railways in the Victorian Economy* (New York: Augustus M. Kelley Publishers, 1968).

-------- *Studies in Railway Expansion and the Capital Market in England: 1825-1873*. (London: Frank Cass and Co. Ltd., 1970).

Byatt, I. C. R. *The British Electrical Industry, 1875-1914: The Economic Returns to a New Technology*. Oxford: Oxford University press, 1979.

Carter, Susan B.,…[et al.], *Historical Statistics of the United States, Earliest Times to the Present*, Millennial Edition (Cambridge University Press, 2006).

Chandler, Alfred D., Jr. “Patterns of Railroad Finance, 1830-1850,” *Business History Review*, 28:248-263 (September 1954).

-------- *Henry Varnum Poor, Business Editor, Analyst and Reformer* (Cambridge, Mass., 1956).

--------, ed. *The Railroads: The Nation’s First Big Business* (New York, 1965).

-------- *The Visible Hand: The Managerial Revolution in American Business*. Cambridge, Mass.: Harvard University Press, 1977.

-------- *Scale and Scope: The Dynamics of Industrial Capitalism*. Cambridge: Harvard University Press, 1994.

Cottrell, P. L. *Industrial Finance, 1830-1914: The Finance and Organization of English Manufacturing Industry* (London and New York: Methuen & Co. Ltd., 1979).

David, Paul A. “The Growth of Real Product in the United States Before 1840: New Evidence, Controlled Conjectures”, *Journal of Economic History*, Vol. 27, No. 2 (Jun., 1967): 151-97.

DeCanio, Stephen, and Joel Mokyr. “Inflation and the Wage Lag during the American Civil War.” *Explorations in Economic History* 14 (1977): 311-36.

Edwards, Jeremy and Sheilagh Ogilvie. “Universal Banks and German Industrialization: A Reappraisal.” *The Economic History Review*, New Series, Vol. 49, No. 3 (Aug., 1996), 427-446.

Engerman, Stanley. “The Economic Impact of the Civil War.” *Explorations in Economic History* 3 (1966): 176-99.

Farrell, J., and G. Saloner. "Standardization, Compatibility and Innovation." *Rand Journal of Economics*, Vol. 16, No. 1, Spring, 1985: 70-83.

Fishlow, Albert. *American Railroads and the Transformation of the Antebellum Economy*. Harvard University Press, (Cambridge, 1965).

Fogel, Robert William. *Railroads and American Economic Growth*. Johns Hopkins Press, (Baltimore, 1964).

Fohlin, Caroline. “Bank Securities Holdings and Industrial Finance before World War I: Britain and Germany Compared.” *Business and Economic History*, Vol. 26, No. 2, Winter 1997, 463-75.

-------- "Banking Systems and Economic Growth: Lessons from Britain and Germany in the Pre-World War I Era." *Review (00149187)*, Vol. 80, No. 3, May/Jun. 1998, 37 (11 pp.). Retrieved from Academic Search Premier database.

-------- "The Balancing Act of German Universal Banks and English Deposit Banks, 1880-1913." *Business History*, Vol. 43, No. 1, Jan. 2001, Vol. 43, 1-24.

-------- *Finance Capitalism and Germany's Rise to Industrial Power*. Cambridge: New York, NY. Cambridge University Press, 2007.

Fremdling, Rainer. *Eisenbahnen und deutsches Wirtschaftswachstum 1840-1879* (Dortmund: Gesellschaft fur Westfalische Wirtschaftsgeschichte, 1975).

---------, Ruth Federspiel and Andrea Kunz (eds.), *Statistik der Eisenbahnen Deutschlands 1835-1989*, (Quellen und Forschungen zur historischen Statistik von Deutschland, vol. 17), (St. Katharinen: Scripta Mercaturae Verlag 1995).

Friedlaender, Ann F., Clifford Winston and Kung Wang. "Costs, Technology, and Productivity in the U.S. Automobile Industry." *The Bell Journal of Economics*, Vol. 14, No. 1 (Spring, 1983), 1-20.

