8401487

Sullivan, Edgar Joseph

RELATIONSHIP BETWEEN FIRM SIZE AND TECHNICAL INNOVATION: AN EMPIRICAL REEXAMINATION

City University of New York PH.D. 1983

University
Microfilms
International 300 N. Zeeb Road, Ann Arbor, MI 48106

PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark __√__.

1. Glossy photographs or pages ______
2. Colored illustrations, paper or print ______
3. Photographs with dark background ______
4. Illustrations are poor copy ______
5. Pages with black marks, not original copy ______
6. Print shows through as there is text on both sides of page ______
7. Indistinct, broken or small print on several pages __√__
8. Print exceeds margin requirements ______
9. Tightly bound copy with print lost in spine ______
10. Computer printout pages with indistinct print __√__
11. Page(s) ____________ lacking when material received, and not available from school or author.
12. Page(s) ____________ seem to be missing in numbering only as text follows.
13. Two pages numbered ____________. Text follows.
14. Curling and wrinkled pages ______
15. Other ______________________________

RELATIONSHIP BETWEEN FIRM SIZE AND TECHNICAL INNOVATION: AN EMPIRICAL REEXAMINATION

by

Edgar J. Sullivan

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

1983

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

8/8/83
date

Chairman of Examining Committee

8/16/83
date

Executive Officer

Professor Steven Lustgarten

Professor Peter M. Gutmann

Professor Gerald A. Pogue
Supervisory Committee

The City University of New York

ACKNOWLEDGEMENTS

I am very much indebted to my Dissertation Supervisory Committee: Professors Steven Lustgarten, Peter M. Gutmann and Gerald A. Pogue of the City University of New York and Patrick A. Casabona of St. John's University. In particular, I am most appreciative of the considerable assistance that Professor Lustgartgen, The Committee Chairman, has provided from the inception to the completion of this project. He and William Hession, a former member of the Baruch College faculty, planted the seeds that underlie the topic selection and the framework of the empirical study. Daniel O'Reilly and Richard Reinstein of Data Resources, Inc. provided considerable help with adapting a censored data algorithm to my specific problem.

I am also deeply indebted to my fellow employes at General Motors Corporation. In particular, the help of Linda Steinman, who provided invaluable and seemingly endless assistance with computer programming, and of Marion Brady, who generously typed this manuscript, earlier drafts and considerable correspondence with my Dissertation Committee, was very much appreciated.

I would be remiss if I did not also acknowledge the contributions of the many corporate R&D directors who responded to my survey as well as those who shared their considerable practical insights into this issue with me on the telephone and in direct interviews. Lastly, I would like to acknowledge the forbearance of my family -- my wife, Bess, and my children, Patricia, Danny and Rosemarie -- during the numerous hours I have devoted to this project.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

CHAPTER I

INTRODUCTION

Technological Progress - A Critical Factor in a Modern Economy

Technological progress is critical to the efficient functioning of our modern economic system. It is the primary source of per capita economic growth and the key to improvements in the quality of goods consumed. Based on a study by Denison, technological progress was responsible for nearly half of the growth in U.S. national income between 1929 and 1969, while growth in total factor inputs accounted for the remainder.[1]

Without technological progress, output would remain constant in an economy with a stable population and level savings.[2] Once the advantages of specialization are exhausted, technological innovation is the only means by which real income and output can expand more rapidly than factor inputs.[3] Moreover, with the unemployment rate in many of the major industrial nations at the highest level since the nineteen-thirties and with many policymakers wary of stimulative fiscal and monetary policies in the wake of the inflationary problems of the nineteen-seventies, technical progress is a timely subject. At the June 1982 summit meeting in Versailles, the leaders of the major industrial nations issued a communique on the need to support technology. The communique noted that "technology is the way governments can restore growth to their stagnant economies."[4]

The benefits of technological progress go far beyond the capability of producing more goods with less labor. Innovation is the key to remaining competitive in most industries. A Booz-Allen study, for example, indicated that it is commonplace for major manufacturing companies to derive 50% or more of their sales from products which are new within the past ten years, while a Department of Commerce study indicated that 90% of pharmaceutical prescriptions are for products developed within the past fifteen years.[5] Innovation can also open up new frontiers and contribute to our overall well-being. Within a generation of its introduction, the computer is having a profound effect on virtually every facet of our lives. Discoveries such as the Salk vaccine have represented major breakthroughs in health care, while more subtle, but important, developments such as the energy-absorbing steering column and catalytic converters have improved automotive safety and air quality.[6]

Economic Issues Related to Technological Progress

Given the critical importance of technological progress, a considerable amount of research has been published on the business environment most conducive to innovation. The seminal studies on this subject have largely focused on two closely related issues: the impact of market structure on innovation and whether large firms are proportionately more innovative than small firms.[7]

Economic researchers have also focused on the issue of whether scientific breakthroughs provide the principal stimulus for innovation or if it is largely the result of entrepreneurs and firms recognizing unsatisfied wants and then developing and marketing products to fill this void. Almarin Phillips is the principal proponent of the former view, while Jacob Schmookler has been closely associated with the latter. More recently, Nelson and Winter have suggested that a good innovation strategy must focus on both technological feasibility and market demand for a possible new product.[8]

A number of other issues associated with innovation have been investigated by economic researchers. For example, Mansfield -- one of the most prolific researchers in this area -- has looked at topics such as the diffusion of innovations among the firms within an industry, determinants of the speed of application of new technology, social and private returns from innovations and government financing of research and development. Others such as Kamien and Schwartz and Nelson and Winter have looked at competitive reactions.[9]

Scope of The Present Study

The present study will focus on the relationship between innovation and firm size. In the second chapter, the principal theoretical aspects of this question are discussed. The major obstacles to testing this relationship and the principal empirical studies published previously are discussed in the third chapter. My hypothesis, data set, statistical model and empirical results are presented in chapter four.

This hypothesis is less polarized that many of the prior studies which typically started from the premise that either large or small firms were the principal bastions of innovative output. The large and current data set employed is well suited to exploring possible nuances in the relationship between firm size and innovative output. It permits quantification of possible differences in the relationship between firm size and innovative intensity among various major industrial groupings as well as calculation of inflection points, if this relationship is not monotonic. Moreover, since many of the frequently quoted empirical studies on this issue are based on data which are more than twenty years old, additional insight can be gleaned from a fresh data set -- particularly if the relationship between innovative output and firm size is changing over time. And by specifically addressing the heteroscedasticity and censored data problems which are inevitable in empirical research on this question, some of the shortcomings of prior studies can be corrected.[10]

The fifth and final chapter of this study will discuss the implication of these empirical findings for public policy.

FOOTNOTES - CHAPTER I

[1]Edward F. Denison, Accounting for United States Economic Growth, 1929-1969 (Washington, D.C.: Brookings Institution, 1974), p. 127.

[2]Rudiger Dornbusch and Stanley Fischer, Macro Economics (New York: McGraw-Hill, 1978), pp. 558-563.

[3]Schumpeter distinguished between invention and innovation. In his work, innovation refers only to the process of bringing new technologies to market. In this paper, innovation will be used in the broader context recently suggested by Nelson and Winter. Under this definition, innovation refers to all those activities from basic research to invention to development to the marketing and/or the use in the production process of new technology. Richard R. Nelson and Sidney G. Winter, "In Search of Useful Theory of Innovation," Research Policy 6 (January 1977): 61-62.

[4]"The Pitfalls of Trying to Promote Innovation," The Economist, 26 June - 2 July 1982, p. 95.

[5]Management of New Products (New York: Booz, Allen & Hamilton, 1968), p. 2; Patents Spur to American Progress (Washington D.C.: U.S. Department of Commerce, 1965), p. 8.

[6]Although technological progress represents the principal means for bringing about quantitative and qualitative improvements in our living standards, it -- like everything else in life -- can be used for perverse purposes. Nuclear power, for example, can heat homes but it can also be used to destroy nations.

[7]A review of the literature on this subject and an extensive bibliography are included in: Morton I. Kamien and Nancy L. Schwartz, Market Structure and Innovation (Cambridge: Cambridge University Press, 1982).

[8]Almarin Phillips, Technology and Market Structure: A Study of the Aircraft Industry (Lexington, Mass.: Lexington Books, 1971); Jacob Schmookler, Invention and Economic Growth (Cambridge, Mass.: Harvard University Press, 1966); Nelson and Winter, "Theory of Innovation" : 54.

FOOTNOTES - CHAPTER I

[9]Edwin Mansfield et al., The Production and Application of New Industrial Technology (New York: W. W. Norton & Company, 1977); Edwin Mansfield, Industrial Research and Technological Innovation (New York: W. W. Norton & Company, 1968); M. I. Kamien and N. L. Schwartz, "On the Degrees of Rivalry for Maximum Innovative Activity," Quarterly Journal of Economics 90 (May 1976); Richard R. Nelson and Sidney G. Winter, "The Schumpeterian Tradeoff Revisited," The American Economic Review 72 (March 1982).

[10]Heteroscedasticity is inherent in cross-sectional analysis with a comprehensive data set of firms ranging in size from fledgling enterprises with annual sales of less than $100,000 up to behemoth firms approaching $100 billion in sales. And since specific quantification of innovative inputs or output for all of the observations in a comprehensive cross-section of firms is not available, censored data problems are inevitable in this type of empirical research.

CHAPTER II

THEORETICAL ISSUES UNDERLYING THE FIRM SIZE - INNOVATIVE OUTPUT CONTROVERSY

Background

Neither the theoretical arguments supporting the view that innovative output increases more than proportionately with firm size nor those espousing the opposite position are incontrovertible. Schumpeter and Galbraith have argued that the resources and economies of scale associated with large size are conducive to innovation. These arguments seem plausible and they are consistent with some empirical analysis. But given the numerous exceptions observable in the marketplace, it is apparent that the Schumpeter-Galbraith position does not represent a universal principle.[1]

Although there are few, if any, specific theoretical models to buttress the case of those who contend that large size thwarts innovation, many credible arguments have been advanced in support of their position. It is frequently suggested that the bureaucratic operating procedures of a large enterprise invariably offset the advantages of size, while others have suggested that industrial firms with heavy investment in standardized high-volume production equipment will resist change.[2] And prominent economists such as Blair, Brozen, Joan Robinson and Stocking contend that under purely competitive conditions inventions would be applied most rapidly. They assume that the existence of many competitors will prompt firms to seek out and apply new ideas, whereas greater complacency and tacit collusion are likely in an environment with few competitors.[3]

Schumpeter-Galbraith Hypotheses Concerning Propensity of Large Firms to Innovate

Schumpeter, on the other hand, notes that:

> As soon as we go into details and inquire into the individual items in which progress was most conspicuous, the trail leads not to the doors of those corporations that work under conditions of comparatively free competition but precisely to the doors of the large concerns -- which, as in the case of agricultural machinery, also accounts for much of the progress in the competitive sector -- and a shocking suspicion dawns upon us that big business may have had more to do with creating that standard of living than with keeping it down.[4]

In fact, Schumpeter did the seminal work on fully explaining the important role that economic agents play in technological progress. In his widely quoted Capitalism, Socialism and Democracy he implies that the advantages of large firm size in achieving technological advance stem primarily from economies of scale. But in an earlier work, The Theory of Economic Development, he implies that the returns to innovation stem largely from the monopoly power associated with new products. Presumably, considerable market power can be exercised between the time that a new product is introduced and the time that competitors eventually catch up.[5]

Galbraith in a subsequent work seems to push Schumpeter's view that progress is most conspicuous in large concerns even further. He notes the following:

> There is no more pleasant fiction than that technical change is the product of the matchless ingenuity of the small man forced by competition to employ his wits to better his neighbor. Technical development has long since become the preserve of the scientist and the engineer. Most of the cheap and simple innovations have, to put it bluntly and unpersuasively, been made . . .
>
> Because development is costly, it follows that it can be carried on only by a firm that has the resources associated with considerable size.[6]

Factors Suggesting Large Size May Be Conducive to Innovation

Many researchers have looked beyond Galbraith's sweeping generalizations and focused on specific factors related to firm size and propensity to innovate. A number of reasons have been advanced in support of the view that large firm size is conducive to innovation.

The first of these, which will be discussed in this paper, is an elaboration of the Galbraithian view. It contends that large size may facilitate ready access to costly equipment such as wind tunnels and electron microscopes and specialized technical skills. Bell Laboratories might be viewed as the epitome of an environment where a researcher has ready access to many skills and one in which the potential for cross-fertilization of ideas is considerable.

Second, others contend that large firms can maintain a balanced portfolio of R&D projects, while smaller firms incur a considerable and, perhaps, inordinate amount of risk when they commit their limited resources to a research and development project with uncertain prospects for technical and commercial success.

Third, others have noted that larger firms may be able to realize economies of scale in marketing and financing new products. Moreover, the ability to finance a research project from internal cash flow may be advantageous since outside suppliers of capital invariably require disclosure which could inject an added element of risk in the case of new product development.

Fourth, large producers are also presumed to have an advantage in process improvements since the per unit cost of innovation can be easily spread over a large volume of output.[7]

Similarly, it has been suggested that there may be a per unit cost differential in complying with government regulations. Large firms can spread the costs of testing and developing new products or processes to meet individual standards over more units.[8] For example, Chrysler indicated that its costs of compliance with fuel economy, emissions, and safety regulations on a per unit basis will be almost twice those of GM between 1978 and 1985.[9]

Galbraithian View - An Overstatement

Galbraith's assertion that the costs of innovation will limit this endeavor to firms of considerable size is clearly an exaggeration. In this regard, Scherer asserted that: "Professor Galbraith is guilty of out-fictionalizing the fiction writers."[10] Some prominent exceptions stand in marked contrast with Galbraith's generalization that considerable resources are a prerequisite for innovation. Chester Carlson's Xerox Copying Machine, Edwin Land's Polaroid Camera and more recently the emergence of computer manufacturers such as Apple and Osborne as well as the presence of many small, but quite innovative, companies in "Silicon Valley" in California and along Route 128 in the Boston area attest to the fact that technological progress is not the exclusive purview of large firms. Nevertheless, Mansfield's empirical findings concerning the chemical industry and numerous prominent examples such as the Apollo Project and RCA's development of the color television suggest that large firms, at a minimum, may be uniquely suited to the demands of some particularly costly research and development projects.[11]

The substantial resources required to redesign the American automobile to meet government regulations and consumer demands for more fuel efficient and safer products is another illustration of an industry in which large size seems to be a prerequisite of technological progress. In this regard, the Ford Motor Company indicated in 1978 that it would have to invest $6 billion -- expressed in constant 1978 dollars -- above its historical rate of capital investment to maintain a technically competitive product line in North America through 1985.[12] Moreover, recent mergers, cooperative R&D agreements and joint ventures among many foreign automobile manufacturers, are consistent with the view that the challenge of bringing about technological progress is expanding in certain industries.[13] Some researchers assert that in mature industries with complex products increasing resource commitments are required to effect technical progress. And in this type of environment, large size becomes a requirement to support efficient research and development.[14] This same point of view is espoused by the eminent physicist, Max Planck. He asserts that:

> . . . with every advance [in science] the difficulty is increased; ever larger demands are made on the achievements of researchers, and the need for a suitable division of labor becomes more pressing.[15]

A division of labor -- which might be most effectively accomplished within the confines of a large laboratory complex -- and sophisticated equipment were clearly required in the case of many of the epochal developments in technology. The efforts of a single individual or home laboratory could not develop one of the early computers or send a man to the moon. And on the more prosaic level, the complete design or redesign of complex product such as the modern automobile with some 15,000 to 20,000 interrelated parts is beyond the capability of the individual genius. It requires the concerted efforts of specialists in computer technology, aerodynamics, metallurgy, chemistry, electronics and robotics.

Concerning the need for considerable resources to effect technological progress in the case of a complex product, Nelson, Peck and Kalachek note the following:

> . . . while it generally takes more resources to redesign a product with a large number of components than one with a small number, the number of diverse elements is significant mainly through their interdependency . . .
>
> The problem with trying to achieve major advances in large and complex systems -- products with a large number of tightly interdependent components -- is that to change any one item causes reverberations throughout the system.[16]

Thus, although there is some support for Galbraith's view that "development is costly," no single firm size appears to be uniquely suited to technological progress. Small firms and independent inventors play an important role in generating new concepts upon which many important advances rest. The resources of medium and larger size firms are generally necessary to transform these ideas into marketable innovations. There are, however, some advances which demand such heavy private development commitments that they can be accomplished most effectively by very large corporations. In this regard, Nelson, Peck and Kalachek note the following:

> The giants, of course, play the dominant role in major far-reaching development efforts such as defense and space and several of them conduct sizeable basic research programs. Both large- and medium-sized companies engage in a considerable amount of far-reaching work in fields requiring less complex systems . . . the private inventor will probably continue to be responsible for a large share of the major advances which do not involve heavy expenses in areas where ingenuity and practical experience are more important than formal training.[17]

<u>Theoretical Support for Advantages of a Diversified Portfolio of R&D Projects Deficient</u>

There is little theoretical support for the hypothesis mentioned by Hamberg and others that large firms may have an advantage over small firms in that they can lessen the considerable risks associated with innovation by spreading them across a portfolio of research and development projects.[18] According to modern financial theory, the value of a firm -- in the absence of some form of economies of scale -- would not be increased by merely forming a portfolio of research and development projects. This action would only replicate an action which the investors typically undertake on their own by investing in a portfolio of stocks rather than in the equity of a single firm.[19] Diversification may, of course, lessen the prospects for failure at the firm level. But in terms of management's principal objective -- maximizing stockholder wealth -- diversification, which does not benefit from interdependencies with other operations of the firm or other R&D projects, is redundant and worthless.

Possible Marketing Advantages Associated With Large Size Firms

In the case of research and development projects, however, interdependencies may be the rule rather than the exception. Research and development projects are generally directed toward making improvements in existing products, creating new products -- which in many cases are closely related to existing products -- and, to a lesser extent, to improved production processes.[20] With most research and development projects aimed at achieving incremental progress in existing market areas, in commercialization -- the ultimate objective of business R&D -- established, and to a considerable extent larger, firms may be able to use their existing sales force, marketing expertise and goodwill to their advantage.

Mansfield indicates that the chances of commercial success in innovation are increased by communication and cooperation between the marketing and R&D staffs within a firm.[21] This consideration does not necessarily imply increasing economies of scale in R&D but it does suggest that the established firm, in which the R&D and market personnel maintain a good working relationship, will be in a better position to exploit opportunities than the new entrant or the fledgling enterprise.

Vernon and Gusen provide a more direct endorsement of the advantages of large firm size in the commercialization of research and development projects. In their empirical study of newly introduced chemical entities, they found that even though there appears to be diminishing returns to scale in the R&D laboratory, the marginal productivity of R&D personnel in larger firms in introducing new products is greater than those in smaller firms.[22] Moreover, Nelson suggests that a firm with a diversified product line may be in a better position to commercialize the fruits of its R&D. This is particularly true in the case of basic research where serendipitous outcomes are common. This phenomenon is illustrated by the Carothers research project for DuPont.

> Carothers' work in linear superpolymers began as an unrestricted foray into the unknown with no particular objective in view. But the research was in a new field of chemistry, and DuPont believed that any new chemical breakthrough would probably be of value to the company.

> The very lack of a special objective, the flexibility of the research project, was an important factor behind its success. . . . at the start of the project Carothers could not possibly have known that his research would lead him to the development a new fiber [nylon].[23]

Large firms may also have a potential edge over their smaller rivals in process innovation. Their more extensive facilities and greater production requirements provide larger firms with a bigger captive market in the case of process innovations which are related to their own production requirements. Smaller firms can, of course, offset this disadvantage by marketing their process innovations. But, ceteris paribus, this suggests that a small firm must sustain a larger commercial risk to earn the same return as a larger firm in the case of a process innovation.

<u>Possible Financing Advantages Associated With Large Size Firms</u>

The financing issue in the firm-size-propensity-to-innovate controversy has some similarities with the diversification question discussed earlier. The cost of capital of a prospective R&D investment is based on the net present value of projected cash flows. Thus, packaging a group of projects differently -- something which investors are presumably capable of doing themselves through arbitrage -- should not affect their value. As Haley and Schall point out, in perfectly competitive markets: ". . . no matter how firms divide or combine the cash flow streams in making them available to the market as debt or equity streams of one or more firms, the total value will be the same . . ."[24]

Once the assumption of perfectly competitive markets is relaxed, however, some factors emerge which suggest that large firms could have a cost advantage in financing. The fact that the flotation costs associated with raising capital externally are largely fixed might favor larger firms over smaller ones.[25] The special tax credits associated with research and development expenditures might also provide greater benefits to larger firms with established earning records.[26]

It is also commonly asserted that an established and presumably larger firm would be at an advantage vis-a-vis its smaller counterpart in that it would be in a better position to finance an R&D project through internal cash flow. Suppliers of capital may be reluctant to finance R&D projects because these investments generally do not entail the purchase of many assets which could be used as collateral. And, correspondingly, for competitive reasons in many cases prospective innovators will be reluctant to provide the suppliers of capital with as much information as they would receive from a more conventional investment opportunity.[27]

Moral Hazard and Indivisibilities

To a large extent, the postulated advantages of large firm size in innovation revolve around the moral hazard issue, indivisibilities and other possible imperfections in the marketplace. If as Arrow suggested, the small inventor can offer shares in his prospective innovation for a fee, technological progress and risk bearing can be viewed separately. In this hypothesized environment, the inventors and the investors bear as much financial risk as they are capable of and willing to incur. Although this type of arrangement would presumably overcome the potential marketing or financial handicaps confronting the small inventor, it would inject the moral hazard issue into the transaction. The more the prospective innovator is divorced from the significant risk bearing of innovation, the more the potential suppliers of capital are asked to take it on faith that the purchased service will be performed in accord with the provisions of the agreement.[28] Nutter, for example, has suggested that smaller firms can access the same technical expertise as larger firms -- without incurring the huge overhead costs associated with maintaining a large laboratory -- by employing the services of special research institutes.[29] Baldwin, however, after investigating this issue observes that:

> Outside R&D services usually lack the initiative, flexibility, and constant attention to a company's technical problems that an internal R&D staff provides. . . . A common fear is that contract researchers perhaps inadvertently, will disclose or make use of confidential information discovered in performing a project in their future work. The decision to terminate a project and accept existing losses rather than pursue an unpromising but still possibly rewarding line of inquiry should be made on an informed basis, and by the firm which is bearing the cost: it is hard for a contract researcher, whose income depends on work done for others, to be objective in his assessment of a project's potential.[30]

Firm Size - Innovation Relationship Ultimately An Empirical Issue

A number of cogent hypotheses have been discussed which suggest that large firms may be proportionately more innovative than their smaller counterparts. But, to the extent that the actual business environment approaches the free market situation discussed by Arrow, the presumed advantages of large size dissipate. And, if the innovative effectiveness of large firms is shackled by the bureaucratic morass described by Cooper or the inflexibility imposed by their prior investment decisions as Abernathy suggests, large firms could be less innovative than small firms. It is also quite possible that in practice the relationship between firm size and innovation may be more flexible than implied by the Schumpeter-Galbraith hypothesis or its antithesis which reflects the views of researchers such as Jewkes, Sawers and Stillerman who extol the inventiveness of small firms.[31] And, perhaps, as Nelson suggests, large firms may be uniquely suited to the prerequisites of innovation in some industries but ill-suited in other industries. Ultimately, this is an empirical question.

FOOTNOTES - CHAPTER II

[1]Joseph A. Schumpeter, Capitalism, Socialism and Democracy, 3d ed. (New York: Harper & Row, 1950); John Kenneth Galbraith, American Capitalism (Boston: Houghton Mifflin, 1956). Mansfield found that the larger chemical companies were more innovative relative to their size than smaller firms. Mansfield et al., The Production and Application of New Industrial Technology, pp. 46-67. In contrast, another study on important innovations during the twentieth century concluded that only about one-quarter of those can be attributed to the organized research of large corporations. John M. Blair, Economic Concentration: Structure, Behavior and Public Policy (New York: Harcourt Brace Jovanovich, 1972), pp. 208-209.

[2]Arnold C. Cooper, "R&D Is More Efficient in Small Companies," Harvard Business Review (May-June 1964): 75-83; William J. Abernathy, The Productivity Dilemma: Road Block to Innovations in The Automobile Industry (Baltimore: The Johns Hopkins Press, 1978).

[3]Mansfield, Industrial Research and Technical Innovation, pp. 102-103.

[4]Schumpeter, Capitalism, Socialism and Democracy, p. 82. It might be also noted that economists have continued to promulgate these ideas. Nearly a decade after Schumpeter's death, Henry Villard noted: ". . . progress is likely to be rapid when firms are large enough or few enough to afford and benefit from research and (2) when they are under competitive pressure to innovate-utilize the results of research." And more recently Heilbroner and Thurow indicated: "Big businesses generate higher rates of technical progress than small, competitive firms, and may well justify their short-run monopoly profits by long-run technical progress." Henry H. Villard, "Competition, Oligopoly And Research," American Economic Review 66 (December 1958): 491; Robert L. Heilbroner and Lester C. Thurow, Economics Explained (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1982), p. 182.

[5]Nelson and Winter, "The Schumpeterian Tradeoff Revisited" : 114-115.

[6]Galbraith, American Capitalism, pp. 86-87.

FOOTNOTES - CHAPTER II

[7]F. M. Scherer, Industrial Market Structure and Economic Performance, 2d ed. (Chicago: Rand McNally Publishing Company, 1980), pp. 413-414.; Edwin Mansfield, "Size of Firm, Market Structure and Innovation," Journal of Political Economy 71 (December 1963): 557; D. Hamberg, "Size of Firm, Oligopoly, and Research: The Evidence," Canadian Journal of Economics and Political Science 30 (February 1964): 62-63.

[8]William J. Abernathy, "Innovation And The Regulatory Paradox: Toward A Theory of Thin Markets," in Douglas H. Ginsberg and William J. Abernathy, eds., Government, Technology and the Future of the Automobile (New York: McGraw-Hill Book Company, 1980), pp.51-52.

[9]"What Is Happening At Chrysler -- The Regulation Squeeze," Chrysler Corporation Press Release (August 1979).

[10]F. M. Scherer, Industrial Market Structure and Economic Performance, p. 415.

[11]It might also be noted, however, that a huge financial commitment, per se, is not sufficient to assure commercial success. RCA's significant investment in more sophisticated tubes during the 1960s, for example, went for nought as a result of the emergence of solid state technology. Richard N. Foster, "A Call For Vision in Managing Technology," Business Week, May 24, 1982, p. 33.

[12]Abernathy, "Innovation And The Regulatory Paradox" in Ginsberg and Abernathy, Government, Technology and The Future of the Automobile, pp. 54-55.

[13]Michael C. Pearce, "International Competition in the World Automotive Industry," in Ibid., pp. 260-262.

[14]Richard R. Nelson, "Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures," Journal of Economic Literature 19 (September 1981) : 1051.

[15]Max Planck, Vortrage und Erinnerungen, 5th ed., quoted in Nicholas Rescher, Scientific Progress: A Philosophical Essay on the Economics of Research in Natural Science (Pittsburgh: University of Pittsburgh Press, 1978), p. 80.

FOOTNOTES - CHAPTER II

[16]Richard R. Nelson, M. J. Peck and E. D. Kalachek, Technology Economic Growth and Public Policy (Washington, D.C.: Brookings Institution, 1967), pp. 26-27.

[17]Ibid., pp. 55-58. Similarly, Pavitt and Wald, based on an empirical study developed during the 1960s, concluded that both large and small firms play essential, complementary and interdependent roles in technological progress. In this regard Shimshoni notes in fields where systems can be developed by relatively small groups, small firms may have an advantage over large firms. He cites a number of examples of major firms (e.g. Jarrell-Ash, Perkin-Elmer, Potter Instrument Company, and Hewlett-Packard) developed through such enterprising efforts. Keith Pavitt and Solomon Wald, The Conditions for Success in Technological Innovation (Paris, OECD, 1971), pp. 12-13; Daniel Shimshoni, "The Mobile Scientist in the American Instrument Industry," Minerva 13 (January 1970) : 59-89.

[18]An intensive study of three firms (one in the chemical industry and two in the drug industry) indicates that the probability of the commercial success of an R&D project is about .12. The major risks, however, are not at the technical level; some 60% of the projects undertaken are successful at this level. Mansfield et al., The Production and Application of New Industrial Technology, pp. 9-10.

[19]Gerald A. Pogue and Kishore Lall, "Corporate Finance: An Overview," Sloan Management Review 15 (Spring 1974) in Stewart C. Myers, ed., Modern Developments in Financial Management (New York: Praeger Publications, Inc., 1976), p. 27.

[20]According to a McGraw-Hill survey, 59% of R&D effort in 1977 was directed toward improvement in existing products, 28% on the development of new products -- many of which were closely related to existing products -- and 13% was allocated for the development of new or improved manufacturing processes. Scherer, Industrial Market Structure and Economic Performance, p. 409.

[21]Mansfield, et al., The Production and Application of New Industrial Technology, pp. 32-33.

[22]John M. Vernon and Peter Gusen, "Technical Change and Firm Size: The Pharmaceutical Industry," Review of Economics and Statistics 56 (August 1974) : 294-301.

[23]Richard R. Nelson, "The Simple Economics of Basic Scientific Research," Journal of Political Economy 67 (June 1959) : 303.

FOOTNOTES - CHAPTER II

[24]Charles W. Haley and Lawrence D. Schall, The Theory of Financial Decisions (New York: McGraw-Hill Book Company, 1973), pp. 190-192. The above discussion centers on the cost of capital issue. Some authors, however, have cited capital requirements as a barrier to entry. Although the suppliers of funds typically favor firms with established earnings records, the capital requirements -- in the absence of interdependencies -- should be equivalent for larger firms, smaller firms and new entrants undertaking identical R&D projects. George J. Stigler, The Organization of Industry (Homewood, Illinois: Richard J. Irwin, 1968), p. 70.

[25]In an empirical study of 238 firms which issued stock in the early 1960s, Archer and Faerber found that flotation costs ranged from 5 percent to 44 percent on new issues ranging in size from $75 thousand to over $29 million and that firm size accounted for 45 percent or nearly all of the explained variation among these different floating costs. Stephen Archer and LeRoy G. Faerber, "Firm Size and the Cost of Externally Secured Equity Capital," Journal of Finance 21 (March 1966): 76-78.

[26]A 25% tax credit on qualified R&D expenditures in excess of expenditures in a base period is allowed under the "Economic Recovery Tax Act of 1981," U.S. Conference Report (S REPT. No. 97-176) on HR 4242, S. 221, August 1, 1981.

[27]Morton I. Kamien and Nancy L. Schwartz, "Self Financing of an R&D Project," American Economic Review 68 (June 1978): 252.

[28]Kenneth J. Arrow, "Economics and the Allocation of Resources for Invention," in Richard R. Nelson, ed., The Rate and Direction of Inventive Activity: Economic and Social Factors (Princeton, Princeton University Press, 1962), pp. 619-611; Kamien and Schwartz, Market Structure and Innovation, p. 25.

[29]G. Warren Nutter, "Monopoly, Bigness and Progress," Journal of Political Economy 64 (December 1956): 526.

[30]William L. Baldwin, "Contracted Research and The Case For Big Business," Journal of Political Economy 70 (August 1962): 296.

[31]John Jewkes, David Sawers and Richard Stillerman, The Sources of Innovation, 2d ed. (New York: W. W. Norton and Company, 1969).

CHAPTER III

EMPIRICAL STUDIES OF THE FIRM SIZE - INNOVATIVE OUTPUT QUESTION

Background

The relationship between firm size and innovative output has been the subject of many empirical studies. Kamien and Schwartz indicate that the "bulk" of the empirical evidence suggests that output does not increase faster than firm size, except in the chemical industry. Research and development outlays seem to increase up to a point and level off.[1] Although much of the empirical analysis performed to date has refuted the Schumpeterian hypothesis, some noted economic researchers challenge the validity of these results.[2] Pavitt, for example, recently noted: "There is no thorough and systematic evidence of low R&D efficiency in large firms, or of diminishing R&D productivity."[3]

This continuing skepticism, even after numerous empirical studies, reflects a variety of factors: first, the variables of interest -- innovative output and, to a lesser extent, firm size -- are not readily available and, consequently, most empirical studies use surrogates. Fisher and Temin, in fact, argue that since the common proxies for innovation -- R&D expenditures and employment -- are inputs rather than outputs, they are inappropriate for tests of the Schumpeterian hypothesis.[4] In contrast, Kamien and Schwartz, who are well aware of the possible shortcomings of these popular surrogates but are willing to accept a "second-best" solution when the best is not readily available, note:

> Studies of the economics of technical advance suffer the shortcomings common to many empirical investigations -- the choice of measures of inputs and outputs of innovation is guided largely by data availability rather than a conceptual framework. However, ingenuity is often displayed in wringing out interesting observations from a meager data base.[5]

Secondly, the prior empirical research is subject to criticism for the statistical procedures employed -- the methods used to control for interindustry differences, possible influences of variables other than firm size and heteroscedastic disturbances.

