AN ECONOMIC ANALYSIS OF STATE LICENSING OF NURSING LABOR

by

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

1975

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

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Acknowledgements

Upon completion of a dissertation, an author will often pause and realize that what began largely as an individual effort has culminated in a collective effort. This has certainly been the case with my thesis. I have benefited greatly by interacting with and learning from a number of individuals as my research progressed.

I cannot, in a brief paragraph, adequately express my thanks to Professor Michael Grossman, Chairman of my dissertation committee. Professor Grossman was a continual source of enlightenment and encouragement. He unselfishly devoted much of his time to my research efforts, and was always willing to confer on any difficulty that developed, no matter how trivial. For this, and for what I was able to learn while working with him, I shall always be grateful.

Similarly, working with the remaining members of my dissertation committee proved to be a valuable experience. Professor Barry R. Chiswick, despite being on leave from the City University with a hectic schedule in Washington D.C., contributed numerous comments and suggestions to drafts of my research. Professor Chiswick was never too busy to respond to inquiries made over the phone on points of difficulty. Professors Linda Edwards and Malcolm Galatin were instrumental in bringing to my attention points which added both theoretical and empirical rigor to the analysis.

I also wish to thank Professor Victor Fuchs of Stanford University and the National Bureau of Economic Research for his interest in my project. Professor Fuchs made available data from which my "observed" and "expected" wage rates were calculated. He also provided numerous research suggestions. Jan Platt of the NBER unselfishly provided assistance in the construction of my data tape. In addition, I benefited from a number of discussions with Professor William Landes while he was at the Graduate Center.

I would be remiss in not thanking the following individuals for their willingness to discuss issues relating to my research. Doug Coate, Dave Malmquist, Hy Sanders, and Ken Wolpin all displayed a remarkable capacity to listen and help me think clearly on a number of points.

I also wish to thank my parents for their encouragement while I was undertaking this project. Finally, my wife Maddy deserves much credit for her patience and willingness to sacrifice all too many things so that I might continue my education.

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Introduction and Summary

The purpose of this essay is an attempt to contribute additional theoretical and empirical content regarding the economic effects of occupational licensure. Particular emphasis is placed on the role of licensure in the health care sector, where such licensure is viewed as a primary impediment to an efficient and rational use of various types of health labor, as well as in attempts to deal with "shortages" of vital health care personnel. Specific application is made with regard to the nursing occupation (registered and practical nurses) since both the nature of licensing and the availability of data permit formulation of a testable econometric model. Thus, we do not perform an exhaustive survey of licensing practices among all or several groups of health labor. Rather, we view the application to nurses as representative of the problems confronted by most categories of health labor and their employers. The latter must attempt to utilize such labor in light of the restrictions imposed by the license.

Chapter I discusses theoretical aspects of licensure which were felt to be overlooked by several authors. We attempt to describe the welfare effects generated when licensure is imposed in a perfectly competitive labor market. We discuss both the nature of the social welfare loss as well as the redistributional effects arising from the license.

In addition, we examine the effects of the imposition of the license on the demand for labor, an area generally given a secondary emphasis by most authors (who primarily concentrate on the supply effects of licensure). Here we apply production theory to a model in which "tasks" (individual production processes) are viewed as primary inputs. These "tasks" are in turn produced by different classes of labor. Using a model of constrained output maximization (corresponding to cost minimization), we obtain results describing an employer's response to the imposition of a license, which makes the participation of unlicensed labor in some tasks illegal. In general, we find that the effectiveness of the license in inhibiting the use of unlicensed labor in licensed labor tasks will depend upon (a) the "share" of the prohibited "task" in final output, (b) the "share" of unlicensed labor in the "task" prior to the imposition of the license, and (c) the relevant Allen partial elasticity of substitution of labor. This discussion additionally permits us to characterize "restrictive" licensure.

In Chapter II, we describe the particular nature and issues involved in the licensing of health labor. The major distinction in this type of licensing, between mandatory and permissive licensure, is made. Mandatory licensure only allows licensed individuals to participate in the activities of a particular occupation, while permissive licensure enables unlicensed individuals to work in an occupation, as long as these individuals do not use the

specific occupational title. The implications of this type of distinction for both the demand and supply of labor is modeled, with specific reference to nursing. In general, the discussion centers on the differences in relative wages and relative numbers employed (registered to practical nurses), resulting from shifts in demand and supply schedules, which may be attributed to the licensing distinction. In addition, a brief attempt is made to amplify work by George Stigler regarding reasons for the introduction of occupational licensing. We confine this effort to the registered nursing occupation.

Since the discussion in Chapter II is based upon the implications of the mandatory-permissive licensure distinction on the supply and demand for registered nurses relative to practical nurses, Chapter III presents an empirical strategy which attempts to separate these effects. A two-equation econometric model is specified with relative wages and numbers (RN to PN) as endogenous variables. The equation system contains variables to measure the effects of the licensing as well as other relevant exogenous variables. A description of the data utilized and interpretation of the variables included is also presented. Due to data limitations and in order to preserve sufficient variation in the nature of licensing across jurisdictions, we confine our cross-section testing to the year 1960.

In the framework developed, we are able to distinguish

between the "direct" effects of licensure, as measured by the licensure dummy variables in each equation, and the "total" effects of licensure, which are derived from the reduced form coefficients of the system. In particular, it is shown that the direct effect licensure coefficient for mandatory registered nursing licensure in the relative demand equation can be used as an estimate of the "perceived" costs employers view violation of the license may impose.