Gallman, Robert. "Commodity Output 1839-1899." In National Bureau of Economic Research, *Trends in the American Economy in the 19th Century*, Studies in Income and Wealth, vol. 24. Princeton: Princeton University Press, 1960: 13-67.

Goldsmith, Raymond William. *Financial Intermediaries in the American Economy Since 1900*. Princeton, Princeton University Press for the NBER, 1958.

Gourvish, T.R. *Mark Huish and the London and North Western Railway: A Study of Management* (Leicester,1972).

-------- *Railways and the British Economy, 1830-1914* (London, 1980).

Habakkuk, H. J. *American and British Technology in the Nineteenth Century: The Search for Labour-saving Inventions*. Cambridge: Cambridge University Press, 1962.

Hacker, Louis. *The Triumph of American Capitalism.* New York: Columbia University Press, 1940.

Hall, Peter and Paschal Preston. *The Carrier Wave: New Information Technology and the Geography of Innovation 1846-2003*. London and Boston: Unwin Hyman, 1988.

Hannah, Leslie. *Electricity Before Nationalisation: A Study of the Development of the Electricity Supply Industry in Britain to 1948*. London: Macmillan, 1979.

Hawke, G. R. *Railways and Economic Growth in England and Wales, 1840-1870*. Clarendon Press, (Oxford, 1970).

-------- and M.C. Reed. “Railway Capital in the United Kingdom in the Nineteenth Century.” *The Economic History Review*, New Series, Vol. 22, No. 2 (Aug. 1969): 269-86.

Hoffmann, Walther G., F. Grumbach, and H. Hesse, *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts* (Berlin, Heidelberg, and New York, 1965).

Hughes, Thomas P. *Networks of Power: Electrification in Western Society, 1880-1930*. Baltimore: Johns Hopkins University Press, 1983.

James, John A. “Public Debt Management Policy and Nineteenth-Century American Economic Growth.” *Explorations in Economic History* 21 (1984): 192-217.

Katz, M. L. and C. Shapiro. "Network Externalities, Competition, and Compatibility." *American Economic Review*, Vol. 75, No. 3, June, 1985: 424-40.

-------- "Technology Adoption in the Presence of Network Externalities." *Journal of Political Economy*, Vol. 94, No. 4, 1986: 822-41.

-------- "Systems Competition and Network Effects." *Journal of Economic Perspectives*, Vol. 8, No. 2, Spring, 1994: 93-115.

Keltie, J. Scott (ed. [with the assistance of M. Epstein]). *The Statesman’s Yearbook: A Statistical and Historical Annual of the States of the World, for the Year 1914*, Macmillan and Co. (London, 1914).

Kenwood, A.G. “Railway Investment in Britain, 1825-1875”, *Economica*, New Series, Vol. xxxii, No. 127 (Aug., 1965): 313-22.

Kessel, Reuben, and Armen Alchian. “Real Wages in the North during the Civil War: Mitchell’s Data Reinterpreted.” *Journal of Law and Economics 2* (1959): 95-113. Reprinted in *The Reinterpretation of American Economic History*, ed. Robert W. Fogel and Stanley L. Engerman. New York: Harper & Row, 1971: 459-69.

Kindleberger, C. P. "Standards as Public, Collective and Private Goods." *Kyklos*, Vol. 36, No. 3, 1983: 377-96.

Landes, David S. *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present.* London: Cambridge University Press, 1969.

-------- *The Wealth and Poverty of Nations: Why Some are so Rich and Some so Poor*. New York: W. W. Norton, 1998.

Lewin, H. G. *Early British Railways* (London, 1925).

Lindert, Peter. *Growing Public: Social Spending and Economic Growth Since the Eighteenth Century*. Two volumes. Cambridge University Press, 2004.

Maddison, Angus. *Monitoring the World Economy, 1820-1992* (Development Centre of the Organisation for Economic Co-operation and Development, Paris; OECD Publications and Information Center [distributor], Washington D.C., 1995).