Lastly, implicit and/or explicit censored data problems are a shortcoming of much of the prior empirical work. With many of the prior studies limited to a single industry or samples drawn from Fortune's 500 largest firms, they have been criticized for spanning too narrow a range. Freeman, for example, contends that it is only because the vast number of small firms -- many of which perform no research and development -- were omitted from much of the prior research that the bulk of the empirical results are inconsistent with the Schumpeterian hypothesis.[6]

Direct Measurement of Innovative Output

Finding an appropriate measure of innovative output is, indeed, a formidable task. Only a few researchers, in fact, have even attempted to perform the laborious chore associated with gathering the information required to directly measure innovative output. The onerous demands of this approach are illustrated by the steps taken by Mansfield and his associates to develop a list of innovations for the chemical industry. Their sources included representatives of the chemical-engineering departments at four major universities, trade journals as well as engineering, construction and chemical firms. Moreover, in addition to compiling a list of technical advances, they had to rely on these same sources to rank the innovations on a scale from one to ten.[7]

Although Mansfield's resultant list of some thirty product innovations and some forty-five process innovations over periods ranging between fifteen and twenty years enabled him to test whether the four largest chemical firms were more innovative than some of their smaller counterparts, it only included information on relatively large firms and major innovations. These survey results were not comprehensive enough to draw inferences applicable to the some one hundred chemical companies in the United States -- which may or may not be innovative -- and the relatively obscure innovations which may not be important individually but in aggregate make a significant contribution to technical progress.

Similarly in an earlier study Mansfield contacted trade associations, trade journals and a number of firms to develop a list of innovations for the petroleum refining, steel, railroad and bituminous coal industries.[8] But, as is the case with Mansfield's more recent study, these lists only included a relatively small number of firms in selected industries. Schmookler, whose studies of the economic issues associated with technical change span a number of decades, employed the services of many research assistants to collect data on inventions in selected industries to corroborate the validity of his patent data.[9] And Freeman was able to access information on nearly 2,300 innovations introduced in Great Britain between 1945 and 1980.[10] But, to a large extent, directly measuring innovative output -- even for a single industry -- has been beyond the resources of most researchers. And, with the possible exception of Freeman's data, the recent attempts at directly measuring innovative output are limited to large firms and major breakthroughs and, hence, poorly suited for a comprehensive test of the Schumpeterian hypothesis.[11]

In this regard, Schmookler notes:

> Any feasible list of important inventions that one might compile today for any given field is unlikely in my tentative judgment, to comprise as much as half the sources of technological progress in that field.[12]

He indicates further that this judgment only in part reflects the difficulties encountered in compiling a list of prototype innovations. In large measure it reflects the fact that a great deal of technological change stems from subtle, but important, modifications in the so-called prototype innovations.

Patents As A Measure of Innovations

Patent data are a measure of innovative output which can be used to test the Schumpeterian hypothesis. Scherer used this proxy in his frequently referenced empirical test of this issue.[13] Patents have the advantage of conformity to a minimum standard. Before issuance of a patent, the U.S. Patent Office must be reasonably convinced that the invention is new, not obvious and that it possesses practical utility. Despite these advantages, a straight count of patents has some major limitations: (i) the propensity to patent can vary from industry to industry and from firm to firm; (ii) even though patents must satisfy minimum criteria, there is a wide range of variation in importance among patents.

Moreover, patent data relate only to inventions, while innovations -- the variable of interest for testing the Schumpeterian hypothesis -- go beyond invention and include the development and the successful marketing of new products. It is, in fact, possible that small firms could be more than proportionately inventive, while big firms with their extensive facilities for product development and testing and large production and marketing capacity could be more than proportionately innnovative.[14]

Against this background, it is not surprising that the effectiveness of patent data as a measure of innovative output for testing the Schumpeterian hypothesis is a controversial subject. Schmookler who worked extensively with patent data found that they tracked inventive activity closely between the turn of the century and World War II. He observed, however, a sharp deviation from this relationship in the postwar period.[15] According to Schmookler, firms curtailed their use of the patent system after 1940 for a number of reasons:

> Chief among these were (1) a vigorous antitrust policy initiated in the late 1930s under which tens of thousands of patents held by large firms were thrown open to compulsory licensing, (2) the development of judicial attitudes casting doubt on the very patentability of ideas produced in corporate research and development programs, (3) the great growth of government financed corporate R&D, accompanied generally by a government lien on the resulting product which usually diminished the incentive to patent, (4) the prolonged delays at the Patent Office in processing applications, and (5) a growing belief among corporate managers that a headstart usually provides all the protection the innovator either needs or can hope for, so that patents seem less valuable than before.[16]

Notwithstanding Schmookler's reservations, the findings of some researchers suggest that patents may still be a reasonable measure of innovative output. Mueller, based on the correlation between patents and R&D expenditures for the 1958 to 1960 period for some one hundred firms in five different industrial categories, concluded that there is a highly significant relationship between patents and R&D expenditures.[17] Similarly, Comanor and Scherer compared patents for fifty-seven pharmaceutical firms with the sales volume of new products within two years after introduction and the number of R&D personnel. Their patent data reflected observations from the 1952-1957 period. They found a positive and statistically significant relationship between patents and the two other measures of technical change, even when firm size was held constant.[18]

More recently Pavitt, based on comparisons of National Science Foundation data on patent activity and R&D outlays for the 1973-1975 period, concluded that small firms tend to patent more per unit of R&D expenditure than large firms. He offers two possible explanations for this phenomenon:

> The first is the changing nature of industrial R&D as firms get bigger, with more emphasis on testing, applications engineering, and systems and production know-how, all of which are more difficult to patent. The second is the increasing formalization and specialization of the innovative functions within the firm as it gets bigger or more R&D intensive, with the result that R&D statistics capture a higher proportion of all the firm's innovative activities, and the ratio of patents to observed R&D goes down.[19]

Similarly, based on an earlier study Schmookler observed that large firms spent about twice as much per patent as small firms in 1953. Although his explanation of this phenomenon differed somewhat from Pavitt's, Schmookler did not infer, per se, that these findings implied diminishing returns to scale for R&D inputs. He notes a number of other factors could underlie this relationship. Large firms which typically enjoy more entrenched market positions might be less prone to patent their innovations than their smaller counterparts or large firms might generally concentrate their efforts on more elaborate and far-reaching projects.[20]

Sales of New Products As A Measure of Innovations

Comanor and, subsequently, Vernon and Gusen used sales of recently introduced pharmaceutical products as a measure of innovative output for that industry.[21] Although this is a particularly interesting measure of innovative output, which appears to be free from some of the potential problems associated with patent data, its usage appears to be limited. This type of data is not readily available for many industries. Moreover, new sales data are uniquely suited to an industry such as pharmaceuticals in which the bulk of R&D is directed toward new product development. In industries in which a considerable amount of R&D is directed toward process innovations or improvements in existing products, sales of recently introduced products would not be a good measure of innovative output.

R&D Expenditures and R&D Employment - Surrogates for Innovations

Many of the empirical studies of the Schumpeterian hypothesis use the surrogates of R&D employment or R&D expenditures to measure innovative output. These variables, at least in the case of expenditures in recent years, have the advantage of availability for a wide range of firm sizes in many industries -- an essential requirement to draw general inferences about the relationship between firm size and innovative output. The earlier studies such as Grabowski's which used R&D expenditures as a surrogate for innovation were dependent upon gratuitous responses to surveys for their data.[22] But since the issuance of Statement No. 2 of the Financial Accounting Standards in 1974, uniform data covering a wide range of firm sizes are available.

Given the unavailability of a large and consistent data set on R&D expenditures -- at least in the case of empirical work performed before 1974 -- researchers such as Hamberg used R&D employment as a surrogate for innovative output.[23] Data on R&D employment for many of the Fortune 500 and some smaller firms, with a breakdown between professional and non-professional employes, is published annually.[24] This surrogate was selected over R&D expenditures for the sake of availability rather than suitability. Moreover, it could lead to distortions if there are differences in labor and capital intensity of R&D outlays among firms. If a direct relationship between compensation and performance is presumed, R&D outlays should be a better input measure than a mere count of a firm's so-called professional and/or non-professional R&D employes.

Principal Caveat With Using R&D Inputs As Proxy for Innovations

The principal caveat that must be taken into account with using an input as a surrogate for an output is that this approach is only valid if there are constant returns to scale. Diminishing returns to scale would tend to underestimate the contribution of smaller firms, while with increasing returns to scale their contribution would be overstated. Although more work needs to be done on this subject, most of the available information suggests that R&D inputs are an acceptable proxy for innovative output. In this regard Pavitt and Wald in defense of their use of R&D outlays as a surrogate for innovative output note:

> No doubt the relevance and the productivity of R and D can, and do, vary widely from firm to firm. But, between industries and between nations, empirical evidence shows a high correlation between industrial R and D expenditures and technological innovation. Across thirteen industries in the U.S.A. . . . there is a high correlation between R and D intensity . . . and rates of technological innovation . . . And . . . across ten countries and corrected for differences in population size, [there is] a high correlation between national expenditures on R and D and national performance in technological innovation.[25]

In addition to the previously cited studies by Mueller and Comanor and Scherer which suggest that there is a direct relationship between innovative inputs and outputs, Mansfield's empirical work on the relationship between the level of a firm's R&D outlays and the number of significant inventions it produces is consistent with this view.[26] McLean and Round, using the framework of the Comanor-Scherer study, investigated the correlation between three measures of R&D input with output for a sample of 980 Australian manufacturing firms during 1971-1972. For the entire sample, the correlation coefficients were positive and highly significant. Of even greater significance is the fact that, in most cases, the relationship was strictly linear.[27] And Griliches in a study of the effectiveness of R&D expenditures and firm size found constant returns to scale.[28] Moreover, Nelson and Winter note that studies by Kendrick and Terleckyji, which focused on the relationship between growth of total factor productivity and R&D spending, found a "significant effect of an industry's research and development spending upon its measured rate of technical progress."[29]

Measurement of Firm Size

Dollar sales are used in most recent empirical tests of the Schumpeterian hypothesis as the measure of firm size. In contrast with the various measures of innovative output which have been used as left-hand side variables, sales are generally viewed as a suitable measure of firm size for a right-hand side variable. Scherer pointed out that sales are essentially neutral with regard to factor proportions. Interview studies show that sales are the principal scale variable used by firms in setting their R&D budgets. And sales are responsive to short-run changes in demand.[30] Some of the studies, which utilize prewar data, used assets to represent firm size. But as Mansfield noted, this selection was made because some firms did not report sales data in the 1930s.[31]

Soete, however, in his update of Scherer's study, which used mid-1970s data, indicated a ranking of firms by sales will be strongly influenced by the 1973 oil crisis and, hence, he used employment in addition to sales as a measure of firm size.[32] Earlier studies, such as those of Hamberg and Comanor, apparently used total employment as a measure of firm size to correspond with their surrogate for innovative output -- R&D employment.[33]

Controlling Possible Distortions From Factors Other Than Firm Size

Controlling the effects of factors other than firm size which may affect innovative output is a problem common to all empirical investigations of the Schumpeterian hypothesis. All researchers have recognized that technological opportunity varies from industry to industry. As a result, many studies are limited to a single industry, while in the multi-industrial studies, such as Scherer's, the data is partitioned to control for technological diversity. Scherer initially ran a global regression which included all of the 448 firms in his sample. But he subsequently partitioned the sample by industry into fourteen separate groups to control for differences in technical opportunity. Since the resultant samples were not sufficiently large for meaningful statistical analysis, they were consolidated into four groups. Linear regression coefficients of patents on sales were used to assign each of the fourteen industrial categories to one of the four technical opportunity groups. By grouping firms in industries with similar slope coefficients, Scherer assumed that non-size influences on innovative output such as differences in technological opportunity would be eliminated.[34]

To specify better the relationship between innovative output and firm size, some researchers have added right-hand side variables such as measures of diversification and liquidity to their models. Grabowski, for example, used an index of diversification to capture the effect postulated by Nelson that profit expectations from R&D are directly related to the breadth of a firm's product line. He also added a cash flow variable to take account of the fact that "retained earnings and other internally generated funds have a significant impact on investment."[35] Although Grabowski found these variables, for the most part, to be significant in his study of sixteen chemical firms, fifteen petroleum firms and ten drug firms over the 1959-1962 period, most researchers have not found them to be significant in other studies.

Vernon and Gusen in their study of the drug industry tried a diversification variable but they found it to be insignificant.[36] Scherer found diversification to be significant in a global analysis of the 448 firms in his sample but once the sample was partitioned into the fourteen industrial groups this variable became insignificant. He indicated that the diversification index might have acted as a surrogate industry dummy variable in the global test.[37] Similarly, Kamien and Schwartz note that a number of researchers tried to include various measures of liquidity and found them to be insignificant. They suggest that liquidity or profitability may be "threshold factors," necessary to some extent for R&D activity, but possessing no direct (linear) relation with innovative activity.[38]

Heteroscedasticity Problem

Johnston notes: "In many econometric studies, especially those based on cross-section data, the assumption of a constant variance for the disturbance term is unrealistic."[39] It is, in fact, inevitable in comprehensive tests of the Schumpeterian hypothesis which employ cross-sectional data spanning a wide range of firm sizes, that the assumption of constant variance for the disturbance term of the classical linear regression model will not be satisfied. Hence these heteroscedastic disturbances must be corrected before efficient -- minimum variance -- estimators will be available to assess the validity of the Schumpeterian hypothesis.

Prior empirical studies on the relationship between R&D intensity and firm size have not directly corrected for heteroscedasticity. Some have simply ignored the problem. Mansfield in his more recent study of the chemical industry made no adjustment for heteroscedasticity. His data set, however, which was limited to thirty-eight major chemical firms for the 1930-1950 period and fifty-six such firms for the 1951-1971 period, was less susceptible to severe heteroscedasticity than a full scale test of the Schumpeterian hypothesis.[40] Vernon and Gusen in their study of the pharmaceutical industry noted that a logarithmic specification would be well suited to their cross-sectional data set. But since twenty-one of their fifty observations for sales of new chemical entities -- their dependent variable -- take the value of zero, they indicated that a logarithmic specification could not be used.[41]

The researchers who attempted to control for heteroscedastic disturbances used ratios or logarithmic specifications. Grabowski deflated R&D expenditures by sales to correct for scale effects.[42] Mansfield in his earlier work on firms in the steel, petroleum and coal industries used the following semi-log specification:

$$N_j = a_o + a_1 \ln S_j + a_2 (\ln S_j)^2 + a_3 (\ln S_j)^3 + u \qquad (1)$$

The logarithm of S -- the firm's size measured by sales -- was used because "its distribution is less skewed."[43] Presumably, Mansfield's N_j term -- a direct count of innovations -- was not skewed. The u is a random error term. Hamberg used the following log-linear specification to control for heteroscedasticity:

$$\ln R\&D = \ln a_o + a_1 \ln S + u \qquad (2)$$

In the above expression the dependent variable represents R&D employment, while S is a measure of firm size. Hamberg ran this regression with two alternate measures of firm size -- total employment and total assets.[44]

Censored Data Problem

An explicit or implicit censored data problem is a shortcoming common to most of the prior empirical tests of the Schumpeterian hypothesis. Although confining a study to a single or a few industries may facilitate the collection of data, particularly if the researcher is attempting to measure directly innovative output, the results are only applicable to the specific industry test. Comanor begrudingly recognized this in the conclusion of his study on the pharmaceutical industry:

> While little is known about the extent to which this result is applicable to the economy at large, it does appear that there are grounds for considerable doubt as to the position that large firm size is always a necessary condition for rapid technical advance.[45]

Similarly, in the conclusion of the Vernon and Gusen study, which is an updated version of the Comanor study, the following caveat is noted:

> Our results indicate that larger pharmaceutical manufacturers appear to have decided advantages over smaller ones in accomplishing technical change. These results do not appear to be unreasonable when it is realized that the very largest firm in the industry is still relatively small when compared with American manufacturing in general.[46]

A more subtle form of censoring stems from the fact that even the many studies which include a cross-section of industries are based on a select group of larger firms. In this regard Kamien and Schwartz note that most studies focus primarily on firms that have a sustained formal research program.[47] Scherer notes that: "The samples drawn by Worley and Hamberg were neither random nor exhaustive."[48] He indicated that Hamberg's sample was deficient because it was limited to those Fortune 500 firms which reported specifically on their R&D

employment. In the case of Scherer's sample of 448 firms, only 352 firms reported specifically on R&D employment. The ninety-six firms, however, which did not report their R&D employment to the National Research Council census were among the least productive in Scherer's patent survey. Forty-one percent of them obtained no patents in the year he surveyed and seventy percent of them obtained four or fewer patents compared to a mean of thirty-seven per firm for Scherer's full sample.[49]

While Scherer's sample appears to be an improvement over Hamburg's, it is still questionable whether limiting a study to a larger subset of the Fortune 500 firms is an adequate test of the Schumpeterian hypothesis. Substantive questions would remain about the relationship between innovative output and firm size for the bulk of American industry, even if convincing empirical evidence was provided on this relationship for the largest firms in the United States. Scherer was, of course, aware of this potential shortcoming in his analysis. He noted, however, that since there is much evidence that smaller firms are more prone to patent than those in the Fortune 500 group, inclusion of these firms would only reinforce his overall conclusion.[50] This rationale for ignoring the many firms with sales below the levels in the Fortune 500 would probably be acceptable if this presumed higher propensity to patent among smaller firms reflected a higher propensity to innovate. But, as noted previously, even though patenting may be more intensive among smaller firms, this appears to reflect factors unique to this proxy and not a higher propensity to innovate -- the dependent variable Scherer is trying to measure.

Thus, although Scherer correctly identified the need for a comprehensive data set and he included a cubic term in his model to quantify possible inflection points in the relationship between inventive activity and firm size, data limitations prevented him from fully exploiting his valuable insights. In order to quantify better the relationship between firm size and innovative output, and identify any possible inflection points, it is necessary to employ a sample set which spans from the smallest to the largest firms in American industry.

Prior Empirical Studies

Despite the considerable difficulties involved in specifying the relationship between firm size and innovative output, many researchers have accepted the challenge. Some investigators such as Jewkes, Sawers and Stillerman have used the case method to address this issue. Case studies can, of course, provide some fragmentary information on this question but they are not well suited to deriving substantive inferences concerning the thousands of companies in the hundreds of industries comprising American industry. Regression analysis and, to a lesser extent, the rank ordering employed by Freeman provide a more rigorous means of looking at this question, particularly in the current environment where R&D expenditure data are available for thousands of American firms.

As shown on Table I, the findings of Hamberg, Comanor and Scherer suggest that the behavior of large firms, to a considerable extent, is inconsistent with the Schumpeterian hypothesis -- at least for the subsets of the Fortune 500 firms they tested. Although the statistical techniques employed in these studies have done much to lay the groundwork for more comprehensive tests of this question, they have not, as Scherer implies, put this question to rest. He asserts:

> These findings among other things raise doubts whether the big, monopolistic, conglomerate corporation is an efficient engine of technological change as disciples of Schumpeter (including myself) have supposed it to be. Perhaps a bevy of fact-mechanics can still rescue the Schumpeterian engine from disgrace, but at present the outlook seems pessimistic.[51]

The findings of Soete and Freeman, however, suggest that the Schumpeterian hypothesis is not beyond redemption. In fact, with the data sets used by Hamberg, Comanor and Scherer limited to larger firms and in view of the potential shortcoming of the proxies -- R&D employment and patents -- they used for innovative output, it is not surprising that their findings have been challenged.

TABLE I

HIGHLIGHTS OF REPRESENTATIVE EMPIRICAL TESTS OF THE SCHUMPETERIAN HYPOTHESIS

Interindustry Studies -- Listed by Year of Publication	Measure of Innovative Output	Principal Measure of Firm Size	Size of Data Set	Principal Analytical Technique
Hamberg (1964)	R&D Employment	Total Employment	340 *Fortune* 500 firms	Rank correlation and linear regression
Scherer (1965)	Patents	Sales	448 *Fortune* 500 firms	Non-linear regression with cubic term
Comanor (1967)	R&D Employment	Total Employment	387 *Fortune* 500 firms	Linear regression
Soete (1979)	R&D Expenditures	Total Employment & Sales	530 large firms -- all with sales in excess of $100 million	Non-linear regression with cubic term
Freeman (1982)	Innovations	Employment & Output	2,293 innovations from small, medium and large size U.K. firms	Rank ordering for each of three size categories

TABLE I (Continued)

Control for Heteroscedasticity	Inclusion of Non-Size Variable	Principal Findings
Logarithmic specification	None	R&D employment increases more rapidly than total employment in 3 of 17 industrial groups tested.
Regressions also run using a semi-logarithmic specification	Diversification variable -- not significant	Inventive output increases with firm size, but generally at less than a proportionate rate.
Logarithmic specification	None	The elasticity of R&D employment is never significantly greater than 1 and it is less than 1 in 7 of the 21 industry groups.
-	None	Global results support Schumpeterian hypothesis but industry results mixed.
-	None	Overall small firms proportionately less innovative than large firms. But small firms more than proportionately innovative in a few industries.

TABLE I (Continued)

HIGHLIGHTS OF REPRESENTATIVE EMPIRICAL TESTS OF THE SCHUMPETERIAN HYPOTHESIS

Industry Studies -- Listed by Year of Publication	Measure of Innovative Output	Principal Measure of Firm Size	Size of Data Set	Principal Analytical Technique
Comanor (1965)	New chemical entities during the first two calendar years following introduction	Total pharmaceutical sales	57 pharmaceutical firms	Non-linear regression with quadratic term
Vernon & Gusen (1974)	New chemical entities during the first two calendar years following introduction	Total pharmaceutical sales	50 pharmaceutical firms	Non-linear regression with quadratic term
Mansfield (1977)	Innovations weighted by importance and unweighted	Asset size	56 chemical firms -- data collected over 20-year postwar period	Non-linear regression with cubic term

TABLE I - (Continued)

Control for Heteroscedasticity	Inclusion of Non-Size Variable	Principal Findings
Deflated measures of technical change and R&D by a size variable	Diversification and interaction variables significant. Interaction variable (R&D employment x sales) introduced to pick up separate effects -- problems of increased organization and overall size effect -- e.g. better marketing, etc.	There are substantial diseconomies of scale in R&D in the drug industry.
-	Diversification variable insignificant. Interaction variable significant	Larger drug firms are more effective in bringing about technical change.
-	None	Maximum occurs at the size of the largest firm for product innovations and at about the size of the seventh or eighth largest for process innovations.

Soete used the data available in the annual Business Week R&D Survey to take a fresh look at Scherer's analysis.[52] As a measure of innovative output, he used R&D expenditures for each of two years -- 1975 and 1976. In contrast, Scherer used 1959 patent data. Both studies employed the same basic cubic specification for their principal regression analysis.

$$R\&D_j = a_o + a_1 S_j + a_2 S_j + a_3 S_j + u \quad (3)$$

Four separate regressions were run by Soete with this model, using 1975 and 1976 data and alternate right-hand side variables -- total employment and sales for each of the 530 firms in his data set. The results were essentially the same for each of the four tests. R&D outlays increased more than proportionately with firm size for some 500 of the 530 firms in the data set. However, Soete did not specifically address the potential problem of heteroscedasticity and the significance of his results declined markedly when his global sample was partitioned into seventeen industrial groups. His industrial results imply that only three industries -- office equipment, personal care products and chemicals -- large firms carry out proportionately more R&D than small firms.[53]

Given these shortcomings, Soete's empirical work does not appear to provide convincing support for the claim that his results refute the findings of Scherer and the other prior empirical works which found little, if any, relationship between firm size and the propensity to innovate.

> The statistical analysis presented in this paper casts doubts as to the validity of most empirical analysis and the results in the field of firm size and inventive activity.[54]

Freeman's comprehensive data set on innovations and the industrial studies of Mansfield and Vernon and Gusen, however, suggest that the empirical evidence refuting Schumpeter may be less impressive than Scherer believes.

Freeman employed data which has been collected on 2,293 innovations introduced by United Kingdom firms between 1945 and 1980. He observed that small firms -- those with fewer than two hundred employes -- accounted for 12 percent of all industrial innovations. In contrast, this same group of firms accounted for 19 per cent of net output, while their share of employment was 22 per cent. Freeman also analyzed this data by industry. In most industries, small firms were insignificant contributors to innovation. But in a few industries, small enterprises contributed proportionately more than their share of output to innovation. Based on his analysis of this industrial data, Freeman concludes that:

> Those industries in which small firms contributed much less than their share of output or nothing at all, correspond broadly to industries of high capital intensity . . . . The small firms make their contribution mainly in the field of machinery and instrument innovations, where both capital intensity and development costs are low for many products, and entry costs are low for new firms.[55]

Some of the principal empirical tests of the Schumpeterian hypothesis which concentrated on a single industry also suggested that there may be some specific sectors to which this hypothesis applies. Based on the painstaking work of Mansfield and his associates, it is now generally accepted that larger firms account for proportionately more product innovations than their smaller counterparts in the chemical industry.[56]

The two principal empirical studies of the pharmaceutical industry, which are summarized on Table I, show conflicting results. Vernon and Gusen presumed initially that major changes in the Food and Drug Administration's standards were responsible for these differences. During the 1955-1960 timeframe -- the period from which Comanor's data set was drawn -- only the safety of new drugs had to be demonstrated. In contrast, during the 1965-1970 timeframe -- the period on which the latter study was based -- companies had not only to demonstrate a new drug's safety but they had to incur the additional expenses required to prove its effectiveness. To confirm this supposition, Vernon and Gusen applied their model -- a slightly modified version of Comanor's -- to a 1955-1960 data set. They found, however, even in the earlier period large drug firms were "better" at developing new chemical entities than smaller ones but their relative advantage was less than in the 1965-1970 timeframe.[57]

Lessons for Further Study

Based on this review of some representative studies of the Schumpeterian hypothesis, it appears that considerable exaggeration has accompanied the claims that certain findings have done irreparable harm to this hypothesis as well as the competing claims that other findings substantiate it. Too little is known about the behavior of firms below the Fortune 500 size level, especially in the United States, to warrant definitive statements on either side of this issue. But even though prior empirical researchers have not put to rest the questions concerning the validity of the Schumpeterian hypothesis, they have provided a rich foundation for subsequent tests. The considerable work that has been done on measuring innovation, especially the information on the various surrogates, and the models which have been constructed by prior researchers should be very helpful to future investigators.

Moreover, the disparate findings of prior researchers should lead future researchers to employ techniques capable of encompassing a diversity of outcomes. The expectations of many prior researchers that their empirical work would uncover a sweeping refutation or a strong endorsement of the Schumpeterian hypothesis may have been unrealistic. This hypothesis may apply in certain industrial settings and not in others. And, among those industries, if any, to which it applied, its degree of applicability may vary. In one group the largest firms may be the most innovative, in another intermediate size firms might predominate and, perhaps, in another small firms may be the innovative pacesetters.

FOOTNOTES - CHAPTER III

[1]Kamien and Schwartz, Market Structure and Innovation, p. 103.

[2]The term Schumpeterian hypothesis in this paper refers to the theory that large firms are proportionately more innovative than small firms.

[3]Keith Pavitt, "R&D, Patenting and Innovative Activities: A Statistical Exploration," Research Policy 11 (February 1982) : 36.

[4]Franklin M. Fisher and Peter Temin, "Returns to Scale in Research and Development: What Does the Schumpeterian Hypothesis Imply?," Journal of Political Economy 81 (January-February 1973) : 56.

[5]Kamien and Schwartz, Market Structure and Innovation, pp. 102-103.

[6]Christopher Freeman, The Economics of Industrial Innovation, 2nd ed. (Cambridge, Mass. : The MIT Press, 1982), p. 133.

[7]Mansfield, et al., The Production and Application of New Industrial Technology, pp. 46-60.

[8]Edwin Mansfield, Industrial Research and Technological Innovation (New York : W. W. Norton & Company, 1968), pp. 84-100.

[9]Schmookler, Invention and Economic Growth, pp. 269-328.

[10]Freeman, The Economics of Industrial Innovation, p. 140.

[11]I have had considerable personal experience with the obstacles of gathering a list of innovations. Initially, I tried to compile a list of significant innovations in the auto industry to test the applicability of the Schumpeterian hypothesis to that industry. But despite much assistance from industry R&D executives, a large response to a mail survey and an extensive review of trade publications, I have serious reservations concerning whether my list is complete, particularly with regard to the smaller and the more obscure auto supply firms.

FOOTNOTES - CHAPTER III

[12]Schmookler, Invention and Economic Growth, pp. 18-19.

[13]F. M. Scherer, "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions," The American Economic Review 55 (December 1965).

[14]Gilpin, in fact, criticized Jewkes for failing to distinguish between invention and innovation. U.S. Congress. Subcommittee on Economic Growth of the Joint Economic Committee, Technology, Economic Growth, And International Competitiveness, by Robert Gilpin, Joint Committee Print, Study 53-938 (Washington D.C. : Government Printing Office, 1975), p. 49.

[15]Schmookler, Invention and Economic Growth, p. 55.

[16]Jacob Schmookler, Comment on Barkev S. Sanders' paper, "Some Difficulties in Measuring Inventive Activity," in Nelson, ed., The Rate and Direction of Inventive Activity: Economic and Social Factors, pp. 79-80.

[17]Denis C. Mueller, "Patents, Research And Development, And The Measurement of Inventive Activity," Journal of Industrial Economics 25 (November 1966) : 26-37.

[18]William S. Comanor and F. M. Scherer, "Patent Statistics as a Measure of Technical Change," Journal of Political Economy 77 (May/June 1969) : 392-398.

[19]Pavitt, "R&D, Patenting and Innovative Activities" : 36.

[20]Schmookler, Invention and Economic Growth, pp. 32-35.

[21]William S. Comanor, "Research and Technical Change in the Pharmaceutical Industry," The Review of Economics and Statistics 47 (May 1965) : 182-190; Vernon and Gusen, "Technical Change and Firm Size: The Pharmaceutical Industry" : 294-302.

FOOTNOTES - CHAPTER III

[22]Henry C. Grabowski, "The Determinants of Industrial Research and Development: A Study of the Chemical, Drug and Petroleum Industries," Journal of Political Economy 76 (March-April 1968) : 292-306. Grabowski's R&D data were collected via a survey of Fortune 500 firms in selected industries. Forty-one firms, 70% of those surveyed, responded. Although Grabowski asked the respondents to comply with NSF guidelines in specifying R&D outlays, users of the data which have been published in 10K reports since the 1974 ruling have the additional assurance that their data comply with SEC guidelines.

[23]Hamberg, "Size of Firm, Market Structure and Innovation" : 65.

[24]These data is published annually in Industrial Laboratories of the United States (Washington, D.C.).

[25]Pavitt and Wald, The Conditions for Success in Technological Innovation, pp. 24-25.

[26]Mueller, "Patents, Research and Development, and the Measurement of Inventive Activity;" Comanor and Scherer, "Patent Statistics as a Measure of Technical Change;" Mansfield, Industrial Research and Technical Innovation, pp. 40-43. Although Mansfield found inventions and R&D outlays to be highly correlated, he found tentative evidence of diseconomies of scale in a number of industries, increasing returns in the chemical industry and constant returns in the petroleum and steel industries.

[27]Ian W. McLean and David K. Round, "Research Product Innovation in Australian Manufacturing Industries," Journal of Industrial Economics 27 (September 1978) : 1-12. The input variables used by McLean and Round included the ratio of R&D outlays to sales, R&D employes to total work force, and professional employes to total work force. The output measure reflected new products weighted by their relative sales.

[28]This unpublished Griliches study is referenced in: Kamien and Schwartz, Market Structure and Innovation, pp. 79-80.