In Chapter IV, a discussion of the estimation technique used and the empirical results obtained is presented. Most of the variables have signs which meet our a priori expectations. The direct effect of the imposition of mandatory registered nurse licensure on relative demand is found to be the strongest licensure demand variable. In our best specification, we estimate this effect to result in an increase in relative wages of 9.1 percent. This result is consistent with our expectations, but the magnitude of the effect does not permit us to assert that licensure is highly restrictive on the demand side. On the supply side, the effect of the imposition of mandatory practical nurse licensure is quite strong, resulting in an increase in relative numbers (RNs to PNs employed) by some 27 percent. A t-ratio of 2.10 attests to the importance of this effect. In analyzing the supply effect, we attempt to distinguish whether it is the result of "discouraging" potential PN entrants or encouraging those entrants to "switch" to registered nursing.

Our results tend to support the "discouragement" effect of the licensing.

We conclude this chapter by presenting a discussion rationalizing the "significance" of the licensure variables, and interpreting our reduced form coefficients. With regard to the former, we attribute the mild demand effects of mandatory licensure to a combination of poor enforcement efforts, vagueness in the laws, theoretical considerations derived in Chapter I, and conflicting professional aims of the nursing profession.

A brief attempt is made, in Chapter V, to expand the analysis to include the effects of changes in the nature of registered and practical nursing licensure over the decade of the 1960's. Since our data is limited, we treat this effort as a preliminary test. Here we utilize a framework developed by Benham, Maurizi, and Reder. This approach is based upon notions of movements over time responding to initial "disequilibrium" conditions, rather than changes in exogenous variables. However, this model fails to detect any strong evidence concerning the effects of licensure changes on relative wages or numbers over this period. We conclude that these effects do not appear to be present.

The effects of the varying nature of nursing licensure, then, seem to appear in our cross-section 1960 analysis. Our general conclusion, as regards the effects of licensure on the demand for registered relative to practical nurses,

is that mandatory RN licensure may have a small discernible effect (given its sign and magnitude). The main effect of licensure, which appears through mandatory practical nursing licensure, is found on the supply side. Here, this type of licensure increases the ratio of RNs to PNs supplied, by "discouraging" potential practical nursing entrants. These results may provide some insights into the reactions of employers and nursing labor at a time when there has been considerable debate regarding the effects of health manpower licensing.

Chapter I

Theoretical Aspects of Occupational Licensure

I.1 Introduction

Licensure of an occupation has often been rationalized on the grounds that it contributes to the public interest. Formal rationales advanced by proponents often make claims to protection of the public health, safety, and morals. Implicit in such claims are aspects regarding lack of information of consumers, the notion that society "knows best", and statements pointing to the disparity between social and private costs.[1] Members of occupational groups seeking licensure often do so on the grounds that they, as practitioners, are in possession of such specialized competence and knowledge so as to be able to specify the necessary prerequisites which will result in successful practice by new entrants as well as protection and assurance for the public. These occupational groups further believe that they are capable of providing and enforcing the proper regulatory activity "on those rare occasions when an individual does not perform his work competently or ethically".[2]

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[1]Thomas Moore, "The Purpose of Licensing", Journal of Law and Economics, (October, 1961), 103-110.

[2]Harris S. Cohen, "Professional Licensure, Organizational Behavior and the Public Interest", Health and Society, 51, No. 1 (Winter, 1973), 74.

While these statements of both governmental and occupational rationalization of licensure are expressed in terms of avowed altruism, some observers have noted that most of the demand for licensure is generated by occupational groups themselves, and rarely by public or consumer groups. Economists, in particular, have characterized licensure under the general heading of "restraints on entry" and have sought analytical analogies with trade unionism or monopolized industries. The goal of licensure, it is claimed, is not as much altruism as it is a desire to obtain additional rents or surplus to practitioners by imposing costs of entry on new or potential members of the occupation, and by limiting substitution of unlicensed personnel.

The purpose of this first chapter, then, is to investigate the nature of the rents, redistributional effects, and welfare costs created by the imposition of a license. In addition, a model is presented which describes the effects of licensure on the demand for labor. From this analysis, we will attempt to gain insight into what constitutes restrictive licensure.

I.2 Welfare Implications of Occupational Licensure

Although there has been some discussion in the literature regarding the economic aspects of occupational licensure, analyses concerning the nature of the welfare costs, redistributional effects and rents thereby created have often been incomplete. For example, Simon Rottenberg, writing in

"The Economics of Occupational Licensing",[3] devotes much of his effort to an examination of the rents created by licensure (which he asserts is a primary goal of occupational groups seeking licensure), and the implications of the license for entry into the occupation. He states that if incumbents in an occupation have entered at lower costs, the creation of a license, which imposes additional costs on new entrants, will generate rents by curtailing employment and increasing wages. In addition, he notes that the inclusion of a "grandfather clause", which frees incumbents from the added costs, is a necessary requirement for these rents to be secured. Thus, he declares, "incumbents in any trade have the incentive to perpetuate a license requirement...at ever higher standards."[4]

However, Rottenberg's analysis does not completely combine these aspects of licensing. The imposition of added costs on new entrants and a grandfather clause to protect incumbents will not alone generate rents[5] since incumbents will still be employed and willing to work at the prevailing market wage. What is required, as will be shown below, is an increase in demand for labor in the occupation which will

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[3]Simon Rottenberg, "The Economics of Occupational Licensing", Aspects of Labor Economics, A Conference of the Universities-National Bureau Committee for Economic Research (Princeton: Princeton University Press, 1962).

[4]Rottenberg, p. 6.