-------- *The World Economy: Historical Statistics* (Development Centre of the Organisation for Economic Co-operation and Development, Paris, 2003).

Mathias, Peter. *The First Industrial Nation: An Economic History of Britain, 1700-1914* (New York, 1969).

Mitchell, Brian R. "The Coming of the Railway and United Kingdom Economic Growth." *Journal of Economic History*, Vol. XXIV, No. 3 (Sep., 1964): 315-36.

-------- and P. Deane. *Abstract of British Historical Statistics* (Cambridge, 1975).

-------- *European Historical Statistics, 1750-1970* (New York, 1976).

-------- *British Historical Statistics* (Cambridge, 1988).

-------- *International Historical Statistics: Europe, 1750-1993*, 4th ed., Stockton Press (New York, 1998).

-------- *International Historical Statistics: the Americas, 1750-2000*, 5th ed. Palgrave Macmillan, New York, 2003.

Mitchell, Wesley. "The Greenbacks and the Cost of the Civil War." Reprinted in Ralph Andreano, ed. *The Economic Impact of the Civil War*. Cambridge, Mass.: Shenkman, 1962: 66-78.

Mowery, David C. and Nathan Rosenberg. *Technology and the Pursuit of Economic Growth*. Cambridge and New York: Cambridge University Press, 1989.

-------- *Paths of Innovation: Technological Change in 20th Century America*. Cambridge and New York: Cambridge University Press, 1998.

Nelson, R. *Merger Movements in American Industry 1895-1956.* Princeton, N.J.: Princeton Univ. Press for the NBER, 1959.

Obstfeld, Maurice and Alan M. Taylor. *Global Capital Markets: Integration, Crisis, and Growth*. Cambridge, UK; New York: Cambridge University Press, 2004.

Pollard, Sidney. *The Development of the British Economy, 1914-1950.* London: E. Arnold, 1962.

-------- *Britain's Prime and Britain's Decline: The British Economy 1870-1914*. London and New York: E. Arnold, 1989.

Pollins, Harold. *Britain's Railways: An Industrial History,* Rowman and Littlefield, (Totowa, N.J., 1971).

Reed, M.C. "Railways and the Growth of the Capital Market," in M.C. Reed, (Ed.), *Railways in the Victorian Economy* (New York: Augustus M. Kelley Publishers, 1968).

-------- *Investment in Railways in Britain, 1820-1844: A Study in the Development of the Capital Market* (London: Oxford University Press, 1975).

Rhode, Paul W. "Gallman's Annual Output Series for the United States, 1834-1909", National Bureau of Economic Research, Working Paper 8860, April 2002.

Riesser, Jacob. *The Great German Banks and Their Concentration in Connection with the Economic Development of Germany* (Washington, D.C., 1911).

Rosenberg, Nathan. *Technology and American Economic Growth*. New York: Harper & Row, 1972.

Rostow, W.W. *The Stages of Economic Growth: A Non-Communist Manifesto*. Cambridge University Press, 1960.

Scitovsky, Tibor. "Two Concepts of External Economies." In *Papers on Welfare and Growth* by Tibor Scitovsky. Stanford: Stanford University Press, 1964.

Shepherd, William G. "What Does the Survivor Technique Show about Economies of Scale?" *Southern Economic Journal*, Vol. 34, No. 1 (Jul., 1967), 113-122.

Shin, Richard T. and John S. Ying. "Unnatural Monopolies in Local Telephone." *The RAND Journal of Economics*, Summer, 1992, Vol. 23, No.2: 171-183.

Stewart, Kenneth G. *Introduction to Applied Econometrics*. Thomson Brooks/Cole, 2005.

Stigler, G. J. "Economics of Scale." *Journal of Law and Economics*, 1:5-71 (1958).

Thomas, W. A. *The Provincial Stock Exchanges* (London: Frank Cass and Co. Ltd., 1973).