FOOTNOTES - CHAPTER III

[29]Nelson and Winter, "In Search of Useful Theory of Innovation" : 42-43.

[30]Scherer, "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions" : 1099.

[31]Mansfield, The Production and Application of New Industrial Technology, p. 49.

[32]Luc L. G. Soete, "Firm Size and Inventive Activity: The Evidence Reconsidered," European Economic Review 12 (December 1979) : 322-325.

[33]Hamberg, "Size of Firm, Oligopoly, and Research: The Evidence," : 63; William S. Comanor, "Research and Technical Change in the Pharmaceutical Industry," Review of Economics and Statistics 67 (May 1965) : 190.

[34]Scherer, "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions" : 1106-1107.

[35]Henry Grabowski, "The Determinants of Industrial Research and Development: A Study of the Chemical, Drug and Petroleum Industries," Journal of Political Economy, 76 (March/April 1968) : 295-296.

[36]Vernon and Gusen, "Technical Change and Firm Size: The Pharmaceutical Industry" : 298.

[37]Scherer, "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions," : 1114-1115.

[38]Kamien and Schwartz, Market Structure and Innovation, p. 98.

[39]J. Johnston, Econometric Methods, 2nd ed. (New York : McGraw-Hill Book Company, 1972), p. 214.

[40]Mansfield, et al., The Production and Application of New Industrial Technology, pp. 51-52.

[41]Vernon and Gusen, "Technical Change and Firm Size: The Pharmaceutical Industry" : 298.

FOOTNOTES - CHAPTER III

[42]Grabowski, "The Determinants of Industrial Research and Development: A Study of the Chemical, Drug, and Petroleum Industries" : 293-295.

[43]Mansfield, Industrial Research and Technological Innovation, pp. 97-100.

[44]Hamberg, "Firm Size, Oligopoly, and Research: The Evidence" : 72.

[45]Comanor, "Research and Technical Change in the Pharmaceutical Industry" : 190.

[46]Vernon and Gusen, "Technical Change and Firm Size: The Pharmaceutical Industry" : 301.

[47]Morton I. Kamien and Nancy L. Schwartz, "Market Structure and Innovation: A Survey," The Journal of Economic Literature 13 (March 1975) : 3.

[48]F. M. Scherer, "Size of Firm, Oligopoly, and Research: A Comment," Canadian Journal of Economic and Political Science 31 (May 1965) : 257.

[49]Ibid.

[50]F. M Scherer, "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions" : 1105.

[51]Ibid., p. 1122.

[52]Soete, "Firm Size and Inventive Activity: The Evidence Reconsidered" : 326-327. The Business Week Survey, which has been available since the mid-1970s, includes all firms that spend $1 million or more on R&D in a given year. Business Week used the Compustat tapes as a source for its data.

[53]Ibid., 336-337.

[54]Ibid.

[55]Freeman, The Economics of Industrial Innovation, p. 141.

FOOTNOTES - CHAPTER III

[56]The investigative techniques employed by Mansfield and his associates largely uncovered epochal innovations and excluded the more mundane. However, since large firms are generally presumed to be particularly adept at the mundane but important task of developing and upgrading existing products, it appears that, if there is any bias, their results may understate the importance of large firms in product development in the chemical industry. Mansfield, et al., The Production and Application of New Industrial Technology, pp. 57-59.

[57]Vernon and Gusen, "Technical Change and Firm Size: The Pharmaceutical Industry" : 294.

CHAPTER IV

CURRENT EMPIRICAL STUDY OF THE FIRM SIZE - INNOVATIVE OUTPUT QUESTION

Rationale for Current Study and Hypothesis To Be Tested

Access to a consistent, up-to-date and comprehensive data set of R&D outlays -- a resource not available to most prior researchers -- has opened up new vistas for exploring the many unanswered questions concerning the relationship between firm size and innovative output.[1] A uniform data set that extends to the thousands of firms below the apex of American industry -- the Fortune 500 -- should provide additional insight into this hoary issue. And of perhaps even greater significance is the fact that a huge data set covering the breadth of American industry is well suited to detecting nuances in interpretation of the Schumpeterian hypothesis. Much of the prior empirical work in this area has aimed at either proving or disproving this hypothesis. But in reality there may be shades of truth on both sides of this issue.

The empirical research presented in this chapter, in fact, is directed toward testing the hypothesis of economists such as Nelson, Peck and Kalachek who inferred that the relationship between firm size and innovation is characterized by interindustry differences.[2] In industries in which R&D is complex, requiring a diversity of skills and a considerable financial commitment, large firms are likely to predominate in innovation. But in industries in which ingenuity is more important than a diversity of skills and costly equipment, small firms are likely to make more than a proportionate contribution to technical progress.

Data Set

The measure of innovative output in the current study is R&D expenditures. This data set was accessed through the Compustat tapes for the year 1980.[3] Included are 2,210 firms which published specific dollar amounts of R&D outlays and 585 firms which reported in their 10K filings with the Securities and Exchange Commission (SEC) that their expenditures for this purpose were "insignificant." In lieu of reporting a specific dollar amount, firms with R&D outlays which are less than one percent of sales have the option of reporting that their expenditures are "insignificant."

Although R&D expenditures are a surrogate for innovative output, they appear to be a reasonable one. The findings of a number of studies referenced previously in this paper suggest that the relationship between R&D expenditures and innovative output is highly significant and, in most cases, strictly linear.[4] And on a purely pragmatic basis when R&D expenditures are compared with the alternatives, they appear to represent a very practical approach to measuring innovative output.

In theory, a comprehensive list of innovations -- weighted by their significance-- would be the most desirable variable. But as I can attest from my experiences with compiling such a list -- even for a study confined to a single industry -- significant omissions are likely, particularly in the case of subtle improvements and smaller firms both of which in aggregate account for a large proportion of technical progress.[5] Patent data -- the other commonly used direct measure of innovative output -- are more likely to be comprehensive than a list of innovations. But since small firms have a higher propensity to patent than large firms, this measure of innovation would not be appropriate for cross-sectional analysis.[6]

Given the inherent problems with measuring innovative output directly, R&D expenditures appear to represent an interesting alternative which has an important attribute lacking in counts of innovations or patent data. If, indeed, there is a linear relationship between innovative inputs and outputs, using the expenditure data will automatically overcome one of the potential shortcomings in the frequently used direct measures. Since innovations differ widely in significance, mere counts of new products, processes or patents, per se, are not sufficient for a thorough analysis. In addition, some form of weighting scheme must be employed. Although somewhat arbitrary, an effective weighting scheme can be designed, with the assistance of knowledgeable experts, for relatively small samples of innovations such as those collected by Mansfield. But, with many firms obtaining hundreds of patents in a single year, this task for a large cross-section of firms would be beyond the resources of most researchers. Thus, although R&D expenditures are a surrogate, they possess some important attributes. Most notably, they circumvent the sampling limitations and the weighting difficulties associated with using the commonly employed direct measures of innovation. Moreover, they also overcame the sampling problems associated with direct counts of innovations.

Dollar sales -- the surrogate for firm size -- for the 2,795 firms included in this study were also accessed through the Compustat tapes for the year 1980. This variable, even though it is not viewed unanimously as the best proxy for firm size, is accepted widely as a good measure. In contrast with employment and total assets, two other commonly used measures of firm size, it has the advantage of being essentially neutral with regard to factor proportions.[7]

Model

The model used to test the relationship between firm size and innovative output in this study is essentially the same as those used by Scherer in his widely quoted study and by Mansfield in one of his more recent studies.[8]

$$R\&D_i = b_o + b_1 S_i = b_2 S_i^2 + S_i^3 + u_i \qquad (4)$$

$R\&D_i$ is the $_i$th firm's 1980 research and development expenditures, S_i, its 1980 sales and u_i an error term.

A nonlinear specification was used to test my basic hypothesis that there are shades of truth in the Schumpeterian hypothesis. The propensity to innovate is presumed to increase more than proportionately with firm size in some cases. But since this relationship is not expected to be universally true, nor invariant, the cubic term was added to identify specific inflection points, if any, at which the relationship might change. The constant term allows for the fact that a certain amount of R&D spending can take place in a year in which a firm has no sales.

Grouping

Prior researchers, such as Scherer and Comanor, who used interindustry data to test the Schumpeterian hypothesis partitioned their sample sets.[9] They indicated that in order to distinguish the effects of firm size on innovation from that of technical opportunity it is necessary to deal with industries which are relatively homogeneous. This step is, perhaps, even more important in the context of my hypothesis which asserts that the relationship between firm size and technological progress varies among industries.

The sample set, which approaches three thousand firms in size, was partitioned into six groups. As a first step, each firm was assigned to one of the National Science Foundation's twenty-six R&D categories.[10] Despite the large size of the overall sample, the number of observations in many of the twenty-six NSF groups was not adequate to perform meaningful statistical analysis. In four of the categories, there were fewer than twenty-five observations, and in the smallest category there were only thirteen firms. Particularly in view of the high collinearity among the independent variables (S, S^2, S^3), further aggregation was required.

Two criteria were employed in aggregating: (i) industries with similar R&D intensities were combined; and (ii) each group had to be sufficiently large to include at least 250 firms. In order to approximate the relationship between R&D intensity and sales for each of the twenty-six NSF groups, the following regression was run for each group:

$$R\&D_i = a_1 + a_2 S_i \qquad (5)$$

The results of these regressions, which are shown in Table VIII -- Appendix A, enabled further aggregation of industries with similar R&D behavior. Based on these guidelines and the regression results, six categories were established. These results, the industries included in each of the six categories and the summary statistics for each category are shown in Tables VIII, IX and X, respectively -- Appendix A.

Ordinary least squares (OLS) were run for each of the six technological opportunity groups using both the basic model shown in equation (4) and a alternate specification which excludes the cubic term. These results are shown on Table II -- zero proxies were used as the dependent variable for each of the 585 firms which reported that their R&D expenditures were insignificant. It is inevitable, however, in cross-sectional regressions of R&D on firm size that the

TABLE II

OLS EQUATIONS RELATING RESEARCH & DEVELOPMENT EXPENDITURES (R&D) TO FIRM SIZE (S) BY TECHNICAL OPPORTUNITY CLASS-- "INSIGNIFICANTS" REPLACED WITH ZERO VALUES

	S	S^2	S^3
Very High	.051 (38.2)	$.282 \times 10^{-6}$ (4.2)	
	.040 (13.9)	$.235 \times 10^{-5}$ (5.0)	$-.634 \times 10^{-10}$ (-4.4)
High	.040 (35.3)	-.104 (-0.5)	
	.031 (21.7)	$.803 \times 10^{-6}$ (9.2)	$-.116 \times 10^{-10}$ (-9.6)
Intermediate	.021 (18.1)	$.981 \times 10^{-6}$ (8.5)	
	.021 (10.9)	$.835 \times 10^{-6}$ (1.5)	$.890 \times 10^{-11}$ (2.7)
Low Intermediate	.007 (7.4)	$.696 \times 10^{-6}$ (7.3)	
	.007 (4.4)	$.462 \times 10^{-6}$ (1.0)	$.145 \times 10^{-10}$ (.54)
Low	.007 (17.7)	$-.217 \times 10^{-6}$ (-4.4)	
	.006 (6.9)	$.261 \times 10^{-6}$ (1.0)	$-.305 \times 10^{-10}$ (-1.9)
Very Low	.004 (19.8)	$-.675 \times 10^{-9}$ (-.24)	
	.007 (18.2)	$-.106 \times 10^{-6}$ (-8.7)	$.815 \times 10^{-12}$ (8.9)

Note: Values in parentheses are t statistics.

TABLE II (Continued)

Constant	R^2	N
-.98 (-0.78)	.95	379
.38 (.3)	.96	
-.74 (-0.5)	.92	325
1.9 (1.4)	.98	
-.59 (-.82)	.90	342
-.66 (-.87)	.90	
.91 (1.1)	.78	306
.75 (.86)	.78	
-.16 (-.55)	.76	280
.06 (.21)	.76	
.07 (.15)	.66	1163
-.70 (-1.5)	.68	

assumption of constant variance for the disturbance term of the classical linear regression model will not be satisfied. This is particularly true in the case of my sample set in which the firms range in size from fledgling enterprises with annual sales of less than $100,000 up to behemoth firms approaching $100 billion in sales. Hence these heteroscedastic disturbances must be corrected before efficient -- minimum variance -- estimators will be available to assess the validity of my hypothesis.

Correction for Heteroscedasticity

Although some prior researchers used logarithmic transformations to reduce unequal variances among the disturbances, none used weighted least squares -- "the most straightforward method of dealing with heteroscedasticity."[11] In fact, with nearly 40%, or 1,167 of the 2,785 firms in the sample set used in this study reporting zero R&D outlays for the year 1980, a log transformation could not be used. This is seemingly only a feasible alternative in the samples of the prior researchers which, for the most part, were restricted to larger firms that perform R&D. Moreover, Loeb and Lin in using a specification error approach to determine the best model for testing the Schumpeterian hypothesis found the non-logarithmic specification to be superior to the logarithmic one.[12]

The weighted least squares approach suggested by Lancaster was used in the present study.[13] The weights were calculated in the following manner:

(1) For each of the six R&D categories, the firms within each group were ranked in ascending order by sales.

(2) After the firms were ranked in sales order, they were sequentially divided into approximately twenty groups.

(3) Then, for each of the some twenty groups, the following OLS regressions were run for the firms within the group:

$$R\&D_i = B_o + B_1 S_i \qquad i = 1 \ldots \text{ within each group}$$

(4) The standard errors (SE) of the some twenty regressions obtained from step (3) were then run against the average sales for each of the groups. The following three alternate specifications were tested:

(a) $SE_k = B_1 S_k \qquad k = 1 \ldots 20$

(B) $SE_k = B_o + B_1 S_k \qquad k = 1 \ldots 20$

(C) $SE_k = B_o + B_1 S_k + B_2 S_k^2 \qquad k = 1 \ldots 20$

(5) Since the results of the runs with the squared term had the lowest standard error, this specification was selected to calculate the weights. The coefficients obtained from equation (C) for each technological opportunity group and the actual sales for each firm within the respective groups were used to calculate a fitted SE for each firm in the total sample. Thus, the weights were calculated in the following manner:

$$W_i = SE_i = \hat{B}_{oj} + \hat{B}_{1j} S_i + \hat{B}_{2j} S_i^2 \quad \text{where } j = 1 \ldots 6$$

$i = 1 \ldots$ total number of firms within each of the j technical opportunity groups.

Weighted Least Squares Regressions

Two sets of weighted least squares (WLS) for each of the six technological opportunity groups were run initially -- the first used zero proxies as the dependent variable for the firms reporting "insignificant" R&D outlays and the second excluded the 585 firms which reported that their R&D outlays were "insignificant." These results are reported in Tables III and IV, respectively.

A comparison of the results reported in Tables II and III demonstrates that correction for heteroscedasticity has an important effect on the interpretation of the results. In most cases, this correction results in a considerable reduction in the t-values. And, in a number of cases, coefficients which under the OLS are statistically significant become insignificant.

Moreover, a comparison of the WLS results shown on Tables III and IV underscores the fact that using convenient proxies -- substituting zeros or omitting the "insignificants" which account for more than 20% of the data set -- could result in some ambiguities or, perhaps, erroneous interpretations. For sample, t-values for a number of the technical opportunity groups -- e.g. the very high, low and very low groups --change from strongly significant to marginally significant when the "insignificants" are omitted. Depending on which one of these two alternate proxies is used for these particular groups, the interpretation of the WLS results varies from convincing support for the view that innovative output increases more than proportionately in relation to sales up to some inflection point to one in which there is only marginal support for this view. The use of both proxies results in ambiguity.

TABLE III

WLS EQUATIONS RELATING RESEARCH & DEVELOPMENT EXPENDITURES (R&D) TO FIRM SIZE (S) BY TECHNICAL OPPORTUNITY CLASS--"INSIGNIFICANTS" REPLACED WITH ZERO VALUES

	S	S^2	S^3
Very High	.0500 (31.6)		
	.0457 (20.9)	$.7730 \times 10^{-6}$ (2.8)	
	.0453 (19.6)	$.1302 \times 10^{-5}$ (1.5)	$-.3971 \times 10^{-10}$ (-0.6)
High	.0409 (2.0)		
	.0418 (1.9)	$-.8650 \times 10^{-6}$ (-0.1)	
	.0422 (1.8)	$-.1403 \times 10^{-5}$ (-0.1)	$.2869 \times 10^{-10}$ (.06)
Intermediate	.0234 (23.4)		
	.0171 (14.6)	$.1299 \times 10^{-5}$ (8.5)	
	.0166 (12.1)	$.2010 \times 10^{-5}$ (1.8)	$-.5065 \times 10^{-10}$ (-0.7)

Note: Values in parentheses are t statistics.

TABLE III (Continued)

Constant	$\bar{R}^2$	N	Number of Firms Reporting Insignificant R&D
.0266 (0.9)	.571	379	29
.0511 (1.7)	.578		
.0538 (1.8)	.578		
.0010 (.06)	.523	325	22
.0023 (.01)	.521		
-.0004 (-.002)	.520		
-.0071 (-0.2)	.480	342	40
.0563 (1.4)	.570		
.0688 (2.0)	.569		

TABLE III (Continued)

WLS EQUATIONS RELATING RESEARCH & DEVELOPMENT EXPENDITURES (R&D)
TO FIRM SIZE (S) BY TECHNICAL OPPORTUNITY CLASS--
"INSIGNIFICANTS" REPLACED WITH ZERO VALUES

	S	S^2	S^3
Low Intermediate	.0115 (18.0)		
	.0097 (10.7)	$.3858 \times 10^{-6}$ (2.9)	
	.0108 (9.0)	$-.3738 \times 10^{-6}$ (-0.7)	$.5527 \times 10^{-10}$ (1.4)
Low	.0051 (109.3)		
	.0068 (12.2)	$-.2146 \times 10^{-6}$ (-3.1)	
	.0065 (9.9)	$.1565 \times 10^{-6}$ (0.4)	$-.4101 \times 10^{-10}$ (-1.0)
Very Low	.0058 (46.8)		
	.0035 (9.6)	$.5405 \times 10^{-7}$ (6.7)	
	.0031 (8.1)	$.1740 \times 10^{-6}$ (4.4)	$-.2333 \times 10^{-11}$ (-3.1)

Note: Values in parentheses are t statistics.

TABLE III (Continued)

Constant	$\overline{R}^2$	N	Number of Firms Reporting Insignificant R&D
-.0649 (-0.6)	.359	306	82
.0261 (0.2)	.375		
-.0211 (0.2)	.377		
.0287 (1.1)	.976	280	87
.0072 (-0.3)	.977		
-.0008 (-0.3)	.977		
.0057 (0.3)	.642	1136	323
.0548 (2.4)	.655		
.0623 (2.7)	.658		

TABLE IV

WLS EQUATIONS RELATING RESEARCH & DEVELOPMENT EXPENDITURES (R&D) TO FIRM SIZE (S) BY TECHNICAL OPPORTUNITY CLASS-- "INSIGNIFICANTS" EXCLUDED

	S	S^2	S^3
Very High	.0514 (32.7)		
	.0483 (21.8)	$.5421 \times 10^{-6}$ (1.9)	
	.0481 (20.7)	$.7993 \times 10^{-6}$ (0.9)	$-.1992 \times 10^{-10}$ (-0.3)
High	.0402 (1.8)		
	.0411 (1.7)	$-.73087 \times 10^{-6}$ (-0.1)	
	.0414 (1.7)	$-.1177 \times 10^{-5}$ (-0.1)	$.2365 \times 10^{-10}$ (0.1)
Intermediate	.0244 (23.7)		
	.0183 (14.8)	$.1200 \times 10^{-5}$ (7.6)	
	.0182 (12.4)	$.1398 \times 10^{-5}$ (1.2)	$-.1404 \times 10^{-10}$ (-0.2)

Note: Values in parentheses are t statistics.

TABLE IV (Continued)

Constant	$\overline{R}^2$	N
.0511 (1.8)	.596	350
.0688 (2.3)	.599	
.0701 (2.3)	.598	
.0157 (0.1)	.521	303
.0091 (0.05)	.521	
.0067 (0.03)	.519	
.0319 (0.8)	.504	302
.1021 (2.7)	.583	
.1035 (2.7)	.581	

TABLE IV (Continued)

WLS EQUATIONS RELATING RESEARCH & DEVELOPMENT EXPENDITURES (R&D) TO FIRM SIZE (S) BY TECHNICAL OPPORTUNITY CLASS-- "INSIGNIFICANTS" EXCLUDED

	S	S^2	S^3
Low Intermediate	.0125 (17.3)		
	.0114 (10.7)	$.2158 \times 10^{-6}$ (1.4)	
	.0137 (9.5)	$-.1223 \times 10^{-5}$ (-2.0)	$.1030 \times 10^{-10}$ (2.4)
Low	.0051 (98.7)		
	.0095 (14.4)	$-.5454 \times 10^{-6}$ (-6.6)	
	.0094 (12.1)	$-.4643 \times 10^{-6}$ (-1.1)	$-.8838 \times 10^{-11}$ (-.2)
Very Low	.0060 (42.5)		
	.0051 (10.2)	$.2053 \times 10^{-7}$ (1.9)	
	.0049 (9.1)	$.8552 \times 10^{-7}$ (1.7)	$-.1251 \times 10^{-12}$ (-1.3)

Note: Values in parentheses are t statistics.

TABLE IV (Continued)

Constant	$\bar{R}^2$	N
.1410 (1.0)	.361	224
.1974 (1.4)	.364	
.0990 (0.7)	.377	
.1009 (3.0)	.980	193
.0125 (0.4)	.984	
.0140 (.4)	.983	
.0545 (1.9)	.668	840
.0721 (2.4)	.669	
.0766 (2.6)	.669	

Censored Data Algorithm

In order to clarify these ambiguities, it is necessary to include estimated values of the so-called "insignificants" in the analysis. Although the SEC for 10K reporting purposes permits R&D expenditures which are greater than 0 but equal to or less than 1% of sales to be designated as insignificant, these values are definitely not immaterial in the context of the present study. One percent of sales is a large absolute dollar amount for many of the firms in the sample set. The 585 firms reporting "insignificant" R&D outlays account for 21% of the total sample and within the six groups, the "insignificants" range from 7% of the high technological opportunity groups to nearly 30% of the very low group.

The Schmee-Hahn iterative least squares technique, which is a specific application of the Dempster, Laird, Rubin EM Algorithm, was used to take proper account of the "insignificants" -- the censored values.[14] This method was selected because it has good convergence properties and is a rather straightforward method of handling a censored data problem. Although the technique described in the Schmee-Hahn article was based on a particular example of a simple linear model with normally distributed random variation and censoring to the right, the authors note that their procedure:

> . . . is not limited to any special form of relationship and can be applied to multiple regression or, more generally, to any situation for which least squares procedures are used.[15]

Two modifications were required to adapt the specific case described by Schmee-Hahn to the present problem. First, the present problem involves censoring to the left -- all the censored values are assumed to be equal to or less than 1% of sales -- in contrast with the "right" censoring described in the Schmee-Hahn example.[16] Secondly, since sigma is rather large and likely to assign meaningless negative values to R&D for censored values, a log normal distribution was assumed. Based on examinations of the fitted censored observations and absolute values of the residuals over certain ranges of sales, this appears to be an appropriate assumption.[17] The derivation of the specific version of this censored data algorithm, which was adapted to the particular requirements of my empirical study and developed in conjunction with Dr. Daniel O'Reilly, Manager of Mathematical and Statistical Applications for Data Resources Inc., is shown in Appendix B.

The resultant censored data iterative least squares procedure is as follows:

Iteration 0

Step $I^{(0)}$: The R&D and sales are fit to equation (1) using the previously described weighted least squares regression analysis. The censored observations are set at 1% of sales -- the upper limit. Then the $\hat{b}_0^{(0)}$, $\hat{b}_1^{(0)}$, $\hat{b}_2^{(0)}$, $\hat{b}_3^{(0)}$ and $\hat{\sigma}^{(0)}$ derived from this regression are used to obtain the initial estimates for

b_o, b_1, b_2, b_3 and σ , respectively.

Step II$^{(0)}$: The initial regression results fit from Step I$^{(0)}$ are used to calculate the expected value of each censored observation. The expected values for the censored $R\&D_i^{(0)}$ observations -- derived from equation (1a) on page two of Appendix B -- are calculated as follows:

$$E(R\&D_i)^{(0)} = R\&D_i^{(0)} \; (F_2/F_1)$$

where:

$R\&D_i^{(0)}$ = The fitted R&D expenditures obtained for firm i using

$b_0^{(0)}$, $b_1^{(0)}$, $b_2^{(0)}$, $b_3^{(0)}$

$$F_1 = \Phi \left((\ln c - \mu) / \sigma \right)$$

$$F_2 = \Phi \left(\frac{(\ln c - \mu)}{\sigma} - \sigma \right)$$

Φ = The standard normal cumulative probability function
c = .01(S)

The values of σ and μ used in computing F_1 and F_2 represent the solutions to equations (2a) and (3a) shown on page three of Appendix B. The solutions are:

$$\sigma = \sqrt{\ln\left(\hat{\sigma}^{(0)} + R\&D_i^{(0)2}\right) - 2 \ln R\&D_i^{(0)}}$$

$\hat{\sigma}^{(0)}$ = Standard error squared of the regression results from Step I

$$\mu = \ln R\&D_i^{(0)} - \sigma^2/2$$

Iteration I

Step $I^{(1)}$: Repeat the least squares procedure replacing the censored values with $E(R\&D_i)^{(0)}$ computed in Step $II^{(0)}$. Then the $\hat{b}_0^{(1)}$, $\hat{b}_1^{(1)}$, $\hat{b}_2^{(1)}$, $\hat{b}_3^{(1)}$ and $\hat{\sigma}^{(1)}$ derived from this regression are used to obtain new estimates for b_o, b_1, b_2, b_3 and σ , respectively.

Step $II^{(1)}$: Use the above parameter estimates to obtain new estimates of the censored observations $E(R\&D_i)^{(1)}$ following the same procedure as in Step $II^{(0)}$.

Further iterations are carried out until convergence, which is defined by a maximum absolute change in each of the four coefficients not exceeding the prescribed tolerance of .001. One group -- the very high technology group -- was also run with a prescribed tolerance of 1×10^{-9}. This produced essentially the same results, although the number of iterations necessary for convergence was about double.

The WLS regressions were recalculated for each of the six technical opportunity groups using this algorithm. These results are reported in Table V. Using the prescribed tolerance, convergence was obtained within three to five iterations in all of the runs and all of the replacement values are greater than zero and less than 1% of sales. The final estimates possess the following properties: they are consistent but biased estimators and, as the sample size increases, they approa.. Maximum Likelihood estimates.[18]

TABLE V

WLS EQUATIONS RELATING RESEARCH & DEVELOPMENT EXPENDITURES (R&D) TO FIRM SIZE (S) BY TECHNICAL OPPORTUNITY CLASS--VALUES FOR "INSIGNIFICANTS" ESTIMATED WITH CENSORED DATA ALGORITHM

	S	S^2	S^3
Very High	.0517 (22.8)		
	.0411 (9.2)	$.1082 \times 10^{-5}$ (2.7)	
	.0391 (8.0)	$.1989 \times 10^{-5}$ (2.0)	$-.6119 \times 10^{-10}$ (-1.0)
High	.0414 (18.9)		
	.0414 (18.9)	$-.3433 \times 10^{-5}$ (-0.5)	
	.0414 (18.9)	$-.4780 \times 10^{-4}$ (-0.5)	$.7668 \times 10^{-10}$ (0.2)
Intermediate	.0294 (19.0)		
	.0131 (4.8)	$.1549 \times 10^{-5}$ (6.9)	
	.0126 (4.2)	$.2108 \times 10^{-5}$ (1.9)	$-.3874 \times 10^{-10}$ (-0.5)

Note: Values in parentheses are t statistics.

TABLE V (Continued)

Constant	$\bar{R}^2$	N	Number of Firms Reporting Insignificant R&D
-.0394 (-0.5)	.578	379	29
.1815 (1.7)	.585		
.2189 (1.9)	.589		
.8508 (1.2)	.527	325	22
.9354 (1.3)	.524		
.9427 (1.3)	.523		
-.4553 (-4.6)	.519	342	40
.2926 (2.1)	.579		
.3079 (2.2)	.578		

TABLE V (Continued)

WLS EQUATIONS RELATING RESEARCH & DEVELOPMENT EXPENDITURES (R&D) TO FIRM SIZE (S) BY TECHNICAL OPPORTUNITY CLASS--VALUES FOR "INSIGNIFICANTS" ESTIMATED WITH CENSORED DATA ALGORITHM

	S	S^2	S^3
Low Intermediate	.0127 (13.7)		
	.0100 (6.9)	$.3299 \times 10^{-6}$ (2.2)	
	.0122 (6.9)	$-.7290 \times 10^{-6}$ (-1.4)	$.7441 \times 10^{-10}$ (2.0)
Low	.0051 (123.4)		
	.0087 (8.5)	$-.4400 \times 10^{-6}$ (-3.5)	
	.0080 (6.7)	$-.8806 \times 10^{-7}$ (-0.2)	$-.3446 \times 10^{-10}$ (-0.9)
Very Low	.0060 (46.7)		
	.0041 (8.6)	$.4000 \times 10^{-7}$ (3.9)	
	.0037 (7.0)	$.1371 \times 10^{-6}$ (3.3)	$-.1812 \times 10^{-11}$ (-2.4)

Note: Values in parentheses are t statistics.

TABLE V (Continued)

Constant	$\bar{R}^2$	N	Number of Firms Reporting Insignificant R&D
-.0780 (-1.0)	.385	306	82
.0482 (0.5)	.397		
-.0107 (-0.1)	.403		
.3343 (6.3)	.982	280	87
-.0287 (-0.2)	.983		
.0187 (0.1)	.983		
-.0394 (-1.3)	.664	1163	323
.0603 (1.5)	.667		
.0823 (2.0)	.668		

Results After Adjusting for Censored Data Problem

The WLS results with the censored data algorithm eliminate some of the potential ambiguities which are inevitable when arbitrary proxies are used -- as was the case with the results reported on Tables III and IV -- for a large proportion of the sample set. The R-bar-squared values and the values for the coefficients of the independent variables are essentially the same under the three approaches and the signs are identical. But in some cases, there were important differences among the t-values under various alternatives. Table VI was supplied to facilitate comparisons among the t-values.[19]

In the very high group,for example, with the censored data algorithm the squared term in the cubic equation is significant, while it is insignificant when the alternative approaches are used. The results are also improved for the high group by the censored data algorithm. In this instance, the sales to the first power term is highly significant when the censored data algorithm is used but it is only marginally significant when the alternative approaches are employed. Even though the results in the case of the intermediate group are similar under each of the three approaches, the censored data algorithm results clear up the ambiguity reflected on Tables III and IV. They suggest that the squared term in the cubic specification is significant. In the case of the low intermediate group, the results of the censored data algorithm suggest that the sales-squared coefficient is significant -- once again arbitrating the contrasting

TABLE VI

COMPARISON OF T STATISTICS AMONG THREE WLS APPROACHES

Group	I Insignificants Zeros			II Insignificants Eliminated		
	S	S^2	S^3	S	S^2	S^3
Very High	31.6			32.7		
	20.9	2.8		21.8	1.9	
	19.6	1.5	-0.6	20.7	0.9	-0.3
High	2.0			1.8		
	1.9	-0.1		1.7	-0.1	
	1.8	-0.1	0.6	1.7	-0.1	0.1
Intermediate	23.4			23.7		
	14.6	8.5		14.8	7.6	
	12.1	1.8	-0.7	12.4	1.2	-0.2
Low Intermediate	18.0			17.3		
	10.7	2.9		10.7	1.4	
	9.0	-0.7	1.4	9.5	-2.0	2.4
Low	109.2			98.7		
	12.1	-3.1		14.4	-6.6	
	9.9	0.4	-0.1	12.1	-1.1	-0.2
Very Low	46.8			42.5		
	9.6	6.7		10.2	1.9	
	8.1	4.4	-3.1	9.1	1.7	-1.3

TABLE VI (Continued)

III Insignificants Estimated		
$\underline{S}$	$\underline{S}^2$	$\underline{S}^3$
22.8		
9.2	2.7	
8.0	2.0	-1.0
18.9		
18.9	-0.5	
18.9	-0.5	0.2
19.0		
4.8	6.9	
4.2	1.9	-0.5
13.7		
6.9	2.2	
6.9	-1.4	2.0
123.4		
8.5	-3.5	
6.7	-0.2	-0.9
46.7		
8.6	3.9	
7.0	3.3	-2.4

results in the case of the two alternative specifications. In the case of the results from the cubic specification, the t-value on the squared term of -1.4 is about half-way between the two alternatives and only marginally significant. The results for the low group are similar under each of the three alternatives. Lastly, in the case of the very low group, the censored data algorithm suggests that the squared term is positive and significant, while the cubic term is negative.