[5]Ibid., p. 11.

generate rents above what would exist had licensure been absent. Rottenberg's analysis of the employment and wage effects of licensure makes the added costs of entry fall on both incumbents and new entrants.[6] It is incomplete since he does not deal with how the existing decline in employment would be distributed among incumbents, or why incumbents in an occupation would desire licensure unless compensation is made for the reduction in employment they might suffer.

Similarly, two other works on licensure, by Thomas Moore[7] and Alex Maurizi[8], are incomplete in their discussion of the effects of licensure. Moore's article, while presenting a comprehensive discussion of possible motives for licensing, neglects to incorporate the notion of a grandfather clause and makes the imposition of the license itself sufficient to generate increased rents.[9] Although he notes that "the more demand is growing for the occupation, the greater the return from licensing"[10], he initially emphasizes the increase in entry costs as resulting in increased rents. He correctly notes that incumbents in the occupation will gain if the

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[6]Rottenberg, pp. 7-9.

[7]Moore, op. cit.

[8]Alex Maurizi, "Occupational Licensing and the Public Interest", Journal of Political Economy, 82, No. 2, Pt. 1, (March/April 1974), 399-413.

[9]Moore, 110-113.

[10]Ibid., 112.

increase in entry costs are in the form of tuition costs and book costs (which are returned to members of the occupation and may to some extent increase the demand for the services of members).[11] However, he tends to emphasize the shift in supply (due to increased entry costs) independently of the demand side. Thus on 111-112 he states:

> The larger the rise in the cost of entry, the greater will be the return to practitioners already in the industry, ceteris paribus. This is true because the amount by which the supply curve of practitioners shifts upward is a function of the rise in the cost of entry. Since supply and demand must tend toward equality, the price of the service and consequently the income of licensed practitioners must rise until equilibrium is reached.

Moore, therefore seems to be emphasizing the shift in supply along a stable demand schedule as the source of rents. However, this shift in supply will generate employment effects, and how these will be distributed among existing practitioners is not made clear. In addition, as I show below, if incumbents to the occupation are protected by a grandfather clause from the provisions of the license, it is not clear that wages will rise simply because the license has been imposed. Although Moore does provide a hypothesis concerning the relationship between rents to incumbents and the growth of demand for the services of the occupation, he relegates this aspect to a secondary role.

Maurizi's note attempts to test the proposition stated

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[11] Moore, 111.

by Moore regarding the growth of demand for the occupation and the returns from licensing. Again, Maurizi's model essentially explains the creation of rents by a rise in entry costs which shifts the supply schedule to the left. Maurizi does not distinguish entrants from members in the profession prior to the license. If, as Maurizi asserts, "after licensing is imposed there will be a drop in entrants and an income gain distributed to members of the profession"[12], we must assume that these members have been freed from the new costs of entry. Once again, it is not clear that all members of the occupation will benefit equally from the rents created. Therefore, a corresponding increase in demand must be introduced when discussing the creation of rents. Thus, while these authors point to the growth in demand as increasing rents over time, initial rents for all incumbents will likewise depend upon shifts in demand. These points will be elaborated below.

A more complete discussion of the welfare implications of occupational licensure may be considered by examining the following graphical model (Figure I) describing the introduction of licensure in a competitive labor market by members of an occupational group.[13] Initial wages (OW_0) and employment (OQ_0) are determined by the intersection of labor (derived)

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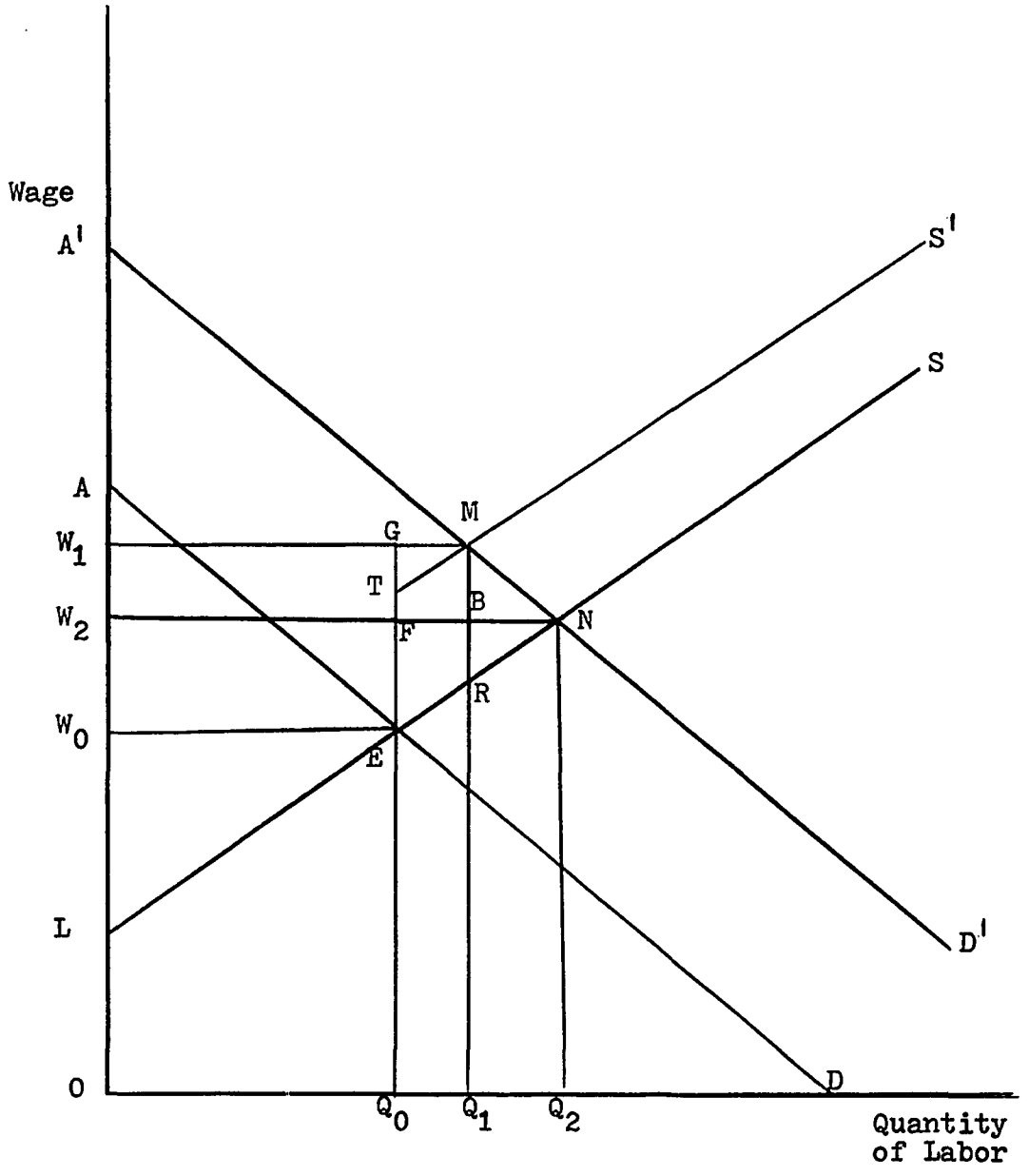
[12]Maurizi, 401.