Tilly, Richard H. "Germany 1815-1870." in Rondo E. Cameron, ed., *Banking in the Early Stages of Industrialization: A Study in Comparative Economic History* (New York, 1967).

-------- "Capital Formation in Germany in the Nineteenth Century." in *Cambridge Economic History of Europe*, VII (1978).

-------- "Financing Industrial Enterprise in Great Britain and Germany in the Nineteenth Century: Testing Grounds for Marxist and Schumpeterian Theories?" in H. J. Wagner and J. W. Drukker, eds., *The Economic Law of Motion of Modern Society: A Marx-Keynes-Schumpeter Centennial* (Cambridge, Eng., 1986), Ch. 9.

U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington, D.C., 1975).

U.S. Office of Management and Budget, *Standard Industrial Classification Manual*, (GPO, 1987), Dun & Bradstreet Information Resources, 1989.

U.S. Treasury Department, Bureau of Statistics, *Statistical Abstract of the United States.* 1882 (Fifth Number. Document No. 394.), 1889 (Twelfth Number. Document No. 1310.), 1895 (Eighteenth Number.). (First Reprinting, Johnson Reprint Corporation, New York, London, 1964).

Ulmer, Melville Jack. *Capital in Transportation, Communication, and Public Utilities: Its Formation and Financing*. Princeton University Press, (Princeton, 1960).

United States Bureau of Labor. Sixth Annual Report of the Commissioner of Labor, 1890. *Cost of Production: Iron, Steel, Coal, etc.* Washington, D.C.: U.S. Government Printing Office, 1890.

-------- Seventh Annual Report of the Commissioner of Labor, 1891. *Cost of Production: The textiles and glass.* Washington, D.C.: U.S. Government Printing Office, 1892.

United States Census Office, 10th Census. *Report on the Manufactures of the United States at the Tenth Census: 1880.* Volume 2. Washington: Government Printing Office, 1883.

--------, 11th Census. *Report on Manufacturing Industries in the United States at the Eleventh Census: 1890.* Pt. 3, Selected Industries. Washington: Government Printing Office, 1895.

United States Department of Labor. *Bulletin of the Department of Labor*. Washington: Government Printing Office. Vol. V (1900), Nos. 27 (March, 1900), 29 (July, 1900).

Weiss, Leonard W. "The Survival Technique and the Extent of Suboptimal Capacity." *The Journal of Political Economy*, Vol. 72, No. 3 (Jun., 1964), 246-261.

Williamson, Jeffrey. “Watersheds and Turning Points: Conjectures on the Long Term Impact of Civil War Financing.” *Journal of Economic History* 34 (1974): 631-61.

Internet Resources

The principal data set used in the empirical analyses of economies of scale and scope in this study, the Bateman-Weiss and Atack-Bateman Samples from the Manuscript Censuses of Manufactures, 1850-1880, are presented in a common format with uniform integrated coding to facilitate their use, and are available on line and downloadable for free through the Inter-university Consortium for Political and Social Research (ICPSR) at the University of Michigan (http://www.icpsr.umich.edu/index.html) and at http://www.vanderbilt.edu/Econ/faculty/Atack/atackj.htm.

Jeremy Atack and Fred Bateman’s article “Nineteenth-Century U.S. Industrial Development through the Eyes of the Census of Manufactures: A New Resource for Historical Research.” (*Historical Methods*, Fall 1999, Vol. 32, No. 4: 177-88.) cited above is an indispensable guide to these data, and is also available on line and downloadable for free at Professor Atack’s home page at http://www.vanderbilt.edu/Econ/faculty/Atack/atackj.htm.

The coding method by which industries are categorized in these data is delineated in detail in the U.S. Office of Management and Budget, *Standard Industrial Classification Manual*, ([GPO, 1987], Dun & Bradstreet Information Resources, 1989.) cited above, and also at http://www.osha.gov/pls/imis/sicsearch.html, the exact page of the site of the U.S. Department of Labor Occupational Safety & Health Administration that allows the user to search the 1987 version SIC manual referred to above by keyword.