Inferences From Principal Empirical Results

In the very high technological opportunity group, innovation appears to increase more than proportionately with firm size up to $11 billion in sales. As shown on Table VII, the sales of all but the two largest firms in the group are below this level and the finding of a non-linear relationship between innovative output and firm size appears to be economically significant. Using the coefficients obtained from the censored data algorithm for each of the three specifications tested, at the maximum sales level the estimated R&D outlays with the quadratic specification is some $500 million or one-third higher than with the linear specification. At the inflection point, the R&D estimates calculated with both the quadratic and cubic specifications are more than one-fifth above the level obtained with the linear specification. Thus, the behavior of the very high technical opportunity group, which includes industries such

TABLE VII

SUMMARY OF INFERENCES ON THE RELATIONSHIP BETWEEN FIRM SIZE AND R&D OUTLAYS*

Group	Inference	Inflection Point	Firms Above Inflection	
		$ Millions	No.	% of Group
Very High	Increasing Up to Point	10,800	2	0.5
High	Linear	-	-	-
Intermediate	Increasing Up to Point	18,100	0	0
Low Intermediate	Increasing Above Point But Based On Low t-value -1.4 on squared term -- could be increasing throughout		21	6.9
Low	Decreasing Throughout	-	-	-
Very Low	Increasing Up to Point	25,200	22	0.9

* Based on results from Table V - the censored data algorithm.

N.S. - Not Significant

TABLE VII (Continued)

Maximum Sales	Estimated R&D At Maximum Sales* Linear Specification	Quadratic Specification	Cubic Specification
	($ Millions)		
26,213	1,355	1,821	1,290
57,729	2,390	N.S.	N.S.
13,780	402	470	469
13,818	175	201	226
12,492	64	40	N.S.
103,143	619	848	148

as aircraft and missiles, office equipment and electronic components seems to conform with the underlying hypothesis. It follows the Schumpeterian hypothesis and it presumably includes a group of industries in which R&D is complex, requiring a diversity of skills and a considerable financial commitment.

The finding of a linear relationship between innovative output and firm size for the high technological opportunity group is more difficult to explain in the context of the Schumpeterian hypothesis, or even in the context of the more flexible view of Nelson, Peck and Kalachek. This is the only one of the six industrial groupings in which R&D outlays do not appear to be proportionately affected by variations in firm size. My initial supposition was that the auto industry -- a mature industry with high R&D expenditures -- was responsible for this linear relationship. But I have run the censored data algorithm for this group, excluding the forty-seven firms in the auto industry, and a linear relationship was still obtained.[20]

The finding of increasing returns to scale in the intermediate group follows the hypothesized pattern. Large firms in industries such as industrial chemicals, heavy machinery and electronic equipment appear to have an advantage in innovation over their smaller counterparts. Presumably they can afford to employ a diversity of R&D skills and purchase costly equipment.

The results for the low intermediate group provide some support for the Schumpeterian hypothesis. But once again the way in which this hypothesis applies seems to depend upon the industrial composition of the group. When the censored data algorithm is run without the cubic term, it appears that innovative output increases more than proportionately with firm size in this group. However, when it is run with the cubic specification, it appears that there may be decreasing returns to scale for most of the firms in the group but increasing returns for the largest twenty-one firms. This may reflect the fact that smaller firms in industries such as food, which presumably do not require costly equipment for R&D, may predominate in innovation, while the firms in the consumer chemical industry may be more than proportionately responsible for technical progress.

The low technological opportunity group is the only category in which the smaller firms clearly seem to be more innovative, on a proportionate basis, than larger firms. Although the results with the cubic specification were insignificant, the results with the non-linear model with a squared term imply decreasing returns to scale. These findings suggest that in industries such as ferrous metals, fabricated metal products and paper, ingenuity is more important than costly equipment. These results are consistent with the findings of Mansfield.[21] And, finally, in the very low technology group my results suggest that in industries such as petroleum refining and textiles large firms, at least up to the $25 billion level, are more than proportionately innovative.

Thus, with the use of a comprehensive data set and some important refinements in statistical techniques, I believe that considerable evidence has been brought forth to show that in many industrial settings innovative output increases more than proportionately with firm size. This relationship, however, does not apply universally, as Schumpeter's most ardent disciples contend. There are some industrial settings in which small firms are proportionately more innovative than large firms. My technological opportunity groups may not be homogeneous enough to provide convincing support for the hypothesis that large firms are responsible for more than their proportionate share of technological progress in industries in which R&D is complex, while small firms predominate in industries in which ingenuity is more important. I believe, however, that my results are, for the most part, consistent with this view.

FOOTNOTES - CHAPTER IV

[1]Since January 1, 1975 uniform standards have been in effect for the reporting and disclosure of R&D outlays. The Financial Accounting Standards Board defines R&D as follows:

> a) Research in planned search or critical investigation aimed at discovery of new knowledge with the hope that such knowledge will be useful in developing a new product or service . . . or a process or technique . . . or in bringing about a significant improvement to an existing product or process.
>
> b) Development is the translation of research findings or other knowledge into a plan or design for a new product or process for a significant improvement to an existing product or process whether intended for sale or use.
>
> The costs include the following:
>
> a) Materials, equipment and facilities. The cost of such materials consumed in research and development activities and the depreciation of such equipment or facilities used in those activities are research and development costs.
>
> b) Costs of personnel engaged in R&D activities.
>
> c) Intangibles purchased from others.
>
> d) Contract services.
>
> e) Indirect costs.

Disclosure is made in the financial statement in each period for which an income statement is presented.

Statement of Financial Accounting Standards No. 2: Accounting for Research and Development Costs (Stamford, Connecticut : Financial Accounting Standards Board, October 1974), pp. 2-7.

FOOTNOTES - CHAPTER IV

[2] Nelson, Peck and Kalachek, Technology Economic Growth and Public Policy, pp. 55-58.

[3]Since the issuance of Statement No. 2 firms are required to report on R&D outlays in their 10K reports filed with the S.E.C.

[4]These studies are discussed in Chapter III of this paper starting on page 34 under the heading: R&D Expenditures and R&D Employment -- Surrogates for Innovations.

[5]In an earlier version of this paper I attempted to use measures of innovative output to test the applicability of the Schumpeterian hypothesis to the auto industry. In this regard a list of innovations was compiled and patent data were collected.

Considerable effort was expended in gathering a list of innovations. Trade publications were reviewed, thirty major automotive firms were contacted through a mail survey as well as follow-up telephone calls, and interviews were conducted with a number of executives of General Motors Corporation directly involved in R&D as well as a representative of the Society of Automotive Engineers. This effort yielded a comprehensive list of innovations for the four principal U.S. manufacturers of passenger cars -- these are the firms that are covered extensively in the trade publications. It was only possible to obtain extensive data on innovations for three other automotive firms, however -- Borg Warner, Dana Corporation and TRW. In total, the resultant list included some 300 technological advances by these seven firms over an eighteen-year span.

Patent data, which are more accessible, were also collected for thirty-five automotive firms for the years 1975 and 1976. These results suggested, however, that either the corporations surveyed were patenting many meaningless inventions or, despite all of my time-consuming efforts and cross-checking, that my innovation survey was severely deficient. For example, based on my innovation survey, in 1976 six innovations were attributed to General Motors, but in that same year the firm was granted 395 patents.

FOOTNOTES - CHAPTER IV

I discussed this considerable dichotomy with Gene Christen -- the Associate Director of General Motors' Patent Section. He indicated that a small part of the gap between patent data and lists of innovations might be explained by the fact that some firms place multiple patents on single inventions. But Christen -- in accord with Schmooker's view -- indicated that the patent data were picking up a number of subtle, but economically important innovations, which are not included in the typical list of innovations. He stressed also that all patents, at least in the case of his corporation, were for products and processes of economic significance.

This experience with gathering data on innovations has indicated quite forcefully to me that a list of innovations is not likely to be comprehensive. Large firms are more likely to be included than smaller firms and epochal innovations are more likely to be included than minor innovations.

[6]The seeming higher propensity to patent of smaller firms vis-a-vis larger firms is discussed in Chapter III of this paper in the section entitled Patents As a Measure of Innovations, pp. 30-33.

[7]The measurement of firm size in prior empirical studies is discussed further on pages 36 and 37 in Chapter III.

[8]Scherer, "Firm Size, Market Structure, Opportunity and the Output of Patented Innovation" : 448; Mansfield et al., The Production and Application of New Industrial Technology, p. 51.

[9]William S. Comanor, "Market Structure, Product Differentiation, and Industrial Research," The Quarterly Journal of Economics 81 (November 1967) : 640; Scherer, "Firm Size, Market Structure, Opportunity, and the Output of Patented Innovations" : 1102-1103.

[10]The National Science Foundation (NSF) in its 1978 Survey of Industrial Research and Development collected extensive information on 11,500 firms -- 4,500 of which have more than 1,000 employes and 7,000 are smaller firms. All manufacturing industries are represented in the sample and those nonmanufacturing industries known, on the basis of earlier, more detailed samples, to conduct or to finance research and development. Based on this information, the NSF has set up a classification scheme which uses two, three and, in a few instances, four digit SIC codes to group industries with similar R&D behavior and technological opportunity.

FOOTNOTES - CHAPTER IV

[11]Domar Gujarati, Basic Econometrics (New York: McGraw-Hill Book Company, 1978) : 207.

[12]Peter D. Loeb and Vincent Lin, "Reseach and Development in the Pharmaceutical Industry: A Specification Error Approach," Journal of Industrial Economics 26 (September 1977) : 45-51.

[13]Tony Lancaster, "Grouping Estimators on Heteroscedastic Data," Journal of the American Statistical Association 63 (March 1968) : 182-191.

[14]Josef Schmee and Gerald J. Hahn, "A Simple Method for Regression Analysis With Censored Data," Technometrics 21 (November 1979) : 417,432; A. P. Dempster, N. M. Laird and D. B. Rubin, "Maximum Likelihood from Incomplete Data via The EM Algorithm," Journal of the Royal Statistical Society B-39 (1977) : 1-22.

[15]Schmee and Hahn, " A Simple Method for Regression Analysis With Censored Data" : 429.

[16]The Schmee-Hahn procedure was specifically designed for right-hand censoring. In quality testing unfailed units frequently remain at the end of the test. This type of problem is common in the physical sciences.

[17]The Lilliefors graphic test was performed on the lowest 25% of the firms based on sales within the group. R. L. Iman, "Graphs For Use With The Lilliefors Test For Normal and Exponential Distributions," American Statistician 36 (May 1982) : 109-112.

[18]Schmee and Hahn performed an extensive simulation analysis comparing the properties of the iterative least squares procedure with those of maximum likelihood. Fourteen different conditions were tested with at least 1,000 runs at each condition and in some cases as many as 10,000 runs were performed. The results of these tests demonstrate that the iterative least squares method and the method of maximum likelihood yielded very similar results and they support the contention of Dr. O'Reilly -- noted in Appendix B -- that: "as the sample size increases . . . we will be dealing with ML estimates." Schmee and Hahn, "A Simple Method for Regression Analysis With Censored Data" : 422-429.

FOOTNOTES - CHAPTER IV

[19]As noted previously, the assumption of a log normal distribution in the censored data algorithm appears to be appropriate on a pragmatic and an empirical basis. When the censored data algorithm was run with a normal rather than a log normal distribution, many of the replacement values for the firms reporting insignificant R&D were negative. From a pragmatic point of view, these estimates are unacceptable since it would be impossible for a significant proportion of any group or even for any firm to have negative R&D outlays. And based on the results of the Lilliefors tests -- referenced above in note 17 -- the assumption of a log normal distribution, at least for the lower end of the sample range, appears appropriate from an empirical perspective.

The T values, however, reported in Tables V and VI are based on the assumption of a normal distribution, this inconsistency implies that these values are bias. But given the comparatively high T values for the S-squared coefficients for most groups -- at least in the case of the quadratic specification -- the overall conclusion that there is a non-linear relationship between the propensity to innovative and firm size appears to be appropriate for most of the technical opportunity groups. For example, in the case of the low group, the T value for the squared term with the quadratic specification is -3.5 when the censored data algorithm is run with the assumption of a log normal distribution and -3.2 when a normal distribution is assumed. A bias of this magnitude does not affect the overall interpretation of the results.

[20]More refined industrial analysis than would be compatible with the level of aggregation in this study is probably necessary to explain the linear relationship for the high technology opportunity group.

[21]Mansfield, Industrial Research and Technological Innovation, p. 108.

CHAPTER V

EXTENDING BEYOND THE PRESENT STUDY

Underpinnings of the Present Study

The role of large and small firms in technical progress has been discussed from a number of perspectives in this paper. At the most basic level, random observations of the origins of some key innovations were cited to underscore that indiscriminate generalizations, which claim that either large or small firms are singularly responsible for technical progress, are groundless. The Xerox Copying Machine, Polaroid Camera and Apple Computer were developed by small firms, while color television, nylon and many of the innovations necessary for the Apollo Project were nurtured by large firms. The study extends beyond these random observations and looks systematically at more substantive issues: (i) whether large or small firms are proportionately more innovative; (ii) possible variations in the relationship between firm size and the propensity to innovate among different industrial categories; and (iii) in industrial groups in which there are economies or diseconomies of scale in R&D, it specifies the point at which they occur.

At the theoretical level, a number of credible arguments have been advanced which suggest that, at least in some industries, large firms may have an advantage over small firms in innovation. These arguments essentially reflect the view that large firms with their considerable financial, physical and human resources are in a better position than their smaller counterparts to develop and market new products and processes. Moreover, it is sometimes inferred that big firms have a further edge in that they can spread the costs of process innovations and government regulations over a larger number of units. These presumed attributes of bigness are, of course, subject to challenge. The bureaucratic operating procedures of a large enterprise many offset the advantages of size, while large firms with heavy investment in high production standardized equipment may be prone to resist change.

To a large extent, the relevance of the arguments advanced in favor of large firms depends upon whether small entrepreneurs and inventors can readily obtain the financial, technical and marketing skills in the marketplace which large firms presumably have in house. Ultimately, these questions must be analyzed empirically. This is particularly true in the case of my hypothesis which maintains that the relationship between innovative output and firm size is not constant across all industries.

Possible Directions for Further Study

The empirical findings presented in this paper suggest that technical progress increases more than proportionately with firm size in many, but not in all, industries. Once the data set is expanded beyond the confines of the FORTUNE 500 firms, it becomes increasingly apparent that the chemical industry is not, as Kamien and Schwartz suggest, the only industry to which the Schumpeterian hypothesis applies.[1]

Although the current empirical analysis includes many important improvements which distinguish it from prior efforts, much remains to be accomplished. It would be preferable to measure innovative output directly rather than through a surrogate. But given the fact that R&D expenditures appear to be a reasonable proxy for technical progress and the formidable nature of the barriers that would be encountered in directly measuring innovative output for a comprehensive data set, this does not appear to be a fertile area in which to look for further improvements.

Similarly, in place of assigning industries to technical opportunity groups it might be desirable to develop a more precise procedure to control non-size variables which may affect innovative output. While this refinement appears to be eminently more practical than trying to measure innovative output directly, prior researchers have not had any meaningful success with efforts in this direction. The highest payoff for further research might come at the micro level. Work at this level could be used to explore if, indeed, our findings of more than proportionate increases in R&D outlays as firm size increases in many industries -- up close to the size of the largest firms -- are related to the commonly advanced hypotheses explaining why large size firms might predominate in innovation. By the same token, it would be of interest to determine if ingenuity -- as Freeman contends -- is more important than considerable resources for technical progress in the low technical opportunity group.[2]

Implications for Public Policy

The present study focused on an important facet of the industrial environment most conducive to technical progress -- the relationship between firm size and innovative output for various technical opportunity groups. This is, of course, not the only public policy issue associated with innovation. A confluence of factors, such as the educational system, tax and patent policies as well as antitrust and trade policies, affect the rate of technical progress.

But particularly in the United States, where responsibility for technical progress rests largely with the individual firm and its management, it is critical that industrial policies, at a minimum, do not inhibit the firm and its management from effectively discharging this important function.[3] Flexible antitrust policies, which take account of the complementary role of large and small firms in the innovative process, are vital.

Bigness alone does not assure success. Exxon, the world's largest corporation in terms of sales, has been unsuccessful thus far in its well-financed foray into the office equipment market. But large enterprises definitely seem to excel at the more complex tasks. Bell Laboratories, which has been the source of breakthroughs in lasers, radar, transistors, digital computing, satellites, software operating systems and countless other technologies, appears to be an example of synergism in R&D. It is unlikely that society would benefit if the annual $2 billion budget of Bell Laboratories and its some 25,000 employes were allocated among smaller units.

Moreover, even the so-called older smokestack industries, as they adapt to an increasingly competitive global marketplace, are likely to require large R&D commitments which may favor bigness. For example, the Group Vice President in charge of R&D for General Motors recently pointed out that innovation in the process technology -- an area where U.S. manufacturers must make significant progress to remain competitive -- is much more demanding than product technology. He noted that it is much more costly and complex to make significant advances in a multi-million dollar stamping press than in a $50 carburetor.

The empirical results of the present study and these examples appear to refute the conclusions drawn from most of the prior tests of the Schumpeterian hypothesis and the conventional wisdom that small organizations are singular founts of technical progress. The findings of this study suggest that policymakers must discreetly evaluate the specifics in each competitive and industrial situation. Rules of thumb which arbitrarily endorse bigness or smallness could be costly.

In fact, in this regard there is some evidence that policymakers may be a step ahead of much of the prior empirical results in their understanding of the relationship of technical progress and firm size. There are some signs that U.S. policymakers are advocating a more permissive attitude toward large firms and R&D joint ventures in certain circumstances. Although U.S. firms cannot share the burden of R&D the way Japanese firms do without basic revisions of antitrust law, the Justice Department has recently indicated that it will not block such ventures, provided they stick to basic research and put no strings on how the members of the venture use the results.[4]

In sum, with technical progress the wellspring of per capita income growth, a linchpin for improvement in the quality of life and an integral component of our national defense system, fostering an environment conducive to innovation is a significant issue for economic researchers and public policymakers. The hypothesis tested and the statistical tools employed appear to provide some meaningful improvements over prior studies. Based on the breadth of the sample set and the improved statistical techniques employed -- directly addressing the heteroscedasticity and censored data problems -- the results of the current study are less tentative than those of prior researchers and better suited to deriving inferences about the interindustry differences which seem to be inherent in the relationship between firm size and innovation.

FOOTNOTES - CHAPTER V

[1]Kamien and Schwartz, Market Structure and Innovation, p. 84.

[2]Freeman, The Economics of Industrial Innovation, p. 141. And to facilitate the work of subsequent empirical researchers, the raw data -- unweighted sales and R&D data by technical opportunity group as well as the weights used for each of the 2,795 firms included in the sample set -- are shown in the Statistical Addendum.

[3]International Competition in Advanced Technology: Decisions for America, by Howard W. Johnson, Chairman : A Consensus Statement Prepared by the Panel on Advanced Technology Competition and Industrialized Allies : Office of International Affairs National Research Council (Washington, D.C. : National Academic Press, 1983), p. 53.

[4]"A Government Nudge for Joint Research," Business Week, December 22, 1980, p. 30B.

Appendix A

TABLE VIII

REGRESSION RESULTS USED TO ASSIGN INDUSTRIES TO TECHNICAL OPPORTUNITY GROUPS*

Classification	SIC Code	Total[1]	Sample Size: Total Less NAs[2]	Sample Size: Number of Insignificants[3]
1. Food and Kindred Products[4]	20	173	91	31
1A.[4]				
2. Textiles & Apparel	22,23	181	88	44
2A.				
3. Lumber, Wood Products & Furniture	24,25	109	53	21
3A.				
4. Paper & Allied Products	26	63	46	15
4A.				
5. Industrial Chemicals	281, 82,86	24	21	2
5A.				
6. Drugs & Medicines	283	55	52	0
6A.				
7. Other Chemicals	284, 5,7, 8,9,	97	74	7
7A.				
8. Petroleum Refining	29	65	34	6
8A.				
9. Rubber Products	30	109	73	18
9A.				

* Results of regressions - R&D Sales ($R\&D_j = a_1 + a_2 S_j + e_j$)

Appendix A

TABLE VIII (Continued)

Sample Size	Output				
Total less	a_1		a_2		
Insignificants	Coefficient	t-Value	Coefficient	t-Value	R^2
60	-7.64	-3.0	.01099	14.8	.79
	-5.52	-3.3	.01045	17.6	.77
44	.6598	1.9	.0022	3.9	.24
	.2712	1.4	.0015	4.2	.16
32	-.3003	-.55	.0103	16.8	.90
	-.0750	-.11	.0066	8.1	.55
31	-.5978	-.37	.0070	7.0	.61
	-.1481	-.15	.0071	9.5	.66
19	-.8132	-.25	.0233	7.7	.76
	-1.1517	-.39	.0234	8.3	.77
52	2.966	.66	.0484	13.8	.79
67	-.2471	-.18	.0187	22.44	.88
	-.3622	-.29	.0188	23.77	.89
28	1.716	.15	.0041	11.31	.82
	0.179	.02	.0042	13.17	.84
55	-.3854	-.48	.0191	37.1	.96
	-.7374	-1.2	.0191	41.3	.96

Appendix A

TABLE VIII (Continued)

REGRESSION RESULTS USED TO ASSIGN INDUSTRIES TO TECHNICAL OPPORTUNITY GROUPS*

Classification	SIC Code	Total[1]	Sample Size: Total Less NAs[2]	Sample Size: Number of Insignificants[3]
10. Stone, Clay & Glass	32	68	45	18
10A.				
11. Ferrous Metals & Products	331-32, 3398-99	71	37	14
11A.				
12. Nonferrous Metals & Products	333-36	34	23	8
12A.				
13. Fabricated Metal Products	34	198	131	32
13A.				
14. Office Computing & Acc. Machinery	357	160	152	8
14A.				
15. Other Non-Electrical Machinery	351-56, 58-59	267	214	26
15A.				
16. Radio & TV Receiving Equipment	365	34	21	3
16A.				
17. Communication Equipment	366	135	122	9
17A.				
18. Electronic Components	367	132	113	16
18A.				

* Results of regressions - R&D SALES ($R\&D_j = a_1 + a_2 S_j + e_j$)

Appendix A

TABLE VIII (Continued)

Sample Size Total less Insignificants	Output a_1 Coefficient	t-Value	a_2 Coefficient	t-Value	$\bar{R}^2$
27	1.6102	0.5	.0128	4.8	.46
	.1548	0.9	.0131	6.7	.50
23	1.2632	1.3	.0049	19.3	.94
	-.3381	-.4	.0048	15.6	.87
15	-1.1740	-0.4	.0105	9.2	.85
	-1.2495	-0.8	.0106	12.7	.88
99	.2103	1.6	.0089	34.6	.94
	-.0498	-0.3	.0086	34.6	.90
144	1.2566	1.3	.0583	142.1	.99
	1.2056	1.3	.0583	143.6	.99
188	-1.8572	-2.3	.0241	31.1	.84
	-1.8005	-2.5	.0240	33.1	.84
18	.1794	.03	.0335	18.3	.95
	-.4343	-.07	.0335	20.6	.95
113	.2802	.19	.0471	35.0	.92
	.2229	.16	.0471	36.5	.92
97	.0468	.05	.0494	25.2	.87
	-.1721	-.22	.0495	27.2	.87

TABLE VIII (Continued)

REGRESSION RESULTS USED TO ASSIGN INDUSTRIES TO TECHNICAL OPPORTUNITY GROUPS*

Classification	SIC Code	Total[1]	Sample Size: Total less NAs[2]	Sample Size: Number of Insignificants[3]
19. Other Electrical Equipment	373-75, 379	104	86	9
19A.				
20. Motor Vehicles	371	69	47	7
20A.				
21. Other Transportation Equipment	373-75, 379	28	13	5
21A.				
22. Aircraft & Missiles	372,376	37	28	6
22A.				
23. Scientific & Mechanical Measuring Instruments	381-82	115	104	6
23A.				
24. Optical, Surgical, Photographical & Other Instr.	383-87	102	86	4
24A.				
25. Other Manufacturing	21,27, 31,39	246	128	55
25A.				
26. Non-Manufacturing	7-17,41-67,737, 739,807 891	2646	913	215
26A.				
Total		5322	2795	585

* Results of regressions - R&D SALES ($R\&D_j = a_1 + a_2 S_j + e_j$)

TABLE VIII (Continued)

Sample Size Total less Insignificants	Output a_1 Coefficient	 t-Value	 a_2 Coefficient	 t-Value	 $\overline{R}^2$
77	.3880	.27	.0216	9.5	.54
	.2038	.16	.0217	10.2	.55
40	-24.2	-2.6	.0403	49.0	.98
	-21.9	-2.8	.0402	52.7	.98
8	-1.064	-1.7	.0100	16.4	.97
	-1.825	-1.6	.0090	6.7	.79
22	-29.1	-1.3	.0576	10.4	.84
	-22.7	-1.4	.0567	12.1	.84
98	.1386	.18	.0463	16.1	.73
	.0597	.08	.0462	16.5	.73
82	-2.202	-1.52	.0496	50.1	.97
	-2.103	-1.52	.0496	51.4	.97
73	-1.717	-3.3	.0031	13.2	.71
	.7300	2.0	.0026	13.0	.57
698	-.3998	-.87	.0067	35.4	.64
	.3430	.69	.0028	18.3	.27
2210					

Appendix A

FOOTNOTES - TABLE VIII

1. All firms listed on Compustat tapes for the year 1980.

2. Includes only those firms which reported specifically on R&D (e.g. a numerical value or a statement that R&D expenditures were insignificant). Firms for which no information on R&D expenditures is available were excluded.

3. Insignificants -- these are firms with R&D expenditures less than 1% of sales which elected to report such expenditures were insignificant rather than giving a specific dollar amount. Firms with expenditures equivalent to 1% or more of sales are required to report the specific amount in their 10K filing with the SEC.

4. For each category the "insignificants" were excluded from the first regression and in the A case the insignificants were assigned zero values.

Appendix A

TABLE IX

INDUSTRIES INCLUDED IN EACH TECHNICAL OPPORTUNITY GROUP

	Number of Firms	A^2 Coefficient#
Very High Technology		
Office Equipment	152	.0583
Electronic Components	113	.0495
Aircraft & Missiles	28	.0567
Optical & Surgical	86	.0496
	379	
High Technology		
Communications	122	.0471
Motor Vehicles	47	.0402
Scientific & Mech. Meas. Instruments	104	.0462
Drug & Medicines	52	.0484
	325	
Intermediate Technology		
Industrial Chemicals	21	.0234
Other Non-Electrical Machinery	214	.0240
Other Electrical Equipment	86	.0217
Radio & TV Receiving Equipment	21	.0335
	342	
Low Intermediate Technology		
Food and Kindred Products	91	.0105
Rubber Products	73	.0191
Stone, Clay & Glass	45	.0131
Nonferrous Metals & Products	23	.0106
Other Chemicals	74	.0188
	306	
Low Technology		
Ferrous Metals & Products	37	.0048
Fabricated Metal Products	131	.0086
Paper & Allied Products	46	.0071
Lumber, Wood Products & Furniture	53	.0066
Other Transportation Equipment	13	.0090
	280	
Very Low Technology		
Textiles & Apparel	88	.0015
Non-Manufacturing	913	.0028
Other Manufacturing	128	.0026
Petroleum Refining	34	.0042
	1163	

A_2 coefficient from Table VIII -- from $(R\&D_j = a_1 + a_2 S_j + e_i)$. The A case was used above -- in these regressions insignificants were assigned a value of zero.

Appendix A

TABLE X

SUMMARY STATISTICS FOR EACH TECHNICAL OPPORTUNITY GROUP

Groups	R&D (Including Insignificants As Zeros)	R&D Excluding Insignificants
	($ Millions)	
Very High		
Mean	22.5	24.4
Median	0.8	1.0
Maximum	1,520.0	1,520.0
Standard Deviation	106.9	111.0
Proportion of Large Firms		
High		
Mean	28.6	30.7
Median	0.9	1.0
Maximum	2,224.5	2,224.5
Standard Deviation	159.5	165.5
Proportion of Large Firms		
Intermediate		
Mean	9.8	11.1
Median	0.9	1.2
Maximum	476.3	476.3
Standard Deviation	36.5	38.7
Proportion of Large Firms		

Appendix A

TABLE X (Continued)

Sales ($ Millions)	Percentage of Firms In Group With Sales Over $2 Billion --- % ---
438.4	
20.7	
26,213.0	
1,855.6	
	5.5
730.4	
25.0	
57,728.5	
3,954.7	
	7.7
428.3	
75.5	
13,689.9	
1,173.1	
	5.0

Appendix A

TABLE X (Continued)

SUMMARY STATISTICS FOR EACH TECHNICAL OPPORTUNITY GROUP

Groups	R&D (Including Insignificants As Zeros)	R&D (Excluding) Insignificants)
	------ ($ Millions) ------	
Low Intermediate		
Mean	9.0	12.3
Median	0.5	1.9
Maximum	227.8	227.8
Standard Deviation	25.3	29.0
Proportion of Large Firms		
Low		
Mean	3.1	4.6
Median	0.2	0.8
Maximum	56.1	56.1
Standard Deviation	8.6	10.1
Proportion of Large Firms		
Very Low		
Mean	3.6	4.9
Median	0.0	0.0
Maximum	489.0	489.0
Standard Deviation	26.3	30.8
Proportion of Large Firms		

TABLE X (Continued)

Sales ($ Millions)	Percentage of Firms In Group With Sales Over $ 2 Billion --- % ----
827.0	
141.4	
13,818.0	
1,754.0	
	13.7
506.0	
81.7	
12,492.1	
1,297.6	
	7.5
902.6	
29.3	
103,143.0	
5,554.5	
	5.1

Derivation of Censored Data Algorithm

First, we will derive the formula given in the paper by Schmee and Hahn for "right" censoring of a normal distribution with mean μ and standard deviation σ. In right censoring, it is assumed that any observation which lies above a cutoff value, c, is censored. It is clear why this is the situation of interest for survival or stress analysis. Since the observation lies to the right of c, we compute the expected value of the distance from μ, d, by

$$d = \frac{1}{1-F(z)} \int_c^\infty (x-\mu) \frac{1}{\sqrt{2\pi}\,\sigma} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right) dx$$

where F(z) is the cumulative standard normal distribution function evaluated at $z=(x-\mu)/\sigma$. The integral is straightforward and we obtain

$$d = \frac{1}{1-F(z)} \left(-\frac{\sigma^2}{\sqrt{2\pi}\,\sigma} \exp\left(-(x-\mu)^2/(2\sigma^2)\right)\Big|_c^\infty\right)$$

$$= \frac{1}{1-F(z)} \sigma f(z)$$

where f denotes the standard normal density function. Hence, the maximum likelihood estimate for a censored value, given μ, σ and c is:

$$\mu + \frac{\sigma f(z)}{1-F(z)} .$$

The situation for "left" censoring is very similar. In this case, the expected distance from μ is given by

$$d = \frac{1}{F(z)} \int_{-\infty}^{c} (x-\mu) \frac{1}{\sqrt{2\pi}\,\sigma} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right) dx$$

$$= \frac{1}{F(z)} \left(-\frac{\sigma^2}{\sqrt{2\pi}\,\sigma} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)\Big|_{-\infty}^{c}\right)$$

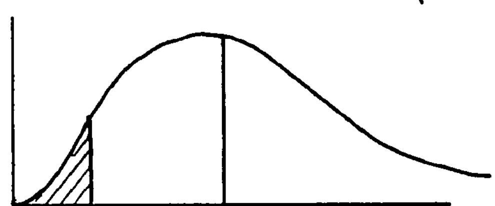
$$= -\frac{\sigma f(z)}{F(z)}$$

Hence, the ML estimate for a "left" censored value, given μ, σ and c is

$$\mu - \frac{\sigma f(z)}{F(z)} .$$

In your model for R&D, we are clearly dealing with "left" censoring and while the assumption of normality on the distribution of the residuals is appealing from the standpoint of being able to test the significance of the coefficients in the model, it is clear that σ is rather large and the above approach is likely to assign meaningless negative values to R&D for censored observations. An examination of residuals for certain ranges of sales, indicates that the assumption of a log-normal distribution on the residuals is quite reasonable. We will now derive the ML estimate of a "left" censored value for a log-normal distribution. If X is a random variable with a log-normal distribution defined by

$$\Pr\{\log X \leq \log x\} = \frac{1}{\sqrt{2\pi}\,\sigma} \int_{-\infty}^{\log x} \exp\left(- \frac{(t-\mu)^2}{2\sigma^2}\right) dt$$



The expected value of a censored value, z, is given by

$$E(z) = M + \frac{1}{F_1} \int_0^c (x-M) \frac{1}{\sqrt{2\pi}\,\sigma x} \exp\left(- \frac{(\ln x-\mu)^2}{2\sigma^2}\right) dx \qquad (1a)$$

where $F_1 = \Phi((\ln c-\mu)/\sigma)$ and Φ is the standard normal cumulative probability function. Substituting $t = \ln x$, we obtain:

$$E(z) = M + \frac{1}{F_1} \int_{-\infty}^{\ln c} (e^t - M) \frac{1}{\sqrt{2\pi}\,\sigma} \exp\left(- \frac{(t-\mu)^2}{2\sigma^2}\right) dt$$

$$= M + \frac{1}{F_1} \left[\int_{-\infty}^{\ln c} e^t \frac{1}{\sqrt{2\pi}\,\sigma} \exp\left(- \frac{(t-\mu)^2}{2\sigma^2}\right) dt - M F_1 \right]$$

$$= \frac{1}{F_1\sqrt{2\pi}\ \sigma} \int_{-\infty}^{\ln c} e^t \exp\left(-\frac{(t-\mu)^2}{2\sigma^2}\right)dt$$

Let $s = (t-\mu)/\sigma$. Then

$$E(z) = \frac{1}{F_1\sqrt{2\pi}\ \sigma} \int_{-\infty}^{\frac{\ln c-\mu}{\sigma}} \exp(\mu+\sigma s)\ \exp(-s^2/2)ds$$

$$= \frac{1}{F_1\sqrt{2\pi}\ \sigma}\ e^{\mu} \int_{-\infty}^{\frac{\ln c-\mu}{\sigma}} \exp(-(s^2 - 2\sigma s + \sigma^2)/2 + \sigma^2/2)ds$$

$$= \frac{1}{F_1\sqrt{2\pi}\ \sigma}\ e^{\mu}\ e^{\sigma^2}/2 \int_{-\infty}^{\frac{\ln c-\mu}{\sigma}} \exp(-(s-\sigma)^2/2)ds$$

Let $w = s - \sigma$. Then

$$E(z) = \frac{M}{F_1\sqrt{2\pi}\ \sigma} \int_{-\infty}^{\frac{\ln c-\mu}{\sigma} - \sigma} \exp1(-w^2/2)\ dw$$

So our basic formula is:

$$\boxed{E(z) = \frac{M}{F_1} F_2}$$

where $F_2 = \Phi\left(\frac{\ln c-\mu}{\sigma} - \sigma\right)$.