[13]I wish to acknowledge several interesting discussions with Professor William Landes in the development of this section.

Figure I

Welfare Effects of Licensure



demand and supply schedules at point E. As a simplifying assumption, all employed workers ($0Q_0$) are considered members of the occupational group and will be referred to as incumbents. These incumbents decide to impose some barrier to entry (a license) which therefore raises the cost of entry to any additional units of labor (beyond $0Q_0$) seeking employment in the industry. As a result, the portion of the supply schedule beyond E rises, reflecting the increased costs of entry (TE). These costs, which may include such magnitudes as training costs, entrance costs (initiation fees), and costs of waiting, are assumed equal for all units of labor beyond E. Note that the portion of the supply schedule LE remains stable, reflecting the fact that incumbents have not imposed the licensing requirements upon themselves (i.e., the use of a grandfather clause). As has been pointed to above, most authors view the <u>entire</u> supply schedule as having shifted. However, this implies that incumbents (i.e., those presently employed) are subject to the costs of the license, and this is not strictly the case. Therefore, equilibrium wages do not necessarily rise. Thus, our supply schedule, after the imposition of licensure, becomes LETS',[14,15]

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[14]The analogy used here is one of the imposition of a per unit tax levied on all units of labor beyond $0Q_0$. It is assumed that the added cost is constant for all units of labor beyond $0Q_0$.

[15]Our analysis considers an intermediate length of run for which all incumbents remain in the occupation. This is most consistent with the question of how incumbents in the occupation gain once licensure is imposed. If we assume a small

The welfare effects of the imposition of licensure are generated by an increase in the demand for the services of labor in the occupation, which creates new opportunities for employment. The introduction of an increase in demand to illustrate the welfare effects has several advantages. It avoids a tangential discussion of how selection of new members to replace retired or deceased members of the occupational group takes place when conditions of stable demand are maintained. It implicitly recognizes the notion that age structure of an occupation may be an important factor in determining which occupations attempt to license, since among other reasons, incumbents will support licensure if they feel they will still be working and able to reap the benefits. Finally, it also takes account of the fact that the license and broad coverage of work requiring a license raises the real costs of employing substitutes (non-licensed labor), where real costs include possible penalties and fines. The rise in these real costs will also shift the demand schedule as indicated. Without the shift in demand, the labor market will remain in its inital equilibrium with the welfare costs being limited to the effect of costs involved in setting up the administrative machinery to establish licensing procedure.

As a result of licensure and the increase in demand

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[15](continued) turnover rate in the occupation, our results would not be substantially altered, but would have some dependence upon how the new entrants were distributed on the portion of the supply schedule LE (that is, on which workers were leaving). Assuming a large turnover rate is not consistent with the belief that occupations license in order to secure rents for incumbents.

(to D') a new equilibrium is established at point M. Wages are now $0W_1$ and employment $0Q_1$.[16] At the higher wage, incumbents ($0Q_0=W_0E$) now receive an addition to their previous rents (LW_0E) of W_0EGW_1. Note that <u>without</u> licensure and the same increase in demand (now composed only of the increase in demand for labor services resulting from an increase in demand for the product), the resulting equilibrium (point N) would have established wages of $0W_2$ resulting in additional rents to <u>incumbents</u> of only W_0W_2EF. As a result of licensure, incumbents receive an additional surplus of W_1W_2FG.

The welfare loss incurred by society may also be observed. At the new equilibrium point M, the value of marginal benefits from employing $0Q_1$ workers, Q_1M, exceeds the marginal (opportunity) cost of resources, read off the original supply schedule Q_1R. As a result, welfare would be enhanced by employing $0Q_2$ workers and operating at point N (the equilibrium point without licensure where marginal benefits from employment are equal to real marginal opportunity costs of using resources elsewhere). Thus licensure, by curtailing employment by Q_2Q_1, imposes a social welfare loss of triangle MNR.[17]

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[16] It is assumed that incumbents do not alter the number of hours worked as a result of the increase in demand.