Using this estimator for censored values, it is possible to develop an EM algorithm for the model. In the first stage the censored values are replaced using the above formula. Of course this requires estimates of μ and σ which are obtained by solving the formulas for the mean and variance of a log-normal distribution, for μ and σ.

$$M = \exp(\mu + \sigma^2/2) \qquad (2a)$$

$$S^2 = \exp(2\mu + \sigma^2)(\exp(\sigma^2)-1) \qquad (3a)$$

Consistent estimates of M and S^2 are obtained from the fitted values of the last regression and a model for the standard error which assumes that the standard error is proportional to sales (this model acknowledges the heteroscedasticity which we know is present). The parameter α in the model

$$S = \alpha \cdot SALES + U$$

is estimated by partitioning the firms under study into ten cells in order of increasing sales. The standard deviation of R&D is then regressed against sales using OLS.*

In the second stage of this variant of the EM algorithm, we re-estimate the basic regression model, obtaining new estimates of M and S^2. We iterate until covergence, which is defined by the maximum absolute change in the parameters not exceeding the prescribed tolerance. While the exact properties of the final estimates may not be immediately obvious, it seems clear that asymptotically, as the sample size increases and the partitioning for the S model is refined, we will be dealing with ML estimates.

* This step was deleted from the program used for the present study. Since weighted data were used in the censored data algorithm, it would be redundant to adjust for heteroscedasticity a second time.

BIBLIOGRAPHY

I. BOOKS

Abernathy, William J. The Productivity Dilemma: Road Block To Innovations In the Automobile Industry. Baltimore: The Johns Hopkins Press, 1978.

Blair, John M. Economic Concentration: Structure, Behavior and Public Policy. New York: Harcourt Brace Jovanovich, 1970.

Denison, Edward F. Accounting for United States Economic Growth, 1929-1969. Washington, D.C.: Brookings Institution, 1974.

Dornbusch, Rudiger, and Stanley Fischer. Macro Economics. New York: McGraw-Hill Book Company, 1978.

Freeman, Christopher. The Economics of Industrial Innovations, 2nd ed. Cambridge, Mass.: The MIT Press, 1982.

Galbraith, John Kenneth. American Capitalism. Boston: Houghton Mifflin, 1956.

Gujarati, Damar. Basic Econometrics. New York: McGraw-Hill Book Company, 1978.

Haley, Charles W., and Schall, Lawrence D. The Theory of Financial Decisions. New York: McGraw-Hill Book Company, 1973.

Heilbroner, Robert L., and Lester C. Thurow. Economics Explained. Englewood Cliffs, New Jersey: Prentice Hall Inc., 1982.

Jewkes, John; Sawers, David; and Stillerman, Richard. The Sources of Innovation, 2nd ed. New York: W. W. Norton and Company, 1969.

Johnston, J. Econometric Methods, 2nd ed. New York: McGraw-Hill Book Company, 1970.

Kamien, Morton I., and Schwartz, Nancy L. Market Structure and Innovation. Cambridge: Cambridge University Press, 1982.

Mansfield, Edwin. Industrial Research and Technological Innovation. New York: W. W. Norton and Company, 1968.

________; Rapoport, J.; Romeo, A.; Villani, E.; Wagner, S.; and Husic, F. The Production and Application of New Industrial Technology. New York: W. W. Norton and Company, 1977.

Nelson, Richard R.; Peck, M. J.; and Kalachek, E. D. Technology, Economic Growth and Public Policy. Washington, D.C.: Brookings Institution, 1967.

Pavitt, Keith, and Wald, Solomon. The Conditions for Success in Technological Innovation. Paris: OECD, 1971.

Phillips, Almarin. Technology and Market Structure: A Study of the Aircraft Industry. Lexington, Mass.: Lexington Books, 1971.

Planck, Max. Vortrage und Erinnerungen, 5th ed. Quoted in Nicholas Rescher, Scientific Progress: A Philosophical Essay on the Economics of Research in National Science, p. 80. Pittsburgh: University of Pittsburgh Press, 1978.

Scherer, F. M. Industrial Market Structure and Economic Performance, 2nd ed. Chicago: Rand McNally Publishing Company, 1980.

Schmookler, Jacob. Invention and Economic Growth. Cambridge, Mass.: Harvard University Press, 1966.

Schumpeter, Joseph A. Capitalism, Socialism and Democracy, 3rd ed. New York: Harper & Row, 1950.

Stigler, George J. The Organization of Industry. Homeward, Illinois: Richard J. Irwin, 1968.

II. Journal Articles

Abernathy, William J. "Innovation And The Regulatory Paradox: Toward A Theory of Thin Markets." In Government, Technology and the Future of the Automobile, pp. 38-61. Edited by Douglas H. Ginsberg and William J. Abernathy. New York: McGraw-Hill Book Company, 1980.

Archer, Stephen and Faerber, Leroy G. "Firm Size And The Cost Of Externally Secured Equity Capital." Journal of Finance 21 (March 1966): 69-83.

Arrow, Kenneth J. "Economics And The Allocation Of Resources For Invention." In _The Rate and Direction of Inventive Activity: Economic and Social Factors_, pp. 609-625. Edited by Richard R. Nelson. Princeton: Princeton University Press, 1962.

Baldwin, William L. "Contracted Research and the Case for Big Business." _Journal of Political Economy_ 70 (August 1962): 294-298.

Comanor, William S. "Research and Technical Change In The Pharmaceutical Industry." _The Review of Economics and Statistics_ 47 (May 1965): 182-190.

________. "Market Structure, Product Differentiation, and Industrial Research." _The Quarterly Journal of Economics_ 81 (November 1967): 639-657.

________. and Scherer, F. M. "Patent Statistics As A Measure Of Technical Change." _Journal of Political Economy_ 77 (May/June 1969): 392-398.

Cooper, Arnold C. "R&D Is More Efficient In Small Companies." _Harvard Business Review_ (May-June 1964): 75-83.

Dempster, A. P.; Laird, N. M.; and Rubin, D. B. "Maximum Likelihood From Incomplete Data Via the EM Algorithm." _Journal of the Royal Statistical Society_ B-39 (1977): 1-22.

Fisher, Franklin M., and Temin, Peter. "Returns to Scale In Research And Development: What Does The Schumpeterian Hypothesis Imply?" _Journal of Political Economy_ 81 (January-February 1973): 56-70.

Grabowski, Henry C. "The Determinants of Industrial Research and Development: A Study of The Chemical Drug And Petroleum Industries." _Journal of Political Economy_ 76 (March-April 1968): 292-307.

Hamburg, D. "Size of Firm, Oligopoly, and Research: The Evidence." _Canadian Journal of Economics and Political Science_ 30 (February 1964): 62-75.

Iman, R. L. "Graphs For Use With The Lilliefors Test For Normal And Exponential Distributions." _American Statistician_ 36 (May 1982): 109-112.

Kamien, Morton I., and Schwartz, Nancy L. "Market Structure And Innovative Activity: A Survey." _The Journal of Economic Literature_ 13 (March 1975): 1-37.

________, and ________. "Self Financing Of An R&D Project." American Economic Review 68 (June 1978): 252-261.

Lancaster, Tony. "Grouping Estimators on Heteroscedastic Data," Journal of the American Statistical Association 63 (March 1968): 182-191.

Loeb, Peter D., and Lin, Vincent. "Research and Development in the Pharmaceutical Industry: A Specification Error Approach." Journal of Industrial Economics 26 (September 1977): 45-51.

McLean, Ian W., and Round, David K. "Research Product Innovation In Australian Manufacturing Industries." Journal of Industrial Economics 27 (September 1978): 1-12.

Mansfield, Edwin. "Size of Firm, Market Structure And Innovation." Journal of Political Economy 71 (December 1963) 556-576.

Mueller, Denis C. "Patents, Research and Development, And The Measure Of Inventive Activity." Journal of Industrial Economics 25 (November 1966): 26-37.

Nelson, Richard R. "The Simple Economics Of Basic Scientific Research." Journal of Political Economy 67 (June 1959): 297-306.

________, and Winter, Sidney G. "In Search Of Useful Theory Of Innovation." Research Policy 6 (January 1977): 36-76.

________. "Research On Productivity Growth And Productivity Differences: Dead Ends And New Departures." Journal of Economic Literature 19 (September 1981): 1029-1064.

Nutter, Warren G. "Monopoly, Bigness and Progress." Journal of Political Economy 64 (December 1956): 520-527.

Pavitt, Keith. "R&D, Patenting And Innovative Activities: A Statistical Exploration." Research Policy 11 (February 1982): 33-51.

Pearce, Michael C. "International Competition In The World Automotive Industry." In Government, Technology and the Future of the Automobile, pp. 259-269. Edited by Douglas H. Ginsberg and William J. Abernathy. New York: McGraw-Hill Book Company, 1980.

Pogue, Gerald A., and Lall, Kishore. "Corporate Finance: An Overview." In Sloan Management Journal 15 (Spring 1974). Quoted in Steward C. Myers, ed., Modern Developments in Financial Management, p. 27. New York: Praeger Publications, Inc., 1976.

Scherer, F. M. "Firm Size, Oligopoly, and Research: A Comment." Canadian Journal of Economic and Political Science 31 (May 1965): 256-66.

________. "Firm Size, Market Structure, Opportunity, And The Output of Patented Inventions." The American Economic Review 55 (December 1965): 1097-1125.

Schmee, Josef, and Hahn, Gerald J. "A Simple Method For Regression Analysis With Censored Data." Technometrics 21 (November 1979): 417-432.

Schmookler, Jacob. Comment on Barkev S. Sanders' Paper, "Some Difficulties In Measuring Inventive Activity." In The Rate and Direction of Inventive Activity: Economic and Social Factors, pp. 78-83. Edited by Richard R. Nelson. Princeton: Princeton University Press, 1962.

Shimshoni, Daniel. "The Mobile Scientist in the American Instrument Industry." Minerva 13 (January 1970): 59-89.

Soete, Luc L. G. "Firm Size And Inventive Activity: The Evidence Reconsidered." European Economic Review 12 (December 1979): 319-340.

Vernon, John M., and Gusen, Peter. "Technical Change And Firm Size: The Pharmaceutical Industry." Review of Economics and Statistics 56 (August 1974): 294-302.

Villard, Henry H. "Competition, Oligopoly And Research." American Economic Review 66 (December 1958): 483-497.

III. Magazine Articles and Other

"A Government Nudge for Joint Research." Business Week, December 22, 1980, p. 30B.

"Economic Recovery Tax Act of 1981." U.S. Conference Report (SREPT. No. 97-196) on HR 4242, S. 221, August 1, 1981.

Foster, Richard N. "A Call For Vision In Managing Technology." Business Week, May 24, 1982, p. 33.

Industrial Laboratories of the United States, Washington D.C. (annual).

International Competition in Advanced Technology: Decision for America. By Howard W. Johnson, Chairman: A Census Statement Prepared by the Panel on Advanced Technology Competition and Industrialized Allies: Office of International Affairs, National Research Council. Washington D.C.: National Academic Press, 1983.

Management of New Products. New York: Booz, Allen & Hamilton, 1968.

Statement of Financial Accounting Standards No. 2: Accounting for Research and Development Costs. Stamford, Connecticut: Financial Accounting Standards Board, October 1974.

"The Pitfalls Of Trying To Promote Innovation." The Economist, June 26-July 2 1982, p. 95.

U.S. Congress. Subcommittee on Economic Growth of the Joint Economic Committee. Technology, Economic Growth, and International Competitiveness, by Robert Gilpin. Joint Committee Print, Study 53-938. Washington, D.C.: Government Printing Office, 1975.

U.S. Department of Commerce. Patents Spur to American Progress, 1965.

"What Is Happening At Chrysler - The Regulation Squeeze." Chrysler Corporation Press Release, August 1979.

STATISTICAL ADDENDUM (RAW DATA)

Very High Group

	SALES	R&D	WEIGHT
'2287B'	0.000	0.000	0.259
'2437B'	0.035	0.013	0.260
SCTI	0.045	0.146	0.260
MKRS	0.052	0.379	0.260
XICO	0.069	0.478	0.261
'2817B'	0.158	0.020	0.264
KENS	0.279	0.368	0.267
'2241B'	0.310	0.030	0.268
GSTL	0.355	0.228	0.269
'2274B'	0.378	0.000	0.270
GYRO	0.570	0.000	0.276
'2203B'	0.662	0.029	0.278
OPTC	0.678	0.033	0.279
'2403B'	0.690	0.020	0.279
BACM	0.780	0.123	0.282
STOY	0.793	0.206	0.282
'2678B'	0.946	NA	0.287
KNGO	1.145	NA	0.293
'2005B'	1.174	0.057	0.293
'2432B'	1.207	0.163	0.294
UMFS	1.224	NA	0.295
HEMO	1.282	0.066	0.297
'1701B'	1.299	0.032	0.297
'2375B'	1.311	0.077	0.297
'1742B'	1.331	0.164	0.298
'1743B'	1.423	NA	0.301
AFPC	1.487	0.044	0.303
'1592B'	1.550	0.498	0.305
SCND	1.605	0.020	0.306
'1946B'	1.727	0.010	0.310
'1877B'	1.861	0.000	0.314
LIFE	1.912	0.340	0.315
'1730B'	2.056	0.088	0.319
'1700B'	2.128	0.025	0.322
ERAI	2.168	0.029	0.323
WLTK	2.169	0.049	0.323
DION	2.204	0.155	0.324
BSLT	2.208	0.135	0.324
NMTX	2.245	0.482	0.325
'1999B'	2.302	0.019	0.327
THRS	2.308	0.438	0.327
SMBL	2.390	0.173	0.329
'1682B'	2.423	0.030	0.330
SRCL	2.462	0.439	0.331
'1769B'	2.473	0.067	0.332
SLAB	2.489	0.072	0.332
IMAG	2.496	0.300	0.332
'1993B'	2.512	0.025	0.333
'1735B'	2.523	NA	0.333
PDGY	2.525	0.230	0.333
'2020B'	2.562	0.053	0.334
DENL	2.605	0.250	0.336
'1804B'	2.637	0.390	0.337
STSI	2.675	0.461	0.338
TGCO	2.684	0.569	0.338
OECO	2.834	0.169	0.342
CBEX	2.949	0.580	0.346
CODY	2.996	0.200	0.347
1PUT	3.186	0.161	0.353
'1813B'	3.225	0.111	0.354
MNTR	3.246	0.124	0.354
'1989B'	3.273	NA	0.355
'1619B'	3.458	0.096	0.361
'1474B'	3.468	0.029	0.361
RDPR	3.560	0.185	0.364
SNTC	3.588	0.000	0.365
PHOT	3.754	0.000	0.369
EMFC	3.801	0.031	0.371
'2089B'	3.808	NA	0.371
DICC	3.926	0.323	0.374
CTML	4.191	0.077	0.382
IDPY	4.218	0.471	0.383
KLAB	4.382	0.065	0.388
SMLS	4.386	0.118	0.388
ENER	4.524	1.569	0.392
QONE	4.549	0.718	0.393
CLCO	4.585	0.000	0.394
'2044B'	4.617	0.292	0.395
STDL	4.671	0.145	0.396
EMLX	4.733	0.617	0.398
TSIC	4.819	0.013	0.401
IRSC	4.884	0.082	0.403
ORBT	4.912	NA	0.404
TNSL	5.108	0.074	0.409
CELC	5.139	0.015	0.410
ECTH	5.188	0.520	0.412
HRES	5.203	0.131	0.412
DIO	5.216	NA	0.412
VDYK	5.222	0.080	0.413
ADDC	5.228	0.122	0.413
TDMC	5.517	0.000	0.421
'1626B'	5.556	NA	0.422
SBM	5.845	0.124	0.431
ISSI	6.021	0.376	0.436
TECH	6.205	0.141	0.442
CTRC	6.210	0.514	0.442
DANK	6.221	0.178	0.442
DELE	6.226	0.090	0.442
ELMG	6.282	0.043	0.444
MSIL	6.285	0.259	0.444
DTRN	6.312	0.659	0.445
CHYC	6.490	0.579	0.450
ESP	6.589	NA	0.453
ASTR	6.732	0.000	0.457
MCRS	6.735	0.277	0.457
MSCCA	6.741	0.220	0.457
EDCC	6.995	0.248	0.465
'1416B'	7.296	0.400	0.474
'1762B'	7.320	NA	0.474
GMIC	7.553	0.224	0.481
SPEX	7.739	0.436	0.487
AUDYB	7.969	0.447	0.493
PHOC	8.040	0.039	0.496
NITR	8.283	0.451	0.503
ANEN	8.304	0.500	0.503
HDIG	8.339	0.115	0.504
DILO	8.366	0.612	0.505
ORR	8.438	0.965	0.507
DMCC	8.503	0.378	0.509
NBEL	8.648	0.231	0.513
WTRS	8.724	0.297	0.516
MDTA	9.115	0.350	0.527
SOLR	9.338	0.479	0.534
CCUP	9.367	1.345	0.535

Sales and R&D expressed in millions of dollars
NA - Represents "insignificants"

WSPR	9.632	0.450	0.542
COGN	9.742	0.427	0.546

	SALES	R&D	WEIGHT
BIEN	9.776	0.666	0.547
REFC	10.149	0.074	0.558
'1423B'	10.470	0.081	0.567
SLCN	10.500	0.821	0.568
IEHC	10.688	0.125	0.573
HIL	10.737	0.061	0.575
'1330B'	11.039	0.224	0.584
EHIL	11.199	0.778	0.588
ADVC	11.669	NA	0.602
'1459B'	11.728	1.619	0.604
EALG	11.961	0.345	0.611
STJM	12.064	0.790	0.614
IPLSA	12.561	1.358	0.628
SCAN	12.694	0.767	0.632
NSCO	12.811	1.786	0.636
KALV	13.749	0.169	0.663
NATL	13.829	0.736	0.666
CCMMQ	13.915	1.478	0.668
SOCR	14.041	0.502	0.672
CCPT	14.096	0.750	0.674
FEI	14.240	NA	0.678
RLST	14.361	0.441	0.681
TERM	14.374	0.816	0.682
ISCS	14.445	1.303	0.684
DORM	14.478	0.936	0.685
DRXR	14.612	0.628	0.689
DATM	14.919	0.957	0.698
SMH	15.098	0.633	0.703
TI	15.194	0.870	0.706
SURV	15.471	0.829	0.714
INTR	15.636	0.967	0.719
TCK	15.641	0.604	0.719
BUCK	15.798	0.988	0.724
JAYA	15.848	0.000	0.725
INFR	15.866	0.274	0.726
ADGE	15.904	1.141	0.727
VRE	16.085	0.458	0.732
ZENT	16.464	1.053	0.743
GSTI	16.805	2.721	0.753
CSCN	16.847	1.571	0.754
GTCI	17.030	0.560	0.760
IDC	17.156	0.053	0.764
GES	17.266	1.000	0.767
DNTY	17.298	NA	0.768
GTI	17.413	0.278	0.771
BTEC	17.463	1.813	0.773
MICO	17.670	0.924	0.779
TDSC	18.392	1.726	0.800
UAP	18.468	NA	0.802
SMSC	18.638	2.125	0.807
INTS	18.775	0.914	0.811
CORC	19.030	0.183	0.819
LGL	19.241	0.565	0.825
APFE	19.678	0.340	0.838
NMIC	19.824	1.000	0.842
MAB	19.830	0.485	0.842
CDIT	20.091	1.070	0.850
CLR	20.243	0.527	0.854
WDCL	20.351	0.815	0.857

DAIO	20.426	1.686	0.860
VITR	20.460	0.834	0.861
OEA	20.604	NA	0.865
LDY	20.710	NA	0.868

	SALES	R&D	WEIGHT
NRD	20.752	1.190	0.869
ALMI	21.600	1.155	0.894
EMOD	22.320	1.115	0.915
TCOR	22.761	0.960	0.928
CRTN	22.784	NA	0.929
DTRM	22.815	1.287	0.930
'2676B'	23.023	0.276	0.936
SEME	23.146	0.365	0.939
DDSC	23.498	2.734	0.950
TBR	23.563	1.105	0.952
SCIFX	23.807	1.795	0.959
REDC	23.822	1.464	0.959
HAEM	23.954	1.196	0.963
IINT	23.957	3.092	0.963
SYKE	24.174	2.057	0.970
RMTK	25.149	3.033	0.998
ICOT	25.286	1.334	1.002
RED	25.314	0.015	1.003
AROS	27.162	NA	1.057
MCSI	27.755	3.764	1.075
RNIC	28.845	NA	1.107
AHA	29.579	2.312	1.128
CADO	30.261	1.299	1.148
LOGE	30.376	0.472	1.152
'2598B'	31.995	2.850	1.199
NBII	32.253	1.210	1.207
APEC	32.613	0.580	1.217
BHIV	33.110	1.403	1.232
SSI	33.267	2.877	1.236
TNL	33.475	NA	1.242
ESCC	34.673	2.079	1.278
TSY	35.803	0.127	1.311
STRY	36.122	1.116	1.320
FATK	37.207	0.380	1.352
DAC	37.242	NA	1.353
BATM	37.314	1.814	1.355
SYSM	37.929	1.884	1.373
SOD	38.273	NA	1.383
VGC	39.269	0.608	1.412
NLCS	39.434	1.810	1.417
NDI	41.400	0.765	1.475
FLP	42.405	4.603	1.504
EEC	42.644	2.568	1.511
FNNG	43.227	2.852	1.528
GSC	43.394	1.817	1.533
DDCC	43.606	1.230	1.539
EA	43.683	1.086	1.541
CCS	44.150	4.628	1.555
SG	44.624	0.793	1.569
METH	44.666	0.631	1.570
'BIO.B'	46.085	3.301	1.612
CCTC	46.253	3.789	1.617
OPTL	47.554	3.624	1.655
AJ	49.516	5.858	1.712
SUPE	49.832	0.926	1.721

VRB	50.126	2.911	1.730
ATTC	50.762	6.123	1.748
BTLY	51.037	2.635	1.756
DYTC	51.772	3.695	1.778
PTNX	52.428	0.922	1.797
DCTL	53.278	0.440	1.822
HUN	55.253	0.334	1.880
MSI	55.613	3.304	1.890

	SALES	R&D	WEIGHT
INGR	56.468	6.205	1.915
TRSC	56.513	3.757	1.916
SLTC	57.120	2.034	1.934
AVAK	58.287	4.393	1.968
CPTC	58.935	1.976	1.987
CYR	60.748	8.821	2.040
SER	60.779	1.431	2.041
DYSN	62.871	10.862	2.102
QUOT	63.809	4.373	2.179
WBR	64.839	NA	2.160
SILI	66.111	7.080	2.197
DDES	66.186	NA	2.199
'1951B'	68.028	NA	2.253
NAO	69.494	1.735	2.295
SCPE	70.718	2.899	2.331
NPD	72.877	2.577	2.394
APPL	75.047	8.328	2.457
DATC	75.366	2.846	2.466
MMIC	77.033	4.001	2.515
EAD	78.401	1.132	2.555
MSY	81.088	6.841	2.633
CAUT	81.151	7.604	2.635
ARN	81.528	0.293	2.646
VRO	83.283	2.421	2.697
SPNG	83.307	0.700	2.698
USSC	86.214	3.020	2.782
HVE	88.000	2.381	2.834
APM	92.526	3.556	2.966
COBE	92.606	8.359	2.968
EMM	98.756	6.082	3.147
PBEN	100.119	3.455	3.186
SPA	100.925	0.712	3.210
UTR	103.601	3.105	3.287
VEE	105.247	4.157	3.335
HCC	106.296	6.024	3.365
TNDM	108.989	8.786	3.443
REC	113.102	8.419	3.563
AAPL	117.126	7.282	3.679
DTS	118.342	6.013	3.714
MOLX	121.523	6.254	3.806
ILAB	122.534	11.413	3.836
IHS	123.183	0.685	3.854
BAR	124.489	2.251	3.892
VRN	125.325	1.920	3.916
CBU	125.600	6.600	3.924
GENA	125.809	8.490	3.930
CEN	127.608	4.863	3.982
AMMS	129.369	10.319	4.033
AWLD	133.624	0.068	4.156
HZ	133.799	6.311	4.161
ADI	135.660	9.126	4.215
AVX	141.138	3.250	4.373
IRF	150.854	3.778	4.653
AUG	157.294	NA	4.8[illegible]
TC	178.466	9.120	5.447
CTS	187.977	3.423	5.71[illegible]

'2775B'	188.545	1.804	5.736
WGER	191.031	3.329	5.807
FPS	197.187	15.907	5.983
RM	200.729	13.379	6.084
ASZ	206.507	5.990	6.250
REYNA	210.252	2.769	6.356
CVN	224.207	22.122	6.754

	SALES	R&D	WEIGHT
BCR	246.544	5.000	7.390
BDC	253.703	9.284	7.593
TNB	254.000	11.926	7.601
DSP	258.224	4.533	7.771
FRM	267.637	20.390	7.988
DPC	270.125	15.348	8.058
MDS	287.370	16.644	8.545
LBP	303.110	4.695	8.989
M	303.751	10.706	9.007
MNES	305.500	6.991	9.056
AMD	309.391	35.136	9.166
DPT	318.826	27.858	9.431
MAI	322.480	6.702	9.534
TAL	376.765	4.595	11.051
OAK	385.586	9.287	11.296
AMH	394.351	62.462	11.540
GLJ	439.419	9.530	12.787
RHR	517.128	NA	14.916
'WAN.B'	543.272	36.655	15.626
'2641A'	570.575	23.614	16.365
BOL	582.681	16.699	16.692
STK	603.493	39.274	17.252
VAR	620.863	40.327	17.718
THI	622.657	11.429	17.766
BHW	639.962	30.345	18.229
DGN	653.887	65.643	18.600
KYO	690.621	8.299	19.576
BNK	758.947	10.800	21.376
MRX	768.661	34.573	21.630
SYB	792.904	24.633	22.263
GRL	825.074	14.300	23.099
INTC	854.561	96.426	23.861
FEN	906.230	10.320	25.188
AIN	909.647	20.643	25.275
BDX	942.031	39.166	26.100
CEA	1,000.061	47.906	27.567
NSM	1,110.053	96.043	30.309
FBI	1,257.294	29.934	33.898
BAX	1,374.384	57.202	36.685
LSI	1,423.397	15.400	37.834
MRD	1,450.785	113.966	38.472
NOC	1,655.400	93.000	43.135
GO	1,729.336	27.556	44.776
CANNY	2,047.126	54.157	51.560
FUJIY	2,270.829	102.112	56.077
AHS	2,339.899	38.900	57.428
DEC	2,368.045	186.392	57.972
ML	2,619.326	9.500	67.684
CDA	2,765.601	182.800	65.302
BGH	2,857.186	193.766	66.895
HWP	3,099.000	272.000	70.927
NCR	3,322.369	201.000	74.478
TXN	4,074.699	188.500	84.646

TXN	4,074.699	188.500	84.646
JNJ	4,837.398	232.800	92.526
HON	4,924.699	295.400	93.269
LK	5,395.699	87.000	96.712
SY	5,427.175	336.470	96.908
MD	6,066.300	199.000	99.971
MMM	6,079.539	282.500	100.016
XRX	8,196.496	434.100	97.525
BA	9,426.199	767.500	87.248
EK	9,734.300	520.500	83.656
UTX	12,324.000	660.296	37.368