[17] It should be noted that we need not include in our measure of welfare loss, the loss of consumers' surplus resulting from possible increases in the price of final output. As Daniel Wisecarver has shown in "The Social Costs of Input Market Distortions", <u>American Economic Review</u>, LXIV, No. 3 (June 1974), the full extent of welfare loss is captured in the area between a factor's derived demand and supply schedules. To include the loss in consumers' surplus as well would be to engage in double-counting and hence overstatement.

It should be pointed out that MNR may not fully approximate the total welfare loss. This may be seen by concentrating on area TMRE which represents the added costs imposed upon new entrants to the occupation (entry costs per unit, TE, times the number of new units, Q_1Q_0, less original opportunity costs ERQ_0Q_1).[18] The extent of the welfare loss will depend upon the nature of these costs. If they are merely monetary transfers to incumbents (e.g., entrance or initiation fees), then no real productive opportunities are foregone, and MNR will represent the welfare loss. However, if these costs include time spent in training or periods of apprenticeship, for which some real productive opportunities have been foregone without any corresponding increase in output while training is being undertaken (or afterward), then area TMER should be included with MNR as approximating the full welfare loss. If some output is being produced while training is being undertaken, then only a portion of TMRE will be included. Thus, the extent of the welfare loss may

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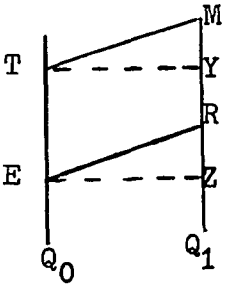
[18] That TMRE represents the additional total costs may be seen from the fact that TMRE is a parallelogram. Drawing lines perpendicular to TE and extending them to MQ_1 at Y and Z form triangles TMY and ERZ. New costs of entry are strictly TE times EZ ($=Q_0Q_1$) which equals TYZE. Triangle ERZ will equal triangle MTY so that TMRE will represent the area of additional cost.



range from MNR to MNRET depending upon the above considerations.

It should be noted that it is probably appropriate to include part or all of TMRE as adding to the welfare loss since the nature of these costs will probably take the form of training costs and hence, some real output foregone (if the license is strictly an artificial barrier we may also expect there to be little increased future productivity from this "training"). This is likely to be the case because occupational groups, in their attempts to obtain legislative support for licensure, will often base their assertions on the need to establish a set of minimum qualifications for entry. It seems reasonable, therefore, to suppose that the stipulation of a minimum training period for new entrants would support this end and make legislators less suspicious of the aims of the occupational groups. This strategy would appear far more feasible in gaining legislative support for licensure than merely requiring entrants to pay an entry fee (a monetary transfer).

Finally, it may be instructive to observe the nature of the redistributional effects imposed by licensure. Without licensure, had equilibrium point N been established (as a result of an increase in the demand for labor), W_1W_2MN would represent part of consumers' (demanders of labor) surplus. However, the imposition of licensure, which establishes equilibrium point M, results in the loss of this portion, with W_1W_2FG being redistributed to incumbents, GMT taking the form

of rents to new entrants, and FTMB taking the form of payments to entrants which absorb part of their training costs. The area FBRE represents a loss of rents to new entrants who now must incur this amount as a cost of entry. Area MNR again represents society's welfare loss which results from curtailment of employment licensure.

Thus, the welfare implications of licensure suggest a gain in rents to incumbents above what would have been generated by an increase in demand had licensure been absent. Surplus is transferred from consumers of labor services to incumbents and new entrants. Hence, an incentive exists for incumbents to create and perpetuate licensure. Society incurs a net welfare loss with the extent of gains and losses depending upon the slopes of demand and supply schedules. In general, rents to incumbents will increase the lower the slope of the demand schedule and the larger the slope of the supply schedule. The total welfare loss to society, area MNRET, will be larger the lower the slope of demand and supply.[19]

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[19]See Appendix I for proof of these points.

I.3 The Effects of Licensure on the Demand for Labor

Most discussions of occupational licensure have emphasized the restrictive effects such licensure imposes on entry to a particular labor market and hence, on the supply of labor. In this section, I will present a general model which describes how such licensure might affect the utilization and demand for labor. In particular, the model suggests that the effects of licensure will be more restrictive for a given expected penalty faced by employers, the larger the share of tasks in production a particular class of labor is prevented from performing, and the larger the share in the production of these tasks this labor class comprised before the license. The model, therefore, borrows from basic production and consumption theory in which the sensitivity of demand for any type of input, given a change in its price, will depend upon the share of that input in the production or consumption process.

Consider then, a process of output maximization[20] in which the production function for output Q is expressed as a function of two tasks, g and f: $Q = Q(g,f)$. Viewing "tasks" as inputs in a production process is not as abstract as it may seem, for many production "processes" may be described in this manner. For example, if we were to consider the output "education", we could certainly envision a production process consisting of substitutable and complementary

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[20]The results of the analysis would not be altered if the aim of the firm were to minimize costs.

tasks such as exams, assignments, and lectures. More specifically, if we were to consider the output (with respect to health care where a variety of outputs are produced) "a patient with clear breathing", we could enumerate several tasks in this production process. These might include suctioning the patient to clear the breathing passage, the performance of a tracheotomy, artificial respiration, placing the patient in oxygen, or even physically thumping or positioning the patient in a manner designed to remove the blockage.

The production function $Q = Q(g,f)$ is assumed to be linear homogeneous in tasks, and we assume that substitution between tasks in the production of output is possible.[21] Each task, g and f, is assumed to be subject to production functions of the form $g = g(L_{g1},L_{g2})$ and $f = f(L_{f1},L_{f2})$ where L_{ij} $(i = g,f;\ j = 1,2)$ represents an input of labor from two classes L_1 and L_2[22]. Again, I assume that each task production function is linear homogeneous in its labor inputs and that substitution between inputs in each is possible. Returning to the above examples, physicians, nurses, and therapists could be employed and substituted for in each of

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[21]Thus, in the above examples, substitution among tasks in the production of "clear breathing" is distinctly possible; similarly, the production manager of the education process (department chairman) may use a number of the above tasks in alternative configurations.

[22]Labor is assumed to fall into two distinct classes distinguised by licensing (to be introduced later).

the tasks (to varying degrees); similarly, teachers, aides, and students could enter the production functions of each of the tasks comprising the output "education".

By Euler's Theorem, we can express the shares of each of the inputs in each production process as:

i) For $Q = Q(g,f)$, (1) $Q = Q_g.g + Q_f.f$ so, $S_{Q,g} = \frac{Q_g.g}{Q}$ and $S_{Q,f} = \frac{Q_f.f}{Q}$ where Q_g, Q_f are marginal products of each task in the production of Q. Similarly,

ii) For $g = g(L_{g1}, L_{g2})$, $f = f(L_{f1}, L_{f2})$ the task production functions, (2) $g = g_{Lg1}.L_{g1} + g_{Lg2}.L_{g2}$, $S_{g,L_{g1}} = \frac{g_{Lg1}.L_{g1}}{g}$, $S_{g,Lg2} = \frac{g_{Lg2}.L_{g2}}{g}$ and (3) $f = f_{Lf1}.L_{f1} + f_{Lf2}.L_{f2}$, $S_{f,Lf1} = \frac{f_{Lf1}.L_{f1}}{f}$ $S_{f,Lf2} = \frac{f_{Lf2}.L_{f2}}{f}$ where g_{Lg1}, g_{Lg2}, f_{Lf1}, f_{Lf2} represent the marginal products of labor in each task; S represents the respective share. By substituting (2) and (3) into (1), we can obtain:

(4) $Q = Q_g.g_{Lg1}.L_{g1} + Q_g.g_{Lg2}.L_{g2} + Q_f.f_{Lf1}.L_{f1} + Q_f f_{Lf2}.L_{f2}$

a result which will be used later on.

The cost constraint faced by the firm is assumed to be of the following form: $C = W_{g1}.L_{g1} + W_{f1}L_{f1} + W_{g2}L_{g2} + W_{f2}L_{f2}$ where W_{ij} represents the wage for a given type of labor in the i^{th} task (i = g,f). The wage received by a given type

of labor is assumed to be equal across tasks ($W_{g1} = W_{f1}$; $W_{g2} = W_{f2}$) but for analytical purposes, I want to examine the effects on the use of labor when a particular W_{ij} changes. The change in the W_{ij} will represent a change in the wage "perceived" by employers due to licensure.

Given the above, we maximize the following Lagrangian expression:

$$Z = Q(g,f) + \lambda\left[C - \sum_{ij}\sum W_{ij}.L_{ij}\right] \text{ where } g = g(L_{g1},L_{g2}),$$

$f = f(L_{f1}, L_{f2})$. Therefore,

$$\frac{\partial Z}{\partial L_{ij}} = Q_i i_{L_{ij}} - \lambda W_{ij} = 0, \quad (i = g,f;\ j = 1,2)$$

$$\frac{\partial Z}{\partial \lambda} = C - \sum_{ij}\sum W_{ij}.L_{ij} = 0.$$

The first-order conditions establish straightforward rules for allocating each type of labor within a given task and across tasks.

i) Within tasks: $\dfrac{g_{Lg1}}{g_{Lg2}} = \dfrac{W_{g1}}{W_{g2}}$; $\dfrac{f_{Lf1}}{f_{Lf2}} = \dfrac{W_{f1}}{W_{f2}}$

that is, equate marginal rates of substitution within tasks to relative wages for each type of labor in a given task.

ii) Across tasks: $\dfrac{Q_g.g_{Lg1}}{Q_f.f_{Lf1}} = \dfrac{W_{g1}}{W_{f1}}$; $\dfrac{Q_g.g_{Lg2}}{Q_f.f_{Lf2}} = \dfrac{W_{g2}}{W_{f2}}$

If we assume the wage paid to a given type of labor is constant across tasks, these conditions reduce to:

$$Q_g.g_{Lg1} = Q_f.f_{Lf1} \ ; \ Q_g.g_{Lg2} = Q_f.f_{Lf2},$$

that is, the marginal contribution to final output of a given type of labor across tasks should be equated.

The effects of the imposition of a license penalizing the use of a particular type of labor in a given task is analogous to changing one of the task wage rates, say W_{g1}, to the firm. The change in this wage to L_{g1} may be one that is "perceived" by the firm in light of possible penalties it faces for using unlicensed L_1 in task g (the performance of which now requires a license).[23] Or, it may reflect a premium above W_{g1} to entice L_1 to perform g, given possible penalties unlicensed L_1 may face in this activity. Therefore, to obtain the effect of such a wage change on the use of L_{g1}, L_{g2} and their factor ratio, I totally differentiate the first-order conditions. I will examine these effects for compensated changes in W_{g1}, that is, holding output constant.[24]

Using Cramer's rule, we can establish the result that $dL_{g1} = \frac{\lambda dW_{g1} \Delta_{11}}{\Delta}$ where Δ_{11} is the cofactor of λdW_{g1}.