	SALES	R&D	WEIGHT
IBM	26,213.000	1,520.000	701.930

High Group

	SALES	R&D	WEIGHT
'2815B'	0.000	0.000	0.259
HOLO	0.006	0.084	0.259
ORSI	0.045	0.263	0.257
'2728B'	0.080	0.021	0.256
WILD	0.134	0.338	0.254
CMDL	0.283	0.763	0.249
'1726B'	0.541	NA	0.241
DENC	0.648	0.079	0.237
'2319B'	0.660	0.020	0.237
'1902B'	0.828	0.030	0.231
'2004B'	0.991	NA	0.225
SCOR	1.158	0.020	0.220
JHSN	1.261	0.071	0.216
SLDSQ	1.403	1.490	0.212
POLXF1	1.645	0.100	0.203
'1687B'	1.646	0.186	0.203
RMA	1.724	0.003	0.201
ARTK	1.793	0.166	0.199
'1698B'	1.806	NA	0.198
'2612B'	1.918	0.030	0.194
CNLG	1.925	NA	0.194
SSII	1.945	0.097	0.193
CNUC	1.976	0.062	0.192
SBEI	1.986	0.208	0.192
DIAG	2.046	0.600	0.190
CLSC	2.069	0.358	0.189
'1880B'	2.130	0.281	0.187
'1933B'	2.147	0.146	0.187
MOCO	2.172	0.092	0.186
'1826B'	2.240	NA	0.184
UMED	2.363	0.467	0.179
'1844B'	2.394	0.150	0.178
GCHM	2.402	0.086	0.178
'1317B'	2.484	0.000	0.175
'2200B'	2.527	0.039	0.174
ELSE	2.577	0.147	0.172
OICO	2.610	0.102	0.171
ADGN	2.635	0.278	0.170
ELMD	2.767	0.007	0.166
AZA	2.783	8.239	0.165
'2017B'	2.899	0.003	0.161
'1941B'	2.925	0.247	0.160
ELCS	2.988	0.016	0.158
BUTL	3.203	0.492	0.151
AND	3.217	0.097	0.151
'1560B'	3.325	NA	0.147
IOMT	3.365	0.024	0.146
'1604B'	3.368	0.000	0.146
'1537B'	3.446	0.000	0.143
IMME	3.500	NA	0.141
'1984B'	3.698	0.141	0.135
REIC	3.820	0.070	0.130
UTEL	3.900	0.032	0.128
'2805B'	4.028	0.000	0.123
ACOM	4.077	0.433	0.122
'1848B'	4.131	0.387	0.120
TLCN	4.157	0.032	0.119
'1644B'	4.366	NA	0.112
'2034B'	4.567	0.050	0.105
'1559B'	4.568	0.613	0.105
ATNW	4.707	0.127	0.101
'2193B'	4.743	NA	0.099
'1937B'	5.375	0.114	0.078
SCRD	5.580	0.589	0.071
ECIN	5.637	0.075	0.069
'1642B'	5.651	0.000	0.069
REID	5.762	0.120	0.065
DEWY	5.917	NA	0.060
NUSY	6.263	0.000	0.048
'1561B'	6.316	NA	0.047
EMCX	6.337	0.348	0.046
OREQ	6.503	0.184	0.040
WMAR	6.504	0.279	0.040
BUNT	6.513	0.188	0.040
'1311B'	6.591	NA	0.037
AUMO	6.622	0.143	0.036
GETE	6.927	0.300	0.026
GBCC	7.072	0.250	0.021
DETX	7.073	0.537	0.021
KLAC	7.249	0.757	0.015
TRNS	7.277	0.738	0.014
EIPM	7.577	0.930	0.004
RADS	7.654	0.129	0.002
BOON	7.815	0.424	0.004
QUAN	7.886	0.648	0.006
'2345B'	7.895	0.765	0.006
GAMA	8.326	0.269	0.021
CHEK	8.402	0.151	0.023
ASON	8.661	0.134	0.032
AMPI	9.239	0.405	0.051
DETC	9.247	0.596	0.052
ALI	9.528	0.125	0.061
BGPH	9.869	0.046	0.073
CYCC	10.053	0.616	0.079
NWPH	10.119	1.835	0.081
SCA	10.257	0.735	0.086
SLON	10.391	0.521	0.090
NEWE	10.442	0.603	0.092
MLAB	10.759	0.938	0.102
HATH	11.000	1.130	0.110
TSII	11.037	1.551	0.112
HIP	11.062	0.040	0.113
SLDN	11.116	0.347	0.114
BASEA	11.202	0.300	0.117
KAL	11.215	0.307	0.118
'1873B'	11.374	0.100	0.123
'1943B'	11.391	NA	0.124
PATH	11.544	0.378	0.129
BOLR	11.808	0.298	0.138
SNR	12.222	0.490	0.151
TEQPQ	12.294	0.060	0.154
'2845B'	12.392	0.208	0.157
KNO	12.681	0.222	0.167
'1430B'	12.874	0.132	0.173
SPDY	13.081	0.091	0.180
NEWP	13.294	0.409	0.187
SBAR	13.309	0.414	0.188
CLSR	13.331	0.532	0.189
USEC	13.565	0.160	0.197
'1956B'	13.579	0.346	0.197
PSI	15.123	1.530	0.249
DRAN	15.326	0.949	0.256
EPSC	16.018	0.324	0.279
CUSH	16.021	1.544	0.279
NURX	16.023	0.031	0.279

FRX	16.033	1.040	0.279

	SALES	R&D	WEIGHT
NBSC	16.525	0.176	0.296
REAL	16.611	0.743	0.299
UTLC	16.661	0.223	0.300
KEVX	17.004	0.977	0.312
TYLN	17.135	0.833	0.316
DIXS	17.325	0.274	0.323
VII	17.839	0.257	0.340
TIX	17.928	1.794	0.343
ANDR	18.491	0.843	0.362
ICDY	18.644	1.000	0.367
ADAC	18.782	2.133	0.371
CPRD	18.946	1.119	0.377
PHON	19.097	0.315	0.382
RMS	19.381	0.074	0.391
INFN	19.626	1.714	0.400
TTL	19.737	1.615	0.403
KVPH	20.065	0.704	0.414
ZENIB	20.260	0.336	0.421
TLX	20.477	1.256	0.428
GRG	20.639	1.882	0.434
ORIR	20.712	2.261	0.436
KTII	20.965	0.815	0.444
RESR	21.400	0.973	0.459
NBIO	21.662	0.158	0.468
GARS	22.178	NA	0.485
MYLN	22.184	0.560	0.485
AMIC	22.401	1.258	0.493
GRMI	22.622	0.000	0.500
TSC	22.831	5.333	0.507
ATW	23.260	0.140	0.521
AMON	23.347	3.362	0.524
MCDY	23.715	1.055	0.537
KPH	23.726	0.984	0.537
HACH	23.750	1.462	0.538
COH	24.505	0.701	0.563
ACLV	24.756	0.271	0.571
ASE	24.962	1.934	0.578
CMTL	25.920	0.797	0.610
QONR	26.985	2.146	0.646
TCH	26.992	0.723	0.646
SHRM	27.391	1.080	0.660
UCS	27.588	NA	0.666
TXS	27.654	1.267	0.668
ART	28.494	NA	0.696
JET	29.355	0.168	0.725
ENUC	30.072	1.865	0.749
PNL	33.334	1.280	0.858
AGMN	33.847	NA	0.875
SFAC	33.978	0.146	0.880
DKJC	34.880	1.750	0.910
AAR	36.099	0.727	0.951
VSH	37.101	0.816	0.984
CMIC	38.066	1.389	1.016
WVTK	38.344	4.210	1.026
BOM	38.857	0.677	1.043
LYC	39.499	3.815	1.064
MKP	42.276	0.424	1.157
JEF	42.802	2.923	1.175
TLAB	43.680	2.302	1.204
BIR	44.062	0.436	1.217
WHT	45.554	0.259	1.266
ELEC	45.578	0.799	1.267
COMM	45.802	0.408	1.275

	SALES	R&D	WEIGHT
HMF	47.012	NA	1.315
SERE	47.849	1.005	1.343
SUP	50.012	0.374	1.415
SNSR	50.718	0.984	1.439
DYNA	51.168	2.179	1.454
ROCK	53.044	1.308	1.516
GDC	53.635	4.425	1.536
LIPE	53.961	0.465	1.547
AELNA	54.469	0.328	1.564
KTOS	55.507	4.180	1.598
MGNE	55.900	3.841	1.611
MORP	57.122	2.617	1.652
RGCY	57.571	2.372	1.667
BMI	58.069	1.571	1.684
KEQU	58.072	0.079	1.684
ISN	58.538	3.453	1.699
TIE	59.805	1.500	1.742
COHR	61.268	4.143	1.790
ICN	63.055	1.087	1.850
ALOG	67.010	5.970	1.981
MTSC	67.151	3.141	1.986
LIEB	72.535	1.184	2.165
CHTT	75.010	1.081	2.247
PDN	75.907	6.342	2.277
NICO	77.394	6.574	2.327
LFE	78.672	1.530	2.369
CREB	79.708	1.005	2.403
ALW	82.160	NA	2.485
TRCO	89.021	NA	2.712
ANDW	89.294	4.685	2.721
WGO	91.939	0.620	2.809
MLT	92.578	3.524	2.829
GRB	93.105	6.686	2.848
FLX	95.459	7.341	2.926
KRC	97.208	8.640	2.984
EDO	97.345	3.058	2.988
SWS	99.525	1.060	3.060
SMPS	101.460	0.244	3.124
AYD	102.908	1.622	3.172
ACRA	102.910	6.068	3.172
CMW	104.347	4.631	3.220
MKC	115.842	10.290	3.600
CHC	122.007	0.567	3.803
MX	122.033	6.300	3.804
KEUF	123.308	3.867	3.846
COA	125.305	1.172	3.912
FKM	128.174	12.403	4.007
SP	131.979	3.534	4.132
WJ	132.794	8.406	4.159
FCT	134.221	0.939	4.206
SPY	134.576	9.729	4.218
'MOG.A'	135.300	5.066	4.242
FSS	146.546	0.489	4.612
CAX	146.821	1.938	4.671
DAN	155.849	NA	4.917
TER	164.970	16.659	5.216
UIC	165.492	1.853	5.234
GEN	167.698	16.517	5.306

SCHC	169.997	1.903	5.381
COO	172.847	6.353	5.475
RNI	179.418	2.377	5.690
MOD	180.770	4.411	5.734
HAY	184.445	2.540	5.854

	SALES	R&D	WEIGHT
FP	185.212	10.446	5.879
SFA	191.997	8.571	6.101
CUB	196.386	0.960	6.244
SE	203.336	6.779	6.471
LOR	212.628	6.365	6.773
SPD	213.623	2.356	6.806
DCI	234.428	4.958	7.482
WPI	249.278	5.799	7.963
SPW	257.882	4.047	8.241
MK	263.687	4.814	8.429
MILI	264.738	18.763	8.463
CCI	267.320	1.616	8.546
RAY	274.435	5.119	8.776
SAA	281.057	11.626	8.989
TRR	295.147	7.379	9.443
PRY	308.489	2.640	9.871
ROR	312.454	11.019	9.998
STX	336.167	9.414	10.757
ROF	349.030	6.832	11.168
ADT	375.040	6.112	11.995
SHC	411.331	5.044	13.145
FS	423.585	3.910	13.531
RAH	432.328	27.033	13.807
SHG	450.524	5.028	14.379
FOX	509.057	29.061	16.207
BEC	549.272	39.785	17.454
SYN	579.514	54.392	18.386
NRI	599.179	3.660	18.990
'2772A'	686.117	36.318	21.637
SMC	693.684	19.192	21.865
JCI	964.854	13.096	29.873
PKN	996.149	62.400	30.774
TEK	1,061.834	91.147	32.649
SRL	1,081.558	71.258	33.208
RVI	1,211.651	51.591	36.847
HRS	1,300.932	57.000	39.297
GLXO	1,456.326	89.528	43.467
GSX	1,521.744	51.039	45.187
'2849A'	1,536.660	15.541	45.576
ICX1	1,586.600	15.100	46.872
PCAR	1,673.708	NA	49.102
SQB	1,675.780	77.250	49.155
STY	1,701.432	58.072	49.804
NT	1,719.667	117.972	50.264
SGP	1,740.400	90.000	50.785
UPJ	1,760.576	147.328	51.289
SKL	1,771.937	135.832	51.573
PLY	1,866.299	96.539	53.901
ABT	2,038.154	97.562	58.030
FTR	2,081.747	18.504	59.055
DCN	2,524.008	32.300	68.920
AMO	2,552.585	68.900	69.525
LLY	2,558.637	200.700	69.652
BOR	2,673.301	63.900	72.034
MRK	2,734.011	233.899	73.269
ERIC	2,859.842	231.300	75.771

PFE	3,029.299	159.900	79.018
MOT	3,098.761	200.000	80.309
BMY	3,158.299	128.600	81.396
ETN	3,176.466	74.328	81.724
WLA	3,479.206	102.935	86.957
AHP	3,798.523	101.643	91.989
BX	3,837.601	79.200	92.570

	SALES	R&D	WEIGHT
NIPNY	4,711.023	227.794	103.615
TRW	4,983.968	66.900	106.299
RTN	5,002.085	129.600	106.465
HR	6,311.800	255.356	114.151
ROK	6,906.500	101.100	114.866
ITT1	7,938.144	375.813	111.994
HMC	7,980.015	222.381	111.767
C	9,225.300	278.400	101.097
F	37,085.507	1,675.000	2,124.703
GM	57,728.515	2,224.500	6,227.487

Intermediate Group

	SALES	R&D	WEIGHT
'2351B'	0.000	0.000	0.242
MODE	0.000	0.000	0.242
'1563B'	0.000	NA	0.242
PCYC	0.129	0.604	0.244
ENZO	0.129	0.056	0.244
'2645B'	0.297	0.018	0.247
ACL	0.653	NA	0.252
BIOG	0.803	0.222	0.254
'2267B'	0.869	1.136	0.255
'2392B'	0.936	0.018	0.256
RVAC	1.080	0.305	0.258
'2250B'	1.176	0.000	0.260
'2633B'	1.370	0.000	0.262
'2707B'	1.393	0.071	0.263
AZIN	1.553	0.013	0.266
BIOC	1.642	0.079	0.267
'2343B'	1.737	0.101	0.268
'2806B'	1.775	NA	0.269
VTSI	2.193	0.217	0.275
'2773B'	2.558	0.133	0.281
ULDY	2.809	0.000	0.284
SONA	2.929	NA	0.286
ALFA	3.010	NA	0.287
'2476B'	3.057	0.175	0.288
'1558B'	3.212	0.021	0.290
APMK	3.225	0.338	0.290
DEXO	3.233	0.071	0.291
'1636B'	3.318	NA	0.292
'1552B'	3.425	0.005	0.293
'2782B'	3.657	0.030	0.297
DAIGQ	3.803	0.083	0.299
'1612B'	4.100	0.000	0.304
HYTK	4.100	NA	0.304
PWRC	4.286	0.293	0.306
MCDRQ	4.362	0.273	0.307
'1955B'	4.615	0.085	0.311
SDYN	4.780	0.275	0.314
BOTH	4.867	0.192	0.315
SPER	5.037	0.361	0.317
TEN	5.046	0.007	0.318
WEC	5.063	0.055	0.318
RIPY	5.129	0.097	0.319
'1787B'	5.345	0.082	0.322
DRIC	5.452	0.010	0.324
OSMO	5.587	0.237	0.326
NWRK	5.606	0.028	0.326
ANDN	5.822	0.027	0.329
'1680B'	6.098	0.006	0.333
MCHT	6.165	0.148	0.334
'1065B'	6.372	0.145	0.337
NUMX	6.475	0.250	0.339
CLY	7.243	0.609	0.350
KUST	7.444	0.306	0.353
STKR	7.466	0.060	0.354
WEB	7.674	0.030	0.357
PMCP	7.725	NA	0.358
UIN	8.263	0.275	0.366
MJEL	8.609	0.000	0.371
POSS	8.695	0.185	0.372
'2015B'	8.735	NA	0.373
RUNN	8.813	NA	0.374
TRON	9.029	0.104	0.377
'1421B'	9.523	NA	0.384
BIRT	9.672	0.360	0.387
FMT	10.140	0.166	0.394
'2784B'	10.180	0.326	0.394
DSNG	10.681	0.000	0.402
'2838B'	10.777	1.021	0.403
RULE	11.282	0.517	0.411
TRF	11.329	0.250	0.411
'1656B'	11.586	0.299	0.415
ERCK	12.100	0.060	0.423
HOEC	12.379	NA	0.427
NACI	12.447	0.451	0.428
GASO	12.678	0.026	0.431
'1346B'	12.851	0.155	0.434
FLAM	13.462	NA	0.443
SLX	13.756	NA	0.447
ECOA	14.073	0.191	0.452
SPEC	14.303	NA	0.456
BET	14.526	NA	0.459
PMFG	14.710	0.122	0.462
MPR	14.807	0.140	0.463
ORCO	15.232	0.434	0.469
MRES	15.546	NA	0.474
VBND	15.648	0.019	0.476
ARTW	16.783	0.072	0.493
'1169B'	17.152	0.367	0.498
'1447B'	17.624	NA	0.505
SLTG	18.410	NA	0.517
ODFX	18.943	0.702	0.525
'2741B'	19.201	NA	0.528
MAX	19.571	0.497	0.534
VLAB	20.104	1.473	0.542
'2687B'	20.159	NA	0.543
HITT	20.621	0.789	0.550
HELXC	20.633	1.174	0.550
DSCP	20.721	1.267	0.551
BOST	20.982	0.320	0.555
YE	21.675	0.340	0.565
WSCI	22.547	0.138	0.578
RODC	22.627	0.350	0.579
ADO	22.943	NA	0.584
KOSS	23.225	0.365	0.588
FSG	23.428	0.292	0.591
MAGN	24.128	0.331	0.602
HWKN	24.167	NA	0.602
SIHS	24.553	0.432	0.608
HMI	24.989	0.047	0.615
SHAV	25.304	0.579	0.619
PWR	26.189	0.910	0.632
GRAI	26.875	NA	0.643
HMA	27.615	0.879	0.654
NWEN	27.959	0.749	0.659
HURC	28.490	1.257	0.667
WELT	28.708	0.808	0.670
ETHM	28.723	0.200	0.670
TO	30.020	0.829	0.689
AUTR	30.535	0.549	0.697
SDUN	32.098	0.650	0.720
TPZ	32.208	0.739	0.722
SLAT	33.166	0.454	0.736
APR	33.307	NA	0.738
RKY	34.294	0.489	0.753
HNW	35.148	0.400	0.766
OLGR	36.542	1.210	0.786

	SALES	R&D	WEIGHT
DUAL	36.872	0.984	0.791
SMKR	38.159	0.090	0.810
AZTC	39.378	NA	0.828
WELB	39.723	0.632	0.834
RBC	40.222	0.376	0.841
ALE	40.535	0.593	0.846
APLI	40.590	0.380	0.846
CHNR	41.450	0.421	0.859
CUO	41.978	NA	0.867
ECA	42.844	1.754	0.880
'1158B'	43.118	0.052	0.884
WALB	43.316	1.165	0.887
LSP	43.624	0.487	0.891
MTIX	43.731	1.334	0.893
WDHD	43.747	1.046	0.893
ION	44.527	2.119	0.905
POWL	45.810	0.310	0.924
ROPE	45.887	0.330	0.925
RCE	46.382	2.994	0.932
PAXL	48.905	0.555	0.970
'1364B'	49.064	0.305	0.972
KLIC	49.780	5.680	0.983
ALEC	49.977	2.947	0.986
IMG	50.060	1.200	0.987
PVIR	50.430	1.346	0.992
LYD	51.360	0.291	1.006
EE	51.863	0.450	1.014
UGIL	53.928	0.285	1.044
MRC	55.067	2.262	1.061
'2842B'	57.104	0.848	1.091
FARC	58.638	1.801	1.114
CLA	60.013	0.450	1.134
JLGI	60.411	1.422	1.140
MTY	60.518	NA	1.142
DUR	60.678	1.300	1.144
KERN	60.885	1.071	1.147
SLS	61.216	0.885	1.152
PSX	62.784	1.752	1.175
MUEL	68.737	0.158	1.263
WEHR	68.796	NA	1.264
AMAT	69.278	8.090	1.271
MTL	71.317	2.433	1.302
VEN	71.743	0.580	1.308
ITHM	73.367	NA	1.332
MGLL	74.026	0.365	1.342
XOX	76.981	0.715	1.385
PGO	78.061	1.517	1.401
TNT	78.855	0.360	1.413
MAXC	83.415	0.450	1.480
ARO	84.932	1.102	1.503
L	86.275	0.931	1.522
RIVL	86.927	0.997	1.532
CASC	87.531	0.925	1.541
BREN	88.110	NA	1.550
CHER	90.204	1.181	1.580
TANT	100.094	4.285	1.726
TOR	100.797	2.800	1.736
MCC	103.217	NA	1.772
CRCH	104.507	2.949	1.791
ITEM	105.208	4.835	1.801
VRC	108.072	3.269	1.844
CORD	108.985	13.436	1.857
ESQ	110.060	0.684	1.873

	SALES	R&D	WEIGHT
CHG	111.134	0.290	1.889
RBG	111.835	2.691	1.899
LOL	112.335	2.970	1.906
RAYM	113.361	4.095	1.921
CMX	114.562	2.240	1.939
SBS	115.381	0.831	1.951
IEMSY	115.509	0.215	1.953
GRAC	116.892	4.742	1.973
NPK	117.952	NA	1.989
KUH	120.494	0.365	2.026
MORF	120.781	0.544	2.030
DNLY	120.997	0.469	2.034
STGR	121.160	1.900	2.036
WNC	122.101	NA	2.050
CAM	123.964	2.917	2.077
CRA	125.705	0.888	2.103
SMP	125.875	NA	2.105
GLK	126.705	4.050	2.117
NMS	127.608	0.606	2.131
CEAQC	129.644	0.000	2.160
AZL	132.072	1.302	2.196
'2350B'	134.155	5.076	2.227
TOK	134.841	3.419	2.237
USMA	135.055	4.641	2.240
BIN	136.452	0.760	2.260
FJQ	137.297	2.500	2.273
SON	138.242	NA	2.287
DURI	140.339	2.402	2.317
PLL	140.803	5.598	2.324
RON	142.920	1.554	2.355
JOSL	143.843	0.700	2.369
DYA	145.347	1.150	2.391
BEZ	146.454	3.100	2.407
NDSN	149.099	7.050	2.445
ISY	150.861	2.200	2.471
BSIN	151.545	0.647	2.481
ESX	152.119	2.687	2.490
WARN	152.438	3.947	2.494
VALM	152.466	2.000	2.495
SSP	153.659	NA	2.512
SUL	154.926	5.338	2.531
FELE	156.088	2.450	2.548
GUL	156.487	2.590	2.554
GCA	170.083	11.270	2.752
TMO	174.630	2.702	2.818
CW	185.539	0.696	2.977
'1268B'	187.330	1.580	3.003
KOL	191.249	8.037	3.061
ROBN	194.152	1.500	3.103
RTE	207.474	1.613	3.296
TDI	208.975	4.558	3.318
MME	222.201	1.179	3.510
MCQA	222.970	1.707	3.521
BARB	226.540	2.910	3.573
TII	227.148	2.818	3.582
BNS	227.472	4.521	3.586
LRI	234.205	0.906	3.684
GULD	238.953	2.383	3.752
HES	241.407	3.594	3.788
CNK	241.776	4.703	3.793
GLE	242.640	4.225	3.806
ESL	243.428	7.800	3.817
POR	250.762	2.700	3.923

	SALES	R&D	WEIGHT
'2611B'	256.866	0.470	4.011
WID	262.070	0.795	4.086
CPU	277.355	14.956	4.306
MANT	277.508	1.319	4.308
'2796A'	284.673	2.500	4.411
SHLM	288.814	NA	4.471
MYG	294.746	4.100	4.556
ECH	301.400	2.216	4.651
MDT	313.560	25.198	4.826
UMT	318.280	2.371	4.893
MKTAY	320.907	2.829	4.931
KMT	325.936	7.158	5.003
GID	327.020	1.897	5.018
SSSS	353.870	3.931	5.401
ITK	355.102	11.870	5.419
CTCO	355.385	4.151	5.423
TYC	360.873	1.560	5.501
ZRN	364.081	0.841	5.546
RC	379.594	2.667	5.767
STNA	392.703	2.677	5.952
AME	400.180	8.100	6.058
TTC	402.000	9.127	6.084
AMT	405.236	3.649	6.130
LANA	408.249	2.193	6.172
ROP	428.253	9.439	6.454
'1284B'	456.440	7.517	6.851
CGG	474.151	5.710	7.099
'BY'	511.293	19.100	7.618
AHO	538.589	3.262	7.997
EPI	543.297	NA	8.063
HYST	629.668	9.500	9.253
SFZ	632.398	NA	9.291
MGC	636.359	5.977	9.345
HPH	642.223	14.343	9.425
'1275A'	681.518	45.436	9.961
PBD	683.862	2.947	9.993
OM	687.398	24.531	10.041
CIW	697.352	8.500	10.176
BGG	708.562	5.237	10.328
TECU	753.072	7.012	10.929
FIG	759.562	7.502	11.016
TRA	764.783	13.076	11.087
SII	784.130	16.353	11.346
CHM	799.800	10.700	11.556
CMZ	816.402	22.800	11.778
HOOV	830.465	7.722	11.965
DOV	835.167	6.000	12.028
RCI	885.059	6.341	12.689
SCO	900.401	8.600	12.891
SNS	926.026	29.084	13.228
JOY	934.329	8.648	13.337
SQD	998.973	19.256	14.180
XLO	1,020.677	15.121	14.462
PH	1,022.376	12.643	14.484
AXO	1,054.015	28.188	14.892
REX	1,083.690	12.816	15.273
AMP	1,155.382	104.000	16.187
ZE	1,185.900	47.800	16.573
BC	1,199.709	32.467	16.748
HT	1,206.155	18.729	16.829
WFI	1,299.673	11.567	17.997
TKR	1,338.499	13.634	18.477
PIO	1,365.765	31.981	18.812

	SALES	R&D	WEIGHT
APD	1,420.759	30.168	19.484
BDK	1,438.299	26.811	19.697
SMB	1,518.703	22.200	20.666
CKL	1,533.653	26.938	20.845
BKO	1,547.444	21.785	21.010
CUM	1,666.642	42.600	22.417
EY	1,740.625	33.994	23.276
EMH	1,802.899	38.700	23.992
CBE	1,836.758	10.881	24.377
KOP	1,929.189	16.411	25.419
AH	2,063.939	49.400	26.908
NL	2,117.552	29.141	27.491
GLD	2,199.861	86.205	28.374
WHR	2,243.181	33.500	28.834
MGR	2,263.601	27.400	29.049
SMF	2,786.601	45.800	34.292
IR	2,970.960	94.000	36.014
MSE	3,132.099	43.800	37.465
CSP	3,146.454	40.000	37.591
'2712B'	3,175.357	82.730	37.845
CZ	3,348.001	94.000	39.329
DI	4,016.299	58.300	44.529
SNE	4,266.484	222.635	46.253
DE	5,469.820	231.195	52.848
RCA	8,011.300	196.900	57.550
CAT	8,597.796	200.200	56.856
MC	13,689.902	476.333	22.796

Low Intermediate Group

	SALES	R&D	WEIGHT
´1849B´	0.000	0.000	1.078
´1901B´	0.000	0.000	1.078
´2756B´	0.012	0.138	1.078
HTCH	0.168	0.186	1.079
´2653B´	0.247	0.040	1.080
´1890B´	0.420	NA	1.082
NGEN	0.887	0.262	1.086
´2395B´	1.870	0.014	1.095
MTNH	2.057	NA	1.096
DOAK	2.099	0.051	1.097
GEOS	2.365	0.046	1.099
FZFM	2.384	0.088	1.099
´1977B´	3.105	0.000	1.106
´2722B´	3.559	NA	1.110
´2710B´	3.560	0.085	1.110
´2621B´	3.590	NA	1.110
ALOE	3.649	0.004	1.111
IDCC	3.923	0.000	1.113
SPCM	4.030	0.216	1.114
SHRW	4.276	NA	1.116
´1755B´	4.334	0.039	1.117
´1527B´	5.149	0.066	1.124
RAIC	5.630	0.095	1.129
CLAY	5.819	0.054	1.130
´2213B´	5.968	0.000	1.132
´1313B´	6.147	NA	1.133
´1821B´	6.329	0.048	1.135
´1836B´	6.352	0.025	1.135
´1455B´	6.525	0.059	1.137
´1452B´	7.465	0.144	1.145
´1030B´	7.982	NA	1.150
´1167B´	8.034	0.000	1.150
STGO	8.326	NA	1.153
AWST	10.172	NA	1.169
UNIF	11.397	0.036	1.180
NMR	11.495	0.079	1.181
WLC	12.131	0.200	1.187
´1257B´	12.548	0.148	1.191
KAYS	12.592	NA	1.191
KVU	13.487	0.088	1.199
NMCN	13.679	NA	1.201
VDRY	14.026	0.040	1.204
LPH	14.629	0.771	1.209
ALFD	15.708	NA	1.219
QUIX	16.052	0.792	1.222
CHSS	16.260	NA	1.224
SGMA	16.490	0.539	1.226
CTE	16.957	0.257	1.230
´1124B´	17.494	NA	1.235
VRSA	18.759	NA	1.247
SNMAC	19.248	NA	1.251
´1025B´	20.584	NA	1.263
CMP	21.218	0.160	1.269
WCEM	21.531	NA	1.271
HRUB	21.718	NA	1.273
JMCK	22.050	NA	1.276
POLY	22.557	NA	1.281
PSTI	22.783	NA	1.283
´1082B´	23.039	NA	1.285
´2726B´	23.221	0.000	1.287
´1008B´	24.013	0.200	1.294
RELX	24.560	0.508	1.299
GPO	27.227	NA	1.323

	SALES	R&D	WEIGHT
CONT	27.709	0.152	1.327
SHEL	28.483	0.642	1.334
NEWC	28.555	NA	1.335
JEFF	29.128	0.244	1.340
NGNA	29.414	0.346	1.342
GPCK	29.885	0.380	1.346
ARTB	30.092	NA	1.348
CHOM	31.029	2.494	1.357
´2579B´	32.434	0.856	1.369
SWED	32.594	1.772	1.371
FBTR	32.656	NA	1.371
EXL	34.271	0.232	1.386
JPC	35.136	0.782	1.394
SUPF	35.429	NA	1.396
NSTS	37.002	0.036	1.410
KROY	37.138	1.491	1.411
SVE	37.195	NA	1.412
DPKG	37.552	0.588	1.415
PBR	38.423	0.200	1.423
SUPDC	38.469	0.280	1.423
´1183B´	38.884	NA	1.427
SGMIA	39.251	0.100	1.430
BIWC	39.634	1.026	1.434
´SK.A´	40.879	0.489	1.445
VOT	43.094	NA	1.465
LIQB	43.776	0.445	1.471
DOBQ	44.220	0.110	1.475
ELDN	45.956	0.605	1.490
GSHL	46.170	0.363	1.492
PRC	47.716	1.608	1.506
LMR	50.015	0.648	1.527
STEW	50.938	0.000	1.535
ALTA	51.278	0.713	1.538
´2220B´	51.278	0.713	1.538
MOXE	51.280	NA	1.538
WEPC	54.440	0.700	1.566
GRV	55.054	2.114	1.572
OPRT	55.075	NA	1.572
SHAT	55.311	NA	1.574
DLI	55.370	0.616	1.575
CEC	56.142	1.235	1.582
SNI	59.025	0.000	1.607
TCG	60.425	0.471	1.620
MACD	60.720	2.710	1.623
OSL	60.823	0.196	1.623
´ATR.A´	63.755	0.031	1.650
ABW	64.247	NA	1.654
RDKN	65.553	1.669	1.666
GLDC	65.849	NA	1.668
OKT	67.660	1.185	1.684
ATA	71.204	NA	1.716
TR	72.303	NA	1.726
´1122B´	72.316	NA	1.726
MINL	73.214	NA	1.734
SPRL	73.417	NA	1.736
CDR	74.644	NA	1.747
BRSL	75.714	NA	1.756
DTRX	76.323	0.949	1.762
OJ	76.351	NA	1.762
LCO	76.732	NA	1.765
PRN	78.211	NA	1.779
FALB	78.722	NA	1.783
FCBN	79.314	NA	1.788

	SALES	R&D	WEIGHT
LAW	81.474	1.200	1.808
'1194B'	81.522	0.878	1.808
DRH	82.625	NA	1.818
MGU	86.108	NA	1.849
ROG	88.093	3.305	1.867
SEE	88.597	1.822	1.871
CFDS	89.636	0.087	1.880
LICIA	89.756	1.501	1.882
URI	91.536	NA	1.897
'1939B'	91.616	1.400	1.898
QCHM	93.483	3.672	1.915
CPY	95.750	0.718	1.935
APA	96.694	NA	1.943
TFCI	100.316	3.869	1.976
OREM	100.442	NA	1.977
MAUI	100.994	0.265	1.982
AFGN	101.196	NA	1.983
PM	105.136	1.531	2.018
ITC	105.820	0.229	2.024
CWED	107.206	2.599	2.037
LARS	108.647	0.115	2.050
'1037B'	117.101	NA	2.125
UFD	118.327	NA	2.136
'1237B'	118.347	0.000	2.136
REA	124.696	NA	2.192
VAL	136.629	3.629	2.298
GBND	139.562	2.200	2.324
CCBM	143.191	NA	2.356
PCT	147.395	NA	2.393
WST	148.174	3.600	2.400
PNT	148.655	2.300	2.404
RSRC	155.221	NA	2.462
RCS	156.621	3.384	2.475
SCL	157.517	5.006	2.483
ROB	158.653	0.000	2.493
HC	162.491	2.477	2.527
MKY	166.938	NA	2.566
FARM	168.860	0.219	2.583
MWK	180.704	1.074	2.687
BLOCA	184.032	4.267	2.717
BW	188.786	4.125	2.758
RELI	189.021	1.015	2.760
'2306B'	190.984	2.717	2.778
'CGL.A'	195.073	NA	2.814
JSTN	197.862	NA	2.838
LOC	199.297	5.014	2.851
ABL	201.732	NA	2.872
NOXLB	204.160	2.638	2.894
VMI	209.918	0.371	2.944
BETZ	212.607	5.965	2.968
SDT	218.012	0.346	3.015
SFDS	218.255	NA	3.017
ACV	229.261	2.396	3.114
CHD	232.224	0.323	3.140
KCC	233.663	0.100	3.152
CAR	236.958	13.801	3.181
FBG	248.186	1.072	3.279
'1443B'	250.798	2.449	3.302
PLIT	253.841	6.370	3.329
DINB	254.156	NA	3.332
CBF	269.262	0.000	3.463
LANC	289.641	NA	3.641
AMN	291.876	1.542	3.660
TRI	296.295	2.837	3.699
FULL	296.860	5.351	3.704
RBD	308.896	4.193	3.808
CTB	323.953	3.900	3.939
FLO	324.073	NA	3.940
AAE	326.379	8.076	3.960
HLY	326.599	1.470	3.962
BDG	330.918	1.889	3.999
OLYB	335.758	NA	4.041
DSO	337.608	15.305	4.057
'1320B'	341.576	0.715	4.091
DMC	346.399	NA	4.133
AGM	349.645	NA	4.161
MEI	349.720	NA	4.162
INP	351.973	1.998	4.181
CBI	357.628	NA	4.230
CMED	365.607	3.438	4.299
UFC	378.857	3.700	4.413
CSL	380.800	1.690	4.429
TYSN	390.319	0.400	4.511
KGM	400.467	NA	4.598
ARM	401.325	5.903	4.606
KNUD	411.191	0.698	4.690
'AZE.A'	413.707	1.555	4.712
RCC	438.076	NA	4.920
MALL	441.795	15.484	4.952
IFF	448.309	28.708	5.008
SAM	450.445	0.000	5.026
IDL	458.923	2.076	5.098
RAYC	462.377	31.900	5.128
DSY	465.952	NA	5.158
GRX	467.126	7.525	5.168
SNL	513.964	10.600	5.566
DEX	534.991	16.100	5.743
ABA	535.583	0.000	5.748
ECON	547.672	11.702	5.850
MCCRK	547.966	2.634	5.853
WWY	557.632	NA	5.934
HVU	572.830	NA	6.062
NLC	616.709	27.727	6.430
AVY	618.653	10.800	6.446
GEB	631.017	NA	6.549
CLX	637.433	11.854	6.602
INR	641.794	4.147	6.639
PRX	644.444	3.102	6.661
FOE	695.580	2.310	7.085
BLL	698.794	7.011	7.112
DAY	716.402	13.798	7.257
PABT	719.902	0.854	7.286
RVB	748.079	1.486	7.518
GCN	759.400	0.000	7.611
ARH	857.511	NA	8.411
ACCOB	887.897	14.256	8.657
SLZ	896.667	1.700	8.728
LZ	902.312	27.747	8.773
HSC	1,063.226	2.178	10.056
IMC	1,088.110	1.600	10.252
LOF	1,159.863	23.070	10.813
SHW	1,263.721	8.854	11.616
NRT	1,281.798	20.463	11.755
ASR	1,284.988	3.360	11.779
HRL	1,321.966	2.324	12.062
ACK	1,322.967	37.400	12.069

	SALES	R&D	WEIGHT
HSY	1,335.289	4.504	12.163
CAG	1,376.808	0.067	12.478
CBM	1,377.484	11.537	12.483
CBT	1,403.743	22.940	12.681
USG	1,474.371	13.009	13.211
GLW	1,529.670	78.767	13.621
STA	1,655.992	7.000	14.548
AYL	1,703.101	5.049	14.889
CSY	1,744.445	7.000	15.187
IGL	1,789.600	8.900	15.509
ITT2	1,866.037	7.510	16.051
SCM	1,892.392	34.200	16.237
HWR	2,141.411	NA	17.952
K	2,150.901	10.100	18.017
REV	2,203.323	69.391	18.369
GY	2,215.205	46.640	18.448
JM	2,266.803	30.500	18.792
OCF	2,285.065	39.514	18.913
R	2,299.462	36.000	19.008
GS	2,315.293	51.041	19.112
OAT	2,405.201	23.000	19.699
DKI1	2,423.699	27.700	19.819
CPB	2,560.568	22.300	20.694
NB1	2,568.685	13.166	20.745
AVP	2,569.099	30.000	20.748
ADM	2,802.010	2.294	22.190
ESM	2,924.886	11.100	22.928
AL1	2,932.000	31.000	22.970
NSI	3,012.771	8.554	23.446
NB	3,018.466	10.500	23.479
GR	3,079.597	49.434	23.834
KLU	3,222.099	18.100	24.647
CMK	3,236.221	11.900	24.726
BUD	3,295.401	NA	25.057
PSY	3,301.699	21.300	25.092
DLP	3,311.001	62.000	25.143
RLM	3,653.200	31.700	26.977
OI	3,905.699	26.900	28.251
CPC	4,120.300	35.700	29.281
BN	4,595.792	18.902	31.393
FIR	4,850.500	81.000	32.427
GIS	4,852.398	45.400	32.434
RAL	4,886.000	25.000	32.565
CL	5,130.460	46.282	33.485
AA	5,147.597	72.800	33.547
AL	5,215.000	47.000	33.788
CFD	5,342.855	16.297	34.233
GF	6,601.253	96.143	37.696
DKI2	6,998.101	27.300	38.445
GT	8,444.011	174.713	39.779
DKI	9,411.500	55.000	39.451
UL	10,343.000	135.000	38.209
PG	10,772.203	227.300	37.331
UN	13,818.003	209.000	25.567

Low Group

	SALES	R&D	WEIGHT
'2667B'	0.053	0.000	0.190
'2753B'	0.332	0.001	0.192
SOTC	0.613	0.001	0.194
SUNTC	0.884	0.048	0.196
TLET	1.142	0.064	0.197
'1589B'	1.453	NA	0.199
ALTC	1.560	NA	0.200
'2431B'	2.140	0.060	0.203
AMSK	2.157	0.008	0.203
SLRN	2.446	0.143	0.205
'2022B'	2.556	NA	0.206
TDYN	2.647	0.118	0.206
'2537B'	2.791	NA	0.207
'1516B'	2.863	0.058	0.208
NOVN	3.089	0.030	0.209
'1571B'	3.124	0.017	0.209
GAIR	3.316	0.000	0.210
GMCC	3.390	0.125	0.211
'2493B'	3.638	0.000	0.212
'2359B'	4.065	0.000	0.215
'1731B'	4.094	NA	0.215
'1772B'	4.112	NA	0.215
ALWS	4.319	0.000	0.216
EXPL	4.851	0.163	0.220
CFED	4.896	NA	0.220
'1536B'	5.204	0.000	0.222
'1242B'	5.569	0.156	0.224
'1795B'	6.296	NA	0.228
MCCL	6.646	0.000	0.231
'1965B'	6.714	0.000	0.231
'1451B'	7.084	0.085	0.233
'1147B'	7.156	0.000	0.234
'1442B'	7.608	NA	0.236
STLO	7.658	NA	0.237
'2464B'	8.445	NA	0.242
ATRO	8.839	0.000	0.244
'2826B'	9.514	NA	0.248
RSC	9.660	0.157	0.249
CUS	10.126	0.000	0.252
LCOR	10.664	0.013	0.255
'1088B'	11.355	0.025	0.259
REMM	11.380	NA	0.259
'2040B'	11.604	NA	0.261
'1035B'	11.616	NA	0.261
FAFO	12.030	0.595	0.263
'1203B'	12.124	NA	0.264
JI	12.169	0.103	0.264
RSMT	12.208	0.010	0.264
UPSNQ	12.931	0.113	0.269
'1331B'	12.972	0.075	0.269
BZOM	13.988	0.101	0.275
CVCO	14.223	NA	0.277
REUT	14.380	0.000	0.278
'2813B'	14.382	0.015	0.278
ALOY	14.705	NA	0.280
HOAN	15.233	0.000	0.283
BTEK	17.054	0.047	0.294
ENVR	17.640	NA	0.297
'1176B'	18.766	0.000	0.304
DRI	18.918	NA	0.305
TMTX	20.021	0.003	0.312
'1031B'	20.817	0.136	0.317
VALT	21.006	0.994	0.318

	SALES	R&D	WEIGHT
MCMN	21.581	NA	0.321
'2042B'	22.121	0.120	0.325
RYPK	22.954	0.172	0.330
BURS	23.241	NA	0.331
GBFH	24.146	0.175	0.337
NUCM	24.349	0.190	0.338
'2627B'	24.833	0.646	0.341
PCHN	25.840	0.813	0.347
POSL	26.938	0.104	0.354
'1136B'	27.329	NA	0.356
STUH	27.348	NA	0.356
PEN	27.923	NA	0.360
MKIV	28.332	0.310	0.362
KIT	28.801	NA	0.365
TRG	29.073	0.057	0.367
'1104B'	29.364	0.181	0.368
RAGN	29.750	0.161	0.371
CVR	31.280	NA	0.380
THFR	31.684	0.597	0.383
EAC	31.945	0.279	0.384
APIN	32.759	0.000	0.389
NID	34.114	NA	0.397
FLCP	34.346	NA	0.399
RDL	34.463	NA	0.399
AVMC	34.595	0.738	0.400
'2693B'	35.152	NA	0.403
CNR	36.925	NA	0.414
FRZ	37.567	NA	0.418
'1021B'	38.841	NA	0.426
IS	39.471	0.169	0.430
HFUR	40.003	0.000	0.433
ROWE	40.803	NA	0.438
PSTR	41.589	0.032	0.442
PREW	41.967	0.159	0.445
'1110B'	42.465	0.390	0.448
ENGH	43.702	NA	0.455
RAE	43.984	0.440	0.457
ACME	44.328	0.845	0.459
BEX	44.601	2.200	0.461
KFM	45.420	0.798	0.465
REG	46.162	NA	0.470
ANDG	46.455	1.517	0.472
FSCR	46.794	NA	0.474
HARC	47.870	NA	0.480
FAR	48.995	0.217	0.487
'1424B'	49.057	NA	0.487
BUF	49.129	0.340	0.488
SYO	49.414	0.088	0.490
'1148B'	49.617	NA	0.491
MDLN	49.740	0.334	0.491
'1978B'	50.044	NA	0.493
GHM	50.239	0.094	0.494
OMT	52.171	NA	0.506
UPRI	52.266	0.348	0.507
'1090B'	52.573	0.596	0.509
'2829B'	54.102	NA	0.518
KNAP	55.450	0.225	0.526
SLV	55.866	0.250	0.528
TWI	56.254	0.157	0.531
AMIR	59.221	NA	0.549
EML	60.581	0.500	0.557
SIF	61.557	NA	0.563
MTE	63.420	0.850	0.574

	SALES	R&D	WEIGHT
BSCF	63.770	NA	0.576
BERK	67.336	NA	0.597
AFUR	70.290	0.000	0.615
CRY	70.827	0.689	0.618
PLD	72.261	1.093	0.627
RIB	72.618	NA	0.629
SOG	76.440	0.898	0.652
KMOR	77.746	1.000	0.660
RESC	78.090	0.000	0.662
ZRO	79.266	NA	0.669
SUW	79.382	NA	0.669
LYON	80.205	0.517	0.674
STRM	80.337	0.239	0.675
ELCN	81.060	0.123	0.679
TJCO	82.247	0.845	0.686
ADIT	82.541	NA	0.688
NHX	83.482	0.455	0.694
TBP	88.965	1.459	0.727
HSI	89.565	1.776	0.730
FLXS	89.847	0.800	0.732
ZIM	90.035	0.420	0.733
FRD	90.265	0.000	0.734
DOUG	91.613	NA	0.742
AMZ	92.737	1.347	0.749
JAME	97.054	2.862	0.775
PCST	97.191	0.508	0.775
LDL	97.721	1.867	0.779
LB	100.029	NA	0.792
'1286B'	100.580	NA	0.796
HMW	101.172	0.405	0.799
CLV	107.593	0.900	0.837
DNT	109.066	NA	0.846
SCX	110.297	0.975	0.853
HASR	111.326	0.500	0.859
CLRK	111.890	0.804	0.863
OFER	113.171	NA	0.870
ICFT	115.837	1.148	0.886
APL	116.689	NA	0.891
'2827B'	117.044	NA	0.893
TRE	121.483	3.798	0.920
RBW	128.240	NA	0.959
KII	130.621	0.885	0.974
RBL	130.737	0.237	0.974
HXL	146.011	4.500	1.064
AO	146.963	NA	1.070
MIR	146.990	0.518	1.070
ASV	147.725	7.300	1.074
BNY	153.561	1.846	1.108
WMH	154.068	NA	1.111
LAZB	155.617	1.230	1.120
CRI	155.621	NA	1.121
WSAU	163.718	0.207	1.168
GFB	168.699	NA	1.197
RXH	168.902	2.110	1.198
CLOW	176.832	0.690	1.244
ABG	184.757	NA	1.291
'VAC.A'	185.967	2.152	1.298
'1288B'	188.260	0.950	1.311
CHB	195.293	0.103	1.352
HONI	201.846	1.166	1.390
TPC	207.692	NA	1.424
PNTA	210.852	0.100	1.442
DTOM	211.524	1.434	1.446

	SALES	R&D	WEIGHT
PHL	229.148	NA	1.547
LEG	229.194	1.500	1.548
CSHR	233.731	2.718	1.574
OHD	234.975	1.713	1.581
LMS	235.048	1.324	1.581
HUF	237.512	1.300	1.595
OMK	251.213	5.415	1.674
MLHR	252.740	6.986	1.683
BLI	256.559	NA	1.704
CSK	257.807	NA	1.711
NX	261.530	NA	1.733
GLT	262.808	1.252	1.740
MG	271.741	1.018	1.791
CDT	275.044	4.842	1.810
SKY	276.572	NA	1.818
GBC	285.594	NA	1.869
FLS	286.641	NA	1.875
NSD	312.876	3.396	2.023
UNR	316.415	0.936	2.043
PRE	317.470	1.900	2.049
ST	341.114	3.920	2.182
DBD	346.928	3.828	2.214
SXI	347.480	NA	2.217
LFBR	357.868	0.283	2.275
PDM	361.237	NA	2.293
BTLR	394.905	2.810	2.479
KES	396.136	0.190	2.486
FHP	397.403	1.452	2.493
ITW	401.654	6.047	2.517
SNA	401.799	4.831	2.517
NSW	426.072	NA	2.650
FLE	427.621	4.781	2.658
AP	430.711	NA	2.675
B	433.897	1.014	2.693
CCP	434.939	0.649	2.698
MY	486.613	1.963	2.977
SONO	490.397	NA	2.998
DSN	492.414	8.844	3.008
CPER	510.289	3.373	3.104
MNC	510.584	5.994	3.105
WYMN	550.215	3.484	3.315
CRS	559.060	13.400	3.361
RHH	571.245	3.762	3.425
WMC	577.490	7.189	3.458
MDC	579.233	1.000	3.467
TGT3	586.099	3.778	3.503
CFL	614.003	0.846	3.648
MLX	614.012	NA	3.648
BMS	662.413	12.008	3.896
CBH	682.261	4.723	3.997
SGS	695.504	8.225	4.064
ROM	709.350	1.565	4.133
SXP	709.601	NA	4.134
MOH	745.213	6.607	4.312
MAS	766.440	10.900	4.417
'1248A'	839.267	13.301	4.773
COT1	871.704	5.657	4.928
MLR	908.437	9.044	5.103
AD	914.868	NA	5.133
AG	923.528	8.027	5.174
SWK	939.790	5.700	5.250
GMT	992.671	NA	5.495
ACF	1,044.641	6.565	5.731

	SALES	R&D	WEIGHT
IK	1,055.883	NA	5.782
HML	1,182.837	2.500	6.341
DTC	1,383.769	0.555	7.174
W	1,409.911	14.222	7.278
CR	1,527.600	10.300	7.734
NAC	1,550.950	NA	7.822
UCC	1,574.825	16.146	7.911
MMB	2,039.278	6.837	9.470
SPP	2,083.233	31.259	9.600
'2586A'	2,516.950	NA	10.732
KMB	2,600.299	31.500	10.916
AST	2,673.589	27.000	11.070
MEA	2,707.200	31.000	11.138
SRT	2,714.174	10.212	11.152
BCC	3,018.939	5.008	11.685
ZB	3,069.800	12.600	11.760
MDE	3,599.641	42.300	12.311
NS	3,706.657	NA	12.371
CHA	3,752.717	NA	12.391
RS	3,760.041	18.707	12.394
WY	4,535.812	52.201	12.244
AC	4,812.199	41.000	11.970
IP	5,042.898	37.000	11.652
CCC	5,119.500	41.000	11.529
AS	5,678.000	29.900	10.362
BS	6,743.000	45.100	6.825
LTV1	8,009.601	41.030	0.379
X	12,492.101	56.100	41.972

Very Low Group

	SALES	R&D	WEIGHT
MEGCQ	0.000	0.000	0.556
TOTH	0.000	0.442	0.556
'2799B'	0.000	0.147	0.556
'1817B'	0.000	0.012	0.556
'2570B'	0.000	0.000	0.556
OGAL	0.000	0.032	0.556
PAN	0.000	0.000	0.556
'2439B'	0.000	0.012	0.556
MAGE	0.000	0.000	0.556
'2816B'	0.000	0.280	0.556
'2508B'	0.000	0.000	0.556
'2595B'	0.000	0.000	0.556
MPC	0.000	0.000	0.556
'2811B'	0.000	0.000	0.556
ARSD	0.021	0.000	0.556
SRES	0.022	0.000	0.556
UAEI	0.022	0.000	0.556
WNCO	0.023	0.000	0.556
TOLM	0.034	0.000	0.556
'1641B'	0.044	NA	0.556
'2694B'	0.056	0.000	0.556
TIMM	0.064	NA	0.556
RUMC	0.065	0.000	0.556
DTLC	0.073	0.022	0.557
'2541B'	0.074	NA	0.557
YG	0.083	0.000	0.557
STAR	0.085	0.018	0.557
CRAM	0.089	0.000	0.557
'2630B'	0.121	0.000	0.557
BGAL	0.138	0.000	0.557
COLX	0.155	NA	0.557
PAGO	0.157	0.000	0.557
JERE	0.173	0.000	0.557
'2244B'	0.179	0.000	0.557
CLVN	0.180	0.000	0.557
'1544B'	0.183	0.000	0.557
'2368B'	0.186	NA	0.557
'2384B'	0.197	0.009	0.557
HRTX	0.201	0.000	0.557
BRON	0.207	NA	0.557
'2732B'	0.213	NA	0.557
CAME	0.222	0.000	0.557
'2617B'	0.226	0.000	0.557
GAMX	0.240	0.677	0.558
'2507B'	0.249	0.000	0.558
'2298B'	0.253	0.000	0.558
'2327B'	0.265	NA	0.558
SSMC	0.274	0.000	0.558
'1753B'	0.291	0.000	0.558
CPET	0.298	0.000	0.558
FUEL	0.311	NA	0.558
KEBA	0.325	0.000	0.558
'2468B'	0.326	NA	0.558
'2622B'	0.334	0.000	0.558
'2323B'	0.337	NA	0.558
TOGS	0.341	0.000	0.558
'2709B'	0.347	0.011	0.558
BOLY	0.351	0.000	0.558
ITRC	0.354	0.000	0.558
BENE	0.385	0.514	0.558
CITGS	0.390	0.000	0.558
SHN	0.406	0.000	0.559
ZENY	0.410	0.000	0.559
'2584B'	0.413	0.000	0.559
'2358B'	0.430	0.000	0.559
'2747B'	0.433	NA	0.559
WULF	0.436	0.000	0.559
'2411B'	0.491	NA	0.559
LDAL	0.498	NA	0.559
'2363B'	0.502	0.025	0.559
USES	0.502	NA	0.559
'2601B'	0.521	0.000	0.559
MNNG	0.555	0.000	0.559
'2505B'	0.560	0.000	0.559
MOXA	0.565	NA	0.559
'1969B'	0.586	NA	0.560
'1754B'	0.618	NA	0.560
'2315B'	0.618	0.000	0.560
'1524B'	0.622	0.000	0.560
'2462B'	0.636	0.000	0.560
TAUR	0.640	0.000	0.560
SCH	0.649	0.000	0.560
TEMP	0.653	0.030	0.560
'2474B'	0.658	0.000	0.560
'2419B'	0.686	0.000	0.560
'2481B'	0.690	0.000	0.560
'2336B'	0.696	0.083	0.560
ROBV	0.705	1.097	0.560
'2091B'	0.708	NA	0.560
BENT	0.765	0.000	0.561
'1739B'	0.769	0.000	0.561
GAME	0.774	0.073	0.561
'1669B'	0.775	0.000	0.561
'2662B'	0.793	0.020	0.561
RYNMS	0.810	0.000	0.561
FREC	0.820	0.000	0.561
'2501B'	0.879	0.000	0.561
TERA	0.883	NA	0.561
'1899B'	0.924	NA	0.562
'2461B'	0.926	NA	0.562
PSMTS	0.936	0.000	0.562
PECO	0.961	0.000	0.562
ANTS	0.966	0.000	0.562
CDTS	0.977	0.000	0.562
ANPI	0.997	0.000	0.562
DSON	1.017	0.000	0.562
MDRTS	1.063	0.000	0.562
'2518B'	1.065	0.000	0.562
'2804B'	1.071	0.248	0.563
'1750B'	1.079	0.003	0.563
'1550B'	1.084	0.000	0.563
HEND	1.114	0.000	0.563
NRG	1.129	NA	0.563
'1477B'	1.140	0.000	0.563
'2257B'	1.161	0.000	0.563
DTRH	1.164	0.000	0.563
CYTX	1.186	0.081	0.563
TLTK	1.191	NA	0.563
ARET	1.205	0.000	0.563
'1855B'	1.213	0.000	0.563
USAC	1.218	0.002	0.563
LNINS	1.241	0.000	0.564
'2197B'	1.256	0.009	0.564
MRTRS	1.285	0.000	0.564
MUT	1.290	0.000	0.564
CENG	1.300	0.000	0.564

	SALES	R&D	WEIGHT
GROV	1.303	0.000	0.564
'2322B'	1.318	0.000	0.564
TRT	1.337	0.000	0.564
'2335B'	1.345	0.000	0.564
KYPTS	1.359	0.000	0.564
COGCA	1.369	NA	0.564
'2076B'	1.380	0.000	0.564
'2635B'	1.381	0.000	0.564
AFMIS	1.388	0.000	0.564
MMTGS	1.432	0.000	0.565
'2239B'	1.477	NA	0.565
'2498B'	1.483	0.000	0.565
REIPS	1.484	0.000	0.565
OXEX	1.518	0.000	0.565
DCT	1.519	0.000	0.565
'2330B'	1.548	0.000	0.565
'2458B'	1.551	0.000	0.565
'2663B'	1.560	0.013	0.565
'1667B'	1.561	NA	0.565
'2771B'	1.590	0.110	0.566
SPMC	1.599	0.002	0.566
LAFY	1.678	NA	0.566
ALST	1.696	NA	0.566
STOG	1.727	NA	0.566
CLSM	1.732	0.000	0.566
'1822B'	1.750	NA	0.567
SNLTF	1.778	0.000	0.567
'1895B'	1.780	0.000	0.567
TWC	1.786	0.000	0.567
'2460B'	1.796	0.000	0.567
'2425B'	1.797	0.000	0.567
MEO	1.860	NA	0.567
SLEC	1.862	NA	0.567
WALJ	1.870	0.000	0.567
TIRTZ	1.900	0.000	0.567
AMLE	1.904	0.000	0.568
'2484B'	1.905	0.000	0.568
'2010B'	1.919	NA	0.568
CMRTS	1.920	0.000	0.568
SDM	1.944	0.000	0.568
'2604B'	1.947	NA	0.568
'1950B'	1.966	0.000	0.568
PIUT	2.023	0.000	0.568
NUPC	2.035	0.000	0.568
KATE	2.049	0.000	0.568
'2556B'	2.071	0.000	0.569
HISI	2.084	0.323	0.569
'2228B'	2.091	NA	0.569
USMI	2.106	0.000	0.569
KCNI	2.142	0.000	0.569
ICSR	2.145	NA	0.569
'2211B'	2.151	0.000	0.569
'2085B'	2.159	0.039	0.569
FCARS	2.194	0.000	0.569
'2590B'	2.229	0.000	0.569
TOWRS	2.245	0.000	0.570
'2758B'	2.256	0.000	0.570
PKWY	2.260	0.000	0.570
'1577B'	2.286	NA	0.570
'1790B'	2.311	0.137	0.570
RRT	2.374	0.000	0.570
VYQT	2.391	0.000	0.570
RIVES	2.399	0.000	0.570

	SALES	R&D	WEIGHT
'2651B'	2.425	0.000	0.571
'1575B'	2.463	0.000	0.571
'2487B'	2.496	0.000	0.571
'2746B'	2.502	0.000	0.571
MTLR	2.515	NA	0.571
'1708B'	2.525	NA	0.571
FASTS	2.528	0.000	0.571
'2056B'	2.589	0.000	0.572
MINVS	2.591	0.000	0.572
RWES	2.591	NA	0.572
WMTGS	2.625	0.000	0.572
APITS	2.649	0.000	0.572
ORGN	2.660	NA	0.572
GRELS	2.684	0.000	0.572
'1523B'	2.703	0.000	0.572
CRTYZ	2.775	0.000	0.573
LFSC	2.792	0.000	0.573
'1807B'	2.829	0.090	0.573
'2475B'	2.838	0.000	0.573
CT	2.902	0.000	0.573
'1971B'	2.919	0.000	0.574
JOIN	2.965	0.000	0.574
'1499B'	2.982	NA	0.574
PRISS	3.011	0.000	0.574
'1593B'	3.020	NA	0.574
PENS	3.037	0.057	0.574
'1463B'	3.068	NA	0.574
'2496B'	3.109	0.000	0.575
IFII	3.172	0.000	0.575
'1981B'	3.271	NA	0.576
TTEC	3.276	0.058	0.576
HAMTS	3.297	0.000	0.576
'1785B'	3.334	0.070	0.576
GOCO	3.369	NA	0.576
TIER	3.389	0.000	0.576
ODRES	3.461	0.000	0.577
'1980B'	3.482	0.000	0.577
USEG	3.542	0.000	0.577
'1780B'	3.622	NA	0.578
HSMTS	3.681	0.000	0.578
'1491B'	3.795	0.000	0.579
'1522B'	3.798	NA	0.579
INV	3.869	0.000	0.579
PHOG	3.895	0.112	0.579
DIPC	3.904	0.056	0.580
PAYF	3.935	NA	0.580
YORK	3.944	NA	0.580
JMBRS	3.955	0.000	0.580
BAYS	3.970	0.000	0.580
'1881B'	3.997	0.000	0.580
'2564B'	4.012	NA	0.580
DMIS	4.067	0.237	0.580
DVAL	4.108	0.000	0.581
'1940B'	4.123	0.000	0.581
EDUC	4.160	0.618	0.581
PTRI	4.164	0.378	0.581
'2282B'	4.189	0.000	0.581
'2376B'	4.304	0.000	0.582
'1587B'	4.325	0.000	0.582
ETR	4.348	0.000	0.582
ATTV	4.372	NA	0.582
ESCI	4.377	0.583	0.582
HSO	4.377	0.000	0.582

	SALES	R&D	WEIGHT
AHMC	4.380	0.169	0.582
OILT	4.388	0.000	0.582
DMG	4.429	0.000	0.583
'1431B'	4.441	NA	0.583
'1505B'	4.501	0.000	0.583
CTRIS	4.508	0.000	0.583
'1596B'	4.600	0.000	0.584
INVX	4.603	0.000	0.584
VERY	4.614	0.000	0.584
MUTRS	4.630	0.000	0.584
'2620B'	4.657	0.000	0.584
'1033B'	4.664	0.049	0.584
KRMC	4.742	NA	0.585
PRCLS	4.767	0.000	0.585
'1686B'	4.819	0.000	0.585
'1621B'	4.872	0.000	0.585
DAAA	4.908	NA	0.586
'1056B'	4.932	0.000	0.586
FCRES	4.936	0.000	0.586
'1987B'	4.940	NA	0.586
APF	5.145	0.000	0.587
ETCO	5.188	0.082	0.587
TRYLS	5.345	0.000	0.588
'1154B'	5.370	NA	0.588
DCL	5.397	NA	0.588
DCOM	5.400	0.317	0.588
'1864B'	5.463	NA	0.589
'2543B'	5.493	0.000	0.589
'1595B'	5.511	0.000	0.589
SUM	5.580	0.000	0.590
INTO	5.610	0.000	0.590
FGLFS	5.620	0.000	0.590
'1541B'	5.632	0.000	0.590
ATCR	5.649	0.000	0.590
ALGO	5.787	0.136	0.591
EMPO	5.808	0.000	0.591
CENT	5.840	0.864	0.591
MRGN	5.866	0.000	0.591
BARR	5.868	0.476	0.591
BSPR	5.944	0.063	0.592
COMI	5.974	0.000	0.592
'1820B'	5.994	0.000	0.592
NTER	5.995	NA	0.592
WSPTS	6.061	0.000	0.592
'1467B'	6.062	0.000	0.592
'1991B'	6.087	NA	0.593
DTAB	6.109	0.085	0.593
USMRS	6.187	0.000	0.593
ANUC	6.208	0.000	0.593
'1453B'	6.216	NA	0.593
HCFDS	6.245	0.000	0.594
'2837B'	6.248	0.000	0.594
PTRAS	6.252	0.000	0.594
BTM	6.352	0.000	0.594
DTUN	6.456	0.000	0.595
FPM	6.611	0.000	0.596
CHEF	6.638	0.000	0.596
NUTS	6.650	NA	0.596
GTSC	6.674	0.000	0.596
CNSL	6.755	0.000	0.597
'1908B'	6.759	0.000	0.597
HAIC	6.809	0.010	0.597
'2054B'	6.856	0.000	0.597

	SALES	R&D	WEIGHT
MORA	6.952	0.000	0.598
'1692B'	7.101	0.000	0.599
SCFM	7.121	NA	0.599
CLFL	7.130	0.000	0.599
DMRTS	7.153	0.000	0.599
'1486B'	7.168	0.000	0.599
AMTC	7.169	0.037	0.599
YNK	7.216	0.000	0.599
SEP	7.293	0.000	0.600
TRCC	7.326	0.000	0.600
TMKT	7.334	0.155	0.600
USPTS	7.409	0.000	0.600
'1745B'	7.440	0.000	0.601
'1231B'	7.444	NA	0.601
ZFSH	7.492	0.000	0.601
NDAC	7.505	0.950	0.601
RNX	7.542	0.000	0.601
MTG	7.586	0.000	0.602
'2049A'	7.753	0.000	0.603
'2357B'	7.788	NA	0.603
'1252B'	7.792	NA	0.603
POLC	7.865	0.050	0.603
CLNP	7.937	0.000	0.604
'1362B'	8.041	0.000	0.604
BIFL	8.044	0.103	0.604
'2283B'	8.055	0.000	0.604
AUNL	8.068	NA	0.604
'1156B'	8.102	0.000	0.605
'1329B'	8.136	0.000	0.605
'1471B'	8.394	0.017	0.606
MHED	8.396	NA	0.606
GBD	8.410	NA	0.606
NZ	8.427	NA	0.607
URETS	8.473	0.000	0.607
DRCH	8.560	0.000	0.607
FRASS	8.579	0.000	0.608
TLRT	8.584	0.000	0.608
TRNT	8.602	NA	0.608
NECT	8.617	NA	0.608
NLTH	8.633	0.000	0.608
BLCK	8.659	0.000	0.608
'1222B'	8.704	NA	0.608
COME	8.782	0.312	0.609
POLA	8.828	NA	0.609
AUXT	9.041	1.200	0.610
'1087B'	9.065	NA	0.610
FECO	9.350	NA	0.612
MAGC	9.360	1.138	0.612
HADS	9.429	0.000	0.613
'1128B'	9.520	0.000	0.613
MTHA	9.544	0.000	0.613
'1502B'	9.643	0.000	0.614
CDEV	9.657	0.000	0.614
'1856B'	9.658	0.700	0.614
'2373B'	9.667	0.000	0.614
GNR	9.671	NA	0.614
MTMIS	9.717	0.000	0.614
'1810B'	9.754	NA	0.615
PETS	9.768	0.000	0.615
'1332B'	9.906	0.000	0.615
'1617B'	9.946	0.000	0.616
ESTO	9.949	NA	0.616
LROY	9.984	0.000	0.616