Substituting $\lambda = \frac{Q_g g_{Lg1}}{W_{g1}}$ from first-order conditions, we obtain $\frac{dL_{g1}}{dW_{g1}} = \frac{Q_g g_{Lg1} \Delta_{11}}{W_{g1} \Delta}$ as a compensated substitution effect (where Δ is the bordered Hessian determinant). In elasticity form, $\eta_{Lg1,Wg1} = \frac{Q_g \cdot g_{Lg1} \Delta_{11}}{L_{g1} \Delta}$. Multiplying the

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[23] These perceptions will depend upon both the magnitude of the "fine" or punishment involved and the probability of conviction.

[24] See Appendix II for the complete development.

right-hand side by $\frac{Q}{Q}\cdot\frac{g}{g}\cdot\frac{L_{g1}}{L_{g1}}$ we obtain:

$$\eta_{L_{g1},W_{g1}} = \frac{Q_g \cdot g}{Q} \cdot \frac{g_{Lg1}\cdot L_{g1}}{g} \cdot \frac{Q}{L_{g1}^2}\frac{\Delta_{11}}{\Delta} = S_{Q,g}\cdot S_{g,L_{g1}} \cdot \frac{Q}{L_{g1}^2}\frac{\Delta_{11}}{\Delta}$$

where the shares are defined above. Since $Q = Q_g \cdot g + Q_f \cdot f = Q_g g_{Lg1}\cdot L_{g1} + Q_g g_{Lg2}\cdot L_{g2} + Q_f f_{Lf1}\cdot L_{f1} + Q_f f_{Lf2}\cdot L_{f2}$, from (4) above, we obtain:

$$\eta_{L_{g1},W_{g1}} = S_{Q,g}\cdot S_{g,Lg1}\cdot \frac{(Q_g g_{Lg1} L_{g1} + Q_g g_{Lg2} L_{g2} + Q_f f_{Lf1} L_{f1} + Q_f f_{Lf2} L_{f2})\Delta_{11}}{L_{g1}^2\ \Delta}$$

where the last expression on the right is the Allen "own" partial elasticity of substitution[25] for L_{g1} in output Q. Therefore,

$$\eta_{Lg1,Wg1} = S_{Q,g}\cdot S_{g,Lg1}\cdot \sigma_{Lg1,Lg1}.$$

Similarly, we can show the compensated cross-elasticity to be:

$$\eta_{L_{g2},W_{g1}} = S_{Q,g}\cdot S_{g,L_{g1}}\cdot \sigma_{Lg1,Lg2}.$$

Note that $\eta_{Lg1,Wg1} < 0$ and $\eta_{Lg2,Wg1} > 0$ as $\sigma_{Lg1,Lg1} < 0$ and $\sigma_{Lg1,Lg2} > 0$.[26]

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[25] R.G.D. Allen, Mathematical Analysis for Economists (New York: St. Martin's Press, 1967), pp. 503-505.

[26] Note that the signs of the Allen partials are constrained by the following relationship:

$$S_{Q,Lg1}\cdot\sigma_{Lg1,Lg1} + S_{Q,Lg2}\cdot\sigma_{Lg1,Lg2} + S_{Q,Lf1}\sigma_{Lg1,Lf1} + S_{Q,Lf2}\sigma_{Lg1,Lf2} = 0$$

Since the Allen own partial $\sigma_{Lg1,Lg1} < 0$, the remaining Allen partials must in combination be sufficiently positive to offset $\sigma_{Lg1,Lg1}$. Therefore, it is possible for the remaining Allen cross-partials to be > 0. Allen, pp. 504-505. See Appendix II for these results.

Thus the sensitivity of demand for each of the above factors will depend upon the share of task g in the production of Q, the share of "unlicensed" labor (L_{g1}) in the production of task g, and the relevant Allen partial. In general, the elasticities will be greater the larger each of the shares.[27] The results make intuitive sense since if task g were used extensively in production, but L_{g1}'s share in production were quite small, imposing a license prohibiting use of L_1 in g would have a small overall effect on the firm's use of L_1.

From the above, we can also derive the elasticity of substitution between L_{g1} and L_{g2} with respect to a change in W_{g1}. Since $dL_{g1} = \frac{\lambda dW_{g1} \Delta_{11}}{\Delta} = \frac{dW_{g1} \cdot Q_g g_{Lg1} \Delta_{11}}{W_{g1} \Delta}$, then multiplying both sides by $\frac{L_{g1}}{L_{g1}} \cdot \frac{Q}{Q} \cdot \frac{g}{g}$, we obtain:

$$(5)\quad E_{Lg1} = E_{Wg1} \cdot S_{Q,g} \cdot S_{g,Lg1} \cdot \sigma_{Lg1,Lg1}$$

where E_{Lg1} and E_{Wg1} refer to percentage changes in L_{g1} and W_{g1} respectively (i.e. $\frac{dL_{g1}}{L_{g1}}$, $\frac{dW_{g1}}{W_{g1}}$). Similarly, it can be shown that: (6) $E_{Lg2} = E_{Wg1} \cdot S_{Q,g} \cdot \sigma_{Lg1,Lg2}$. Subtracting (6) from (5) we obtain:

$$(7)\quad \frac{E\left(\frac{L_{g1}}{L_{g2}}\right)}{E(W_{g1})} = S_{Q,g} \cdot S_{g,Lg1} \left[\sigma_{Lg1,Lg1} - \sigma_{Lg1,Lg2}\right]$$

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[27] This statement must be qualified since all the Allen partials cannot remain constant. Since we are referring to expressions involving $\sigma_{Lg1,Lg1}$ and $\sigma_{Lg1,Lg2}$, we assume the remaining Allen partials can vary (i.e., $\sigma_{Lf1,Lf1}$ and $\sigma_{Lf1,Lf2}$).

an expression for the elasticity of substitution between L_{g1}, L_{g2} due to a "perceived" change in W_{Lg1} (note that W_{Lg2} does not enter into this expression since this wage is not perceived to change). The above expression will be <0 as $\sigma_{Lg1,Lg1} < 0$ and $\sigma_{Lg1,Lg2} > 0$, and will be larger the greater the share of task g in output Q and the greater the initial share of L_{g1} in task g.

The above model expresses licensure in more specific terms: that is, in the context of permissible and prohibitive tasks.[28] Furthermore, insight into the "restrictiveness" of licensure, as it pertains to the utilization and demand for labor, may be gained. As the above elasticities indicate, restrictiveness may be determined by the share expressions (note that the Allen partials are given by technology). Thus licensure will be potentially[29] more restrictive on the demand side for any given change in perceived wage rates if the share of labor now prohibited

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[28] It should be noted that a good deal of the discussion of licensure, as it pertains to the utilization of labor, is phrased in terms of tasks. This is particularly true in the health sector where the legal implications of various types of labor engaging in 'physician' tasks is widely discussed. The discussion of licensing is often in terms of "permissible scope of activities" or "independent" and "dependent" functions. See for example "Legal Regulation of Health Personnel in the United States," Appendix VII in Report of the National Advisory Commission of Health Manpower, Vol. II (Washington: U.S. Government Printing Office, 1967), pp. 411-415. On p. 411, the Report notes "...the most significant contemporary issues regarding licensure of allied and auxiliary personnel concern the effect of licensure provisions upon the distribution of tasks and duties among each professional and occupational category... For allied and auxiliary personnel...it is necessary to determine those functions which they may not perform under ordinary circumstances." (my emphasis).

from a task was great prior to the license, and if the share of the task under consideration constitutes a large part of production. Thus, if a production process consisted of only one task and utilized one type of labor, imposition of a license could effectively end production (at least until licenses were acquired).

The above model can be extended to discuss the effects of licensure at the industry or labor market level. The imposition of a license would lead each firm to utilize relatively more "licensed" labor, or L_{g2} in our example. In the short-run (the period for which our analysis is developed), each firm would attempt to respond to the "perceived" costs of the license by utilizing more L_2 in task g. As a result, a reallocation of labor would take place, within and across tasks, in each firm. The firm similarly might try to substitute tasks in production as well. Since in the short-run, the ability to substitute tasks in production and labor across tasks is limited, demand would be translated to the external labor market. Hence, the industry's demand for L_2 relative to L_1 would rise along with relative wages (assuming a stable upward sloping supply curve). An equilibrium would result when the increase in relative wages just offset the "perceived" increase in the wage for L_1 in task g, which results from licensure.

These remarks, then, serve as a general theoretical

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[29]Potentially in the sense that employers obey the law.

basis to describe the effects of occupational licensure. In the next chapter we discuss the particular nature of nursing licensure. The concepts developed here, in particular the notions of "tasks" and "restrictiveness" of licensure, will be used to interpret the effects of nursing licensure and to explain empirical effects obtained.

Chapter II

Licensure of Health Labor: The Case of Nursing Labor

II.1 Introduction

In recent years, there has been a substantial amount of discussion within the health sector regarding the proper utilization of allied health labor in the production of medical care. Several independent studies, in particular, the Report of the National Advisory Commission on Health Manpower (1967; cited in Chapter I), the American Medical Association Council on Health Manpower (1970), and the writings of several legal experts in the area of Health Law, have concluded that an expansion of the role of various categories of allied health labor is long overdo. At the same time, these authors have pointed to the inhibiting effects of state licensing in preventing implementation of their suggestions and in the inefficient allocation of health labor. Licensure was alleged to stratify groups of health labor into rigid occupational settings and to leave sufficient doubt in the minds of employers as to the tasks each group could legally perform.

The existence of laws, however, need not mean that individuals have altered their behavior to comply with the expressed aims of those laws. If the aim of health licensure laws was to prevent the utilization of allegedly "unqualified" practitioners, the passage of such laws need not mean that such practices have been or are being effectively dealt with. Indeed, in spite of the amount of discussion regarding

the effects of health licensure laws, which emphasize misallocation of health labor and therefore increasing costs of care, there has not been any attempt to verify such claims. Rather, spokesmen for and against licensure have relied upon interviews and anecdotes as evidence.

The aim of this chapter, therefore, is to provide a framework which may be used to analyze the licensure issue as it pertains to nursing labor. The first part presents a description of the nature of health licensure and a brief attempt to explain the initial reasons for nursing licensure. Next, a model is developed to provide an empirical test as to the effectiveness of nursing licensure.

II.2 Licensure of Health Labor

While most attention concerning licensure in the health field has centered on such practitioners as physicians and dentists, increasing emphasis is being directed to the role licensure plays in the activities of such auxiliary health labor as registered and practical nurses, dental assistants and hygienists, physical therapists, and others.[30] We will, throughout this essay, use the nursing occupation as our frame of reference. Two reasons govern this decision. First, data concerning the numbers employed and earnings of nurses are more accessible than similar data for other health labor

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[30]See for example "Legal Regulation of Health Personnel in the United States," Appendix VII, Report of the National Commission of Health Manpower, op. cit., or Ruth Roemer, "Licensing and Regulation of Medical and Medical-Related Practitioners in Health Service Teams," Medical Care, Vol. IX, 1 (January-February 1971), 42-54.

groups. Secondly, this data is available for a period during which sufficient variation existed in the nature of nursing licensure.

While most categories of health labor are licensed across states, the nature of the licensure varies. To be specific, licensure in the health field is either mandatory or permissive. Mandatory