	SALES	R&D	WEIGHT
HRE	10.084	0.000	0.617
SSFT	10.176	0.885	0.617
'2686B'	10.284	0.000	0.618
MAHI	10.371	0.280	0.618
TRIN	10.406	0.100	0.618
'1721B'	10.430	NA	0.619
PRUF	10.514	0.579	0.619
NORS	10.539	NA	0.619
IRTC	10.587	0.276	0.620
'1230B'	10.633	0.000	0.620
DENVS	10.647	0.000	0.620
ACSC	10.669	NA	0.620
DBAS	10.700	0.048	0.620
COML	10.728	0.000	0.620
'1924B'	10.822	0.000	0.621
'1105B'	10.848	0.000	0.621
PYOL	10.885	NA	0.621
'1336B'	11.046	NA	0.622
WRI	11.076	0.000	0.622
PASQ	11.155	NA	0.623
SYSG	11.304	0.071	0.624
SMK	11.325	NA	0.624
SEALA	11.402	0.000	0.624
MCRA	11.412	0.000	0.624
CHKY	11.426	1.142	0.625
FDR	11.452	2.368	0.625
'1854B'	11.476	0.000	0.625
'1165B'	11.484	0.000	0.625
EDG	11.587	0.000	0.626
TSI	11.601	0.000	0.626
MCCA	11.845	0.000	0.627
CAMO	11.858	0.000	0.627
'1294B'	11.951	NA	0.628
'1178B'	12.017	0.000	0.628
AEST	12.060	1.557	0.628
FLAH	12.069	0.000	0.628
AFAP	12.086	0.041	0.629
JIFF	12.227	NA	0.629
UTC	12.297	0.000	0.630
NMC	12.390	NA	0.630
NOILU	12.462	0.000	0.631
MICH	12.541	0.000	0.631
'1309B'	12.578	0.000	0.631
'2018B'	12.583	0.040	0.631
NPAR	12.628	0.326	0.632
'2032B'	12.634	0.000	0.632
KMSI	12.685	0.056	0.632
'1238B'	12.915	0.000	0.633
AASS	12.934	0.000	0.634
SCIE	12.963	NA	0.634
AEQTS	13.177	0.000	0.635
'2383B'	13.202	NA	0.635
'2812B'	13.334	NA	0.636
TAR	13.341	0.000	0.636
DII	13.413	NA	0.636
'1214B'	13.547	0.047	0.637
NAM	13.695	0.000	0.638
'1964B'	13.758	0.000	0.639
LFTM	13.921	0.000	0.640
PRGS	14.019	NA	0.640
CCITS	14.077	0.000	0.640
ACMT	14.128	0.000	0.641
FBRC	14.135	0.000	0.641

	SALES	R&D	WEIGHT
VSCIC	14.247	0.984	0.641
ICOL	14.355	0.000	0.642
AESM	14.487	NA	0.643
AMTV	14.494	0.175	0.643
TLCO	14.499	1.619	0.643
SWTN	14.504	0.000	0.643
OLA	14.586	NA	0.643
'2055A'	14.694	0.000	0.644
LLA	14.741	NA	0.644
MCFE	14.747	NA	0.644
RPC	14.810	0.000	0.645
CPTD	14.838	NA	0.645
MID1	14.867	0.000	0.645
CMFG	14.915	0.060	0.645
SFCD	15.300	0.215	0.648
NOVUS	15.352	0.000	0.648
CTUC	15.535	2.612	0.649
'1665B'	15.691	0.000	0.650
EQTY	15.754	0.275	0.650
ARG	15.793	0.000	0.651
'2389B'	15.867	0.000	0.651
'2801B'	15.887	NA	0.651
CTUR	15.895	0.000	0.651
MOR	15.956	NA	0.652
HRLN	15.991	0.000	0.652
SHOS	16.074	0.000	0.652
HFIN	16.251	NA	0.653
CHIC	16.277	0.000	0.654
ACT	16.282	0.000	0.654
SHAH	16.293	0.175	0.654
KEYDQ	16.460	0.731	0.655
SADL	16.482	1.100	0.655
EMON	16.539	0.000	0.655
KTI	16.790	0.000	0.657
'1229B'	16.830	NA	0.657
ACTP	16.838	0.146	0.657
MGMA	16.862	0.018	0.657
CMTI	16.952	0.000	0.658
'1269B'	16.972	0.000	0.658
AMTD	17.012	0.000	0.658
KEAN	17.322	0.445	0.660
AORGB	17.349	0.397	0.660
'1375B'	17.419	0.000	0.660
EPRO	17.488	0.245	0.661
'2083B'	17.569	NA	0.661
KIDD	17.638	0.047	0.662
FLWR	17.687	0.000	0.662
MML	17.837	0.000	0.663
FCP	17.847	0.000	0.663
MREC	17.857	NA	0.663
'1036B'	17.958	NA	0.664
KC	18.309	NA	0.666
'1863B'	18.489	0.000	0.667
'1975B'	18.514	0.000	0.667
SDN	18.668	0.000	0.668
'1204B'	18.987	0.000	0.670
DOCO	19.057	NA	0.670
'1363B'	19.110	0.050	0.671
SANS	19.260	NA	0.671
BULDS	19.353	0.000	0.672
MACG	19.367	0.000	0.672
'1139B'	19.416	0.000	0.672
'1352B'	19.466	0.000	0.673

	SALES	R&D	WEIGHT
TPTR	19.474	0.000	0.673
FORM	19.496	NA	0.673
REAT	19.550	NA	0.673
SOFT	19.606	0.031	0.674
ANLY	19.880	0.000	0.675
A	19.953	0.000	0.676
HOMC	19.962	0.000	0.676
SSCN	20.140	0.000	0.677
CIG	20.331	0.000	0.678
NOWT	20.410	0.000	0.678
FGLS	20.657	0.000	0.680
KWN	20.692	0.000	0.680
BAY	20.945	0.000	0.682
SM	20.986	0.000	0.682
'1657B'	21.076	NA	0.682
GIBS	21.125	NA	0.683
RAPD	21.172	1.110	0.683
PAMX	21.178	NA	0.683
'1123B'	21.341	0.000	0.684
CLPP	21.501	0.000	0.685
PRGR	21.754	NA	0.686
BDOL	21.853	0.000	0.687
NATH	21.864	NA	0.687
'1663B'	21.932	NA	0.687
BRC	21.967	0.000	0.688
HAWK	22.249	NA	0.689
MPO	22.527	NA	0.691
STGH	22.635	NA	0.692
ASCY	22.709	0.000	0.692
SEAG	22.854	0.000	0.693
GBR	22.990	NA	0.694
EMPC	23.055	NA	0.694
SEIC	23.060	2.358	0.694
VRT	23.108	0.151	0.695
CHZC	23.171	0.000	0.695
LML	23.194	0.000	0.695
MFAC	23.226	0.861	0.695
'1652B'	23.298	0.000	0.696
SIPP	23.377	1.326	0.696
CRW	23.448	0.241	0.697
'1132B'	23.618	NA	0.698
EVS	23.643	NA	0.698
CLK	23.654	NA	0.698
BIK	23.716	0.000	0.698
'2665B'	23.743	0.000	0.698
'1131B'	24.083	0.071	0.700
BRE	24.357	0.000	0.702
NML	24.458	0.000	0.703
COPB	24.465	0.000	0.703
'1382B'	24.613	NA	0.704
'1415B'	24.730	0.000	0.704
NRRD	24.887	NA	0.705
'2349B'	24.938	NA	0.705
FLC	25.713	0.000	0.710
WC	25.733	0.000	0.710
MYM	25.832	0.000	0.711
BACO	26.272	NA	0.713
AMRX	26.492	NA	0.715
GNRLF	26.564	0.000	0.715
WAXM	26.585	NA	0.715
JONB	26.874	NA	0.717
CDU	26.902	NA	0.717
DRCO	27.296	1.409	0.720

	SALES	R&D	WEIGHT
WHAM	27.464	0.542	0.721
CLTH	27.529	0.000	0.721
STSC	27.608	2.948	0.721
PIX	27.660	NA	0.722
'1445B'	27.673	NA	0.722
BKR	27.686	NA	0.722
ATQ	27.943	0.190	0.723
HAMB	28.444	0.000	0.726
OAR	28.618	0.323	0.727
ROSE	28.877	NA	0.729
'1188B'	29.031	0.000	0.730
UNA	29.042	0.000	0.730
'2787B'	29.106	0.000	0.730
TDD	29.170	0.000	0.731
CULD	29.351	3.563	0.732
CHZM	29.687	NA	0.734
JBBB	29.701	0.000	0.734
PAKS	30.085	0.000	0.736
TGL	30.106	0.000	0.736
IKNG	30.227	0.000	0.737
TELE	30.241	NA	0.737
KFUR	30.344	0.000	0.738
ALON	30.413	0.241	0.738
SLG	30.852	NA	0.741
CUMS	31.065	0.138	0.742
CALI	31.428	0.183	0.744
JLN	31.676	0.695	0.746
ALFMA	31.704	0.091	0.746
CACSC	31.995	0.000	0.748
MATH	32.072	0.809	0.748
SAG	32.555	0.000	0.751
FHOL	32.614	NA	0.751
SJW	32.746	0.000	0.752
FTX1	32.835	0.000	0.753
NHRD	32.858	0.000	0.753
OILC	33.072	0.598	0.754
CCPLS	33.085	0.000	0.754
CSA	33.213	NA	0.755
WFM	33.257	0.000	0.755
MBRS	33.303	NA	0.756
SIRC	33.469	0.054	0.757
MTR	33.899	0.000	0.759
DYTR	34.362	1.586	0.762
'2438B'	34.706	0.000	0.764
'1378B'	34.875	0.000	0.765
KIDS	34.886	0.000	0.765
WTHR	35.384	0.400	0.768
MBC	35.475	NA	0.769
CDN	35.919	0.557	0.771
HDR	36.112	NA	0.772
ANTM	36.215	NA	0.773
'1126B'	36.393	NA	0.774
PROP	36.644	0.396	0.776
PRA	36.732	NA	0.776
'ADR.B'	37.126	4.297	0.778
SRB	37.186	NA	0.779
JWI	37.706	NA	0.782
WEIS	37.733	0.000	0.782
CHHC	38.143	0.070	0.784
MHL	38.287	0.000	0.785
VANS	38.561	0.000	0.787
TEAM	38.811	NA	0.788
FF	38.829	0.000	0.789

	SALES	R&D	WEIGHT		SALES	R&D	WEIGHT
UVR	38.899	0.000	0.789	WLB	56.671	NA	0.895
'1884B'	39.021	0.298	0.790	PDPR	56.728	NA	0.896
HTIG	39.072	0.000	0.790	'1245B'	56.759	0.000	0.896
SORG	39.391	0.138	0.792	ACX	57.335	0.000	0.899
TT	39.551	0.852	0.793	IU1	57.664	0.000	0.901
'1141B'	39.895	NA	0.795	UT3	57.898	0.000	0.903
WLKS	40.477	0.000	0.798	WENT	58.263	0.000	0.905
CGM	40.696	0.000	0.800	PBCO	58.431	NA	0.906
'1439B'	40.729	NA	0.800	AMSY	58.505	4.142	0.906
NEX	41.076	NA	0.802	LBN	59.637	0.692	0.913
AWS	41.151	0.413	0.802	EAZR	59.728	0.000	0.914
JWAT	41.174	NA	0.803	DUNK	60.358	0.074	0.917
GSCC	41.578	0.117	0.805	RCIN	60.506	1.566	0.918
CLNY	41.737	0.000	0.806	BRND	60.959	NA	0.921
DSIC	41.809	NA	0.806	ASA	61.399	0.000	0.924
JUDY	41.843	0.000	0.807	NATO	62.030	0.000	0.927
NTPC	42.448	0.000	0.810	VLCC	62.081	0.000	0.928
WRIT	42.666	0.360	0.812	FLLM	62.353	0.000	0.929
HLAB	43.245	0.001	0.815	PJH	62.362	NA	0.929
WAVR	43.701	NA	0.818	UCT	62.838	NA	0.932
SDOL	43.873	0.000	0.819	COM	63.147	0.000	0.934
SEL	44.136	0.725	0.820	SDL	63.221	1.111	0.934
'1024B'	44.544	0.000	0.823	NLX	63.260	0.428	0.935
'1338B'	44.872	0.000	0.825	DIXN	63.323	0.152	0.935
MSAI	45.231	12.400	0.827	LYND	63.383	NA	0.935
LAWH	45.526	0.000	0.829	NEBS	63.710	0.500	0.937
COVT	45.543	0.053	0.829	DWWS	64.688	NA	0.943
HRWD	45.571	NA	0.829	FCI	66.810	0.000	0.956
PATK	46.728	NA	0.836	MGO	66.949	1.198	0.957
FMIF	46.982	0.000	0.837	MPI	67.180	0.776	0.958
EQ	47.090	0.000	0.838	TLAM	67.263	NA	0.959
BGLY	47.289	0.000	0.839	MYES	67.473	NA	0.960
'1285B'	47.292	NA	0.839	TITNC	67.476	NA	0.960
LDYN	47.349	0.917	0.840	MH	67.724	NA	0.961
FRTX	47.838	NA	0.842	INTG	68.389	NA	0.965
LBY	47.849	0.321	0.843	PI	69.318	0.000	0.971
BSCC	47.873	0.000	0.843	LSB	70.570	0.315	0.978
HGC	48.041	NA	0.844	CIS	71.230	0.900	0.982
BGS	48.050	0.020	0.844	OCER	71.690	0.091	0.985
VLM	48.181	0.000	0.845	XCORA	71.848	1.556	0.986
SCPT	48.241	0.114	0.845	SGC	72.940	NA	0.992
FUR	48.373	0.000	0.846	MAM	73.137	0.000	0.994
LVX	48.849	0.000	0.849	AHST	75.330	0.000	1.007
ADE	48.879	2.424	0.849	BD	75.429	0.310	1.007
SHAA	49.303	NA	0.851	CRL	75.618	0.000	1.008
LOM	49.567	0.000	0.853	NDTA	75.666	0.876	1.009
BRG	49.613	NA	0.853	RXCH	76.416	NA	1.013
WOD	49.830	NA	0.854	HMEY	76.608	0.000	1.014
GULF	50.487	NA	0.858	CDC	76.664	1.211	1.015
XYZL	51.814	NA	0.866	HCH	76.785	0.728	1.015
IMPL	51.919	0.875	0.867	FGN	77.065	0.973	1.017
ARI	51.988	NA	0.867	ALL	77.419	NA	1.019
GATW	52.604	0.135	0.871	CSRE	78.208	4.942	1.024
SGAL	53.005	0.000	0.873	'1225B'	78.371	NA	1.025
DGC	53.681	1.420	0.877	RAUT	78.387	NA	1.025
SDCO	54.442	0.000	0.882	SPTN	79.506	0.146	1.032
ZOND	54.460	NA	0.882	WIEL	79.974	1.079	1.035
'1023B'	54.872	0.000	0.885	ADSNB	80.011	NA	1.035
RPCH	55.393	1.052	0.888	UT7	80.057	NA	1.035
GGP	55.559	0.000	0.889	TEI	80.461	0.000	1.037
MSST	55.637	NA	0.889	MSR	80.484	0.000	1.038
'1376B'	55.845	0.000	0.890	IHP	81.716	0.000	1.045
LGN	56.004	0.257	0.891	FMP	81.885	1.128	1.046

	SALES	R&D	WEIGHT
TAC	82.887	NA	1.052
ALFT	83.422	NA	1.055
PHRS	83.640	0.000	1.056
'2793A'	83.680	1.067	1.057
EBF	83.970	NA	1.058
BFS	84.320	0.000	1.060
WUR	84.828	2.383	1.063
RBI	85.162	NA	1.065
EVAN	86.569	0.000	1.074
SSOL	86.750	0.000	1.075
PBAC	87.138	NA	1.077
'1287B'	87.731	NA	1.081
FOIL	88.194	0.000	1.084
ALY	88.327	0.000	1.084
OLST	89.278	0.000	1.090
CLB	89.398	1.616	1.091
LUBY	89.893	0.000	1.094
FRG	90.012	0.351	1.094
MFYI	90.062	0.000	1.095
CSTL	90.433	0.000	1.097
'1184B'	91.257	NA	1.102
WNK	92.091	0.000	1.107
AFIL	92.120	0.600	1.107
BTK	92.469	NA	1.109
GL	93.471	NA	1.115
LWIS	95.478	0.000	1.127
MP	96.453	NA	1.133
MAF	96.564	0.000	1.134
SWV	96.860	0.447	1.135
CDCK	97.363	NA	1.138
CTL	98.048	NA	1.142
WLHN	99.639	NA	1.152
HAS	100.654	2.333	1.158
'ATX.A'	100.922	0.279	1.160
TKA	101.119	1.484	1.161
MOSE	101.418	0.000	1.162
ROPO	102.763	0.185	1.171
MRCS	105.346	NA	1.186
SMED	105.588	8.205	1.187
MOS	110.529	0.105	1.217
HAML	111.366	NA	1.222
SGB	112.907	NA	1.231
PICN	113.550	0.000	1.235
CHFM	113.586	1.308	1.235
AIRL	114.285	0.000	1.239
GILM	114.583	NA	1.241
ERBL	114.985	0.000	1.243
PICC	115.391	0.000	1.246
SYRA	115.936	NA	1.249
BAYL	116.643	0.000	1.253
CLGN	116.706	NA	1.254
BFLD	116.765	0.000	1.254
WLY	117.828	2.500	1.260
DNNR	118.270	0.000	1.263
FKS	119.345	0.000	1.269
ROUS	119.466	0.000	1.270
GYL	119.649	0.000	1.271
SUO1	119.891	0.903	1.273
BHY	121.254	NA	1.281
STRS	121.972	NA	1.285
GDX	122.012	0.000	1.285
'1234B'	122.576	0.433	1.289
FRA	122.680	0.286	1.289

	SALES	R&D	WEIGHT
SHGO	124.377	0.000	1.299
TCOMA	124.395	NA	1.300
PZA	124.670	0.000	1.301
UBU	125.245	0.000	1.305
IMAT	125.893	5.880	1.308
CHRS	126.104	0.000	1.310
CEM	126.309	2.036	1.311
RGB	126.815	0.892	1.314
GAN	128.481	NA	1.324
'1454B'	129.821	0.000	1.332
MUN	133.530	0.632	1.354
VSTA	134.929	0.000	1.362
TMCLC	135.335	NA	1.365
CRAW	135.573	0.000	1.366
IMI	136.955	1.739	1.374
PHI	138.813	0.000	1.385
SEGA	139.567	1.662	1.390
TMBR	139.621	0.140	1.390
WF	140.127	NA	1.393
CN	140.807	0.934	1.397
ID	141.397	8.103	1.401
UNFI	142.891	0.850	1.410
MDI	143.230	NA	1.412
'1322B'	143.677	0.000	1.414
TXF	144.544	NA	1.420
OSHM	144.889	NA	1.422
INX	146.606	0.000	1.432
JCBS	147.608	0.000	1.438
UT4	147.834	0.000	1.439
BKFS	148.262	0.000	1.442
SNC	148.924	NA	1.446
OBOD	149.543	NA	1.449
FCA	149.674	NA	1.450
SPV	150.503	NA	1.455
PAYP	151.684	0.275	1.462
DCNY	151.756	NA	1.462
BB	156.453	NA	1.490
TULL	157.835	NA	1.499
BNTA	158.741	NA	1.504
HF	158.774	0.000	1.504
LTLE	159.781	NA	1.510
GTE13	161.196	0.000	1.519
WII	162.179	1.265	1.525
CLO	162.907	4.235	1.529
WIE	164.855	0.000	1.540
PCAI	165.110	0.300	1.542
SRR	166.018	NA	1.547
FDO	166.854	0.000	1.552
MJW	166.910	0.000	1.553
'1047B'	168.271	2.542	1.561
IMSI	169.820	0.230	1.570
VOLT	169.846	1.577	1.570
HECH	170.445	0.000	1.574
SLCR	170.819	0.490	1.576
'1001B'	171.071	NA	1.577
CTR	171.431	0.907	1.580
CRD1	172.696	NA	1.587
CLE	173.992	NA	1.595
GEE	174.295	0.000	1.597
CLEA	174.477	0.000	1.598
DUCK	174.565	0.000	1.598
KRUE	175.396	NA	1.603
CVI	175.914	0.000	1.606

	SALES	R&D	WEIGHT
CSS	176.064	0.000	1.607
EFU1	177.940	NA	1.618
AGL	180.902	NA	1.636
TTX	181.740	0.435	1.641
BKY	186.415	1.700	1.669
ABP	186.487	NA	1.669
NRL1	187.021	2.600	1.672
TFI	189.117	0.000	1.685
GILBA	189.283	0.330	1.686
HLME	197.320	0.000	1.733
DPX	197.799	NA	1.736
ELK	201.181	0.580	1.756
SBP	202.086	0.413	1.762
ELDR	203.981	0.000	1.773
ANT	204.019	1.000	1.773
TILE	207.089	NA	1.791
ADG	207.114	0.000	1.792
'1012B'	208.210	NA	1.798
HIGB	208.869	0.000	1.802
SHX	213.069	NA	1.827
KBALB	215.138	1.400	1.839
SHON	215.517	NA	1.842
PEC	216.076	NA	1.845
CRD	216.161	0.000	1.845
'1032B'	216.654	0.430	1.848
IBK	219.016	1.400	1.862
UT5	219.096	0.000	1.863
BJ	220.620	NA	1.872
NOZ	230.436	0.000	1.930
GC	230.827	0.000	1.932
GAO	234.464	0.000	1.954
TYM	235.342	12.232	1.959
GOI	239.182	5.258	1.982
GFD	242.635	1.000	2.002
FAY	243.117	0.000	2.005
VLGE	245.295	NA	2.018
SHB	245.879	0.000	2.022
BIBB	246.002	NA	2.022
WOA	247.807	0.000	2.033
TWN	248.973	NA	2.040
APC	257.699	NA	2.092
IPIPF	258.456	NA	2.096
DRUGA	259.009	0.000	2.099
MSM	264.795	0.000	2.134
CF	265.221	NA	2.136
LIMT	265.333	0.000	2.137
UBO	265.762	1.375	2.139
POW	265.832	NA	2.140
GTE8	267.499	0.000	2.150
TMI	272.396	NA	2.179
NRL	275.522	2.600	2.197
GTE4	278.705	NA	2.216
MYFR	279.552	0.000	2.221
SLT	280.700	NA	2.228
PLN	280.886	0.550	2.229
CBC	284.569	0.000	2.251
SREG	288.866	3.445	2.276
JOS	295.077	NA	2.313
REP	295.826	NA	2.317
CQ	299.726	11.709	2.340
CLN	300.481	3.500	2.345
'1292B'	305.596	0.000	2.375
ADD	307.447	0.000	2.386

	SALES	R&D	WEIGHT
WOOD	308.370	0.000	2.392
AVD	310.325	NA	2.403
CHHO	312.508	0.000	2.416
BIRD	313.162	2.299	2.420
JERR	313.551	NA	2.422
MFD	313.990	0.000	2.425
'1016B'	314.032	NA	2.425
'1307B'	315.506	0.000	2.434
MORR	319.812	NA	2.459
RVS	321.969	1.482	2.472
HB	326.483	1.779	2.499
PON	334.048	NA	2.543
GVL	341.120	NA	2.585
ANX	343.363	NA	2.598
MDP	349.000	NA	2.632
PTN	353.413	NA	2.658
HII	356.731	0.000	2.677
SEWY	357.113	0.000	2.679
KKUL	359.911	0.000	2.696
ABY	365.525	11.276	2.729
SML	368.348	0.000	2.746
OCQ	368.738	NA	2.748
GPS	369.841	0.000	2.755
SED	372.904	0.961	2.773
CUC	376.354	0.900	2.793
KAMNA	381.380	2.528	2.823
PKD	383.080	NA	2.833
SH	384.559	NA	2.841
STRW	390.174	0.000	2.874
PII	396.600	NA	2.912
MFS	399.595	0.161	2.930
ROL	400.386	NA	2.934
BNL1	405.112	0.000	2.962
NOBE	407.813	0.000	2.978
BIV	407.872	NA	2.979
KELY	409.680	NA	2.989
FSM	412.890	0.000	3.008
PNF	418.757	NA	3.043
MB	420.732	13.878	3.054
CCF	427.890	0.000	3.096
RTX	433.523	1.458	3.129
NCS	434.430	0.000	3.135
SVB	434.748	18.840	3.137
ALVLB	437.525	0.000	3.153
GSE	441.342	10.504	3.175
DYN	442.618	0.631	3.183
WSN	448.098	4.222	3.215
AUD	454.934	13.786	3.255
NIKE	457.742	4.100	3.272
BRNO	458.629	0.000	3.277
WRC	465.009	NA	3.314
RDK	465.896	0.066	3.320
FA	468.865	0.000	3.337
'TFT.A'	473.460	NA	3.364
HRD	476.582	NA	3.382
'1979B'	480.100	NA	3.403
FGRP	480.448	0.000	3.405
KB	491.829	NA	3.472
HBO	502.800	3.600	3.536
ALX	505.086	0.000	3.550
'2700A'	515.050	0.218	3.608
RSTO	526.288	0.000	3.674
FLD	527.229	7.290	3.679

	SALES	R&D	WEIGHT
CDISF	528.090	0.000	3.684
DJ	530.700	1.179	3.700
QASU	534.833	0.000	3.724
MLL	566.020	NA	3.906
KWD	590.096	0.585	4.047
VNO	591.469	NA	4.055
CK	603.912	6.800	4.127
DML	607.737	1.462	4.150
EGG	613.093	10.400	4.181
LST	620.475	2.000	4.224
UMM	621.974	0.886	4.233
HD	623.534	0.954	4.242
GRA1	631.304	0.000	4.287
FALCF	634.291	5.554	4.305
GRE	638.312	2.802	4.328
'2675B'	639.118	0.000	4.333
BLT	651.013	0.350	4.402
RII	653.034	0.095	4.414
CAN	659.648	NA	4.452
TCT	660.802	1.510	4.459
NSH	671.086	16.465	4.519
'BBC.A'	673.704	NA	4.534
HSM	674.888	NA	4.541
GAF	677.216	8.634	4.555
MOM	678.759	0.000	4.563
BLY	679.113	3.200	4.566
DWR	706.958	NA	4.727
ICA	713.703	0.000	4.767
'2788A'	721.212	2.400	4.810
PKR	723.268	3.243	4.822
MLN	724.889	0.000	4.831
KDT	729.685	0.000	4.859
COE	729.885	NA	4.860
PAY	750.947	0.000	4.983
VMC	753.980	3.251	5.000
ACA	755.688	2.000	5.010
WU1	758.004	5.400	5.024
HLR	771.720	0.000	5.103
GWW	782.571	NA	5.166
WU	794.203	5.100	5.233
ETX	824.068	NA	5.406
KSF	832.492	NA	5.454
BPC	836.933	NA	5.480
EBS	853.389	0.000	5.575
CULL	864.974	NA	5.642
SMCH	865.017	0.000	5.642
CRT	868.227	NA	5.661
LOW	883.614	0.000	5.749
LDG	893.198	0.000	5.805
MAT	915.690	22.692	5.934
LTC	943.856	NA	6.096
SFS	968.824	NA	6.239
LTR1	969.685	4.328	6.244
UVX	970.246	1.429	6.248
MEYR	972.818	0.000	6.262
USR	973.632	NA	6.267
PNC	983.777	0.959	6.325
'1278B'	985.030	NA	6.332
CAL	992.019	0.000	6.373
UVV	992.373	NA	6.375
BRF	1,000.795	NA	6.423
EFU	1,002.727	NA	6.434
MF	1,012.501	NA	6.490
FLIC	1,061.153	0.000	6.768
KRN	1,098.537	NA	6.982
PEL2	1,100.258	NA	6.992
DNY	1,111.258	NA	7.054
DRV	1,113.925	4.400	7.070
USI	1,144.664	NA	7.245
WIT	1,175.695	14.600	7.421
SYY	1,198.355	NA	7.550
BG	1,220.884	NA	7.678
WPM	1,245.569	1.100	7.818
AVT	1,266.804	NA	7.938
RDS	1,310.404	0.000	8.185
FHFC	1,389.946	NA	8.634
FHR	1,412.962	0.000	8.763
PD	1,440.137	8.500	8.916
PC2	1,481.000	NA	9.145
'GFS.A'	1,483.476	NA	9.159
WAG	1,530.722	NA	9.424
AMF	1,534.030	30.441	9.442
ECK	1,547.753	0.000	9.519
FWC	1,562.542	10.000	9.602
NWA	1,639.330	0.000	10.030
WMT	1,643.199	0.000	10.051
'1219A'	1,668.370	0.000	10.191
MDA	1,769.739	NA	10.753
MCL	1,804.781	14.623	10.947
AR	1,817.032	6.073	11.015
MHI	1,854.466	NA	11.221
UT	1,903.987	3.397	11.494
STN	1,915.958	4.248	11.560
AMA	1,922.398	4.063	11.595
GST	1,933.842	0.996	11.658
JWC	1,966.613	6.898	11.837
PC	2,013.700	NA	12.095
DLL	2,083.761	0.000	12.478
'2707B'	2,159.489	NA	12.890
MCD	2,184.344	NA	13.025
ISS	2,368.456	NA	14.019
MZ	2,373.530	0.000	14.046
TOS	2,387.240	6.247	14.120
PEL	2,472.233	NA	14.575
E1	2,536.080	0.000	14.916
E	2,627.785	0.000	15.404
'1900B'	2,658.609	2.250	15.568
BUR	2,900.648	6.000	16.843
TXC	2,932.160	10.503	17.008
AMX	2,949.169	26.530	17.097
N	3,036.097	49.012	17.550
ABS	3,039.128	0.000	17.566
GOC	3,373.000	38.000	19.288
KMG	3,477.880	8.800	19.823
DH	4,033.536	0.000	22.610
FOR	4,132.582	1.979	23.098
LTR	4,266.117	6.123	23.752
TET	4,272.851	0.183	23.785
AMB	4,276.523	21.272	23.803
CHR	4,518.113	6.742	24.974
'1970B'	4,744.601	3.228	26.059
SLC	4,758.652	1.067	26.125
SLB	4,883.941	188.152	26.719
BCA	5,053.035	165.156	27.514
'IMO.A'	5,091.000	41.000	27.691
WIN	5,388.976	NA	29.070

	SALES	R&D	WEIGHT
ASC	6,419.882	0.000	33.664
GAP	6,989.527	NA	36.084
ASH	8,118.367	14.179	40.630
MRO	8,179.750	16.800	40.867
HAL	8,327.300	64.075	41.435
RJR	8,449.000	NA	41.898
GTE	9,978.871	162.000	47.398
UCL	9,984.097	25.300	47.416
GET	10,150.402	NA	47.977
SOH	11,023.203	24.499	50.803
OXY	12,476.101	63.500	55.067
SUN	12,945.003	36.000	56.326
P	13,376.601	84.259	57.435
SA	15,102.703	NA	61.383
BTI	18,264.003	53.000	66.604
CLL	18,325.503	55.307	66.680
SUO	19,830.003	155.000	68.227
ARC	23,744.304	138.300	69.494
SN	26,133.105	108.337	68.308
PB	26,570.007	13.200	67.930
SC	31,568.007	211.000	60.078
SD	40,479.011	132.534	29.954
RD	47,352.011	317.000	7.393
BP	49,368.011	148.000	20.679
T	50,791.214	418.800	30.695
MOB1	51,875.015	135.000	38.676
MOB	59,510.015	143.000	103.559
MITSY	70,797.062	NA	227.262
XON	103,143.000	489.000	765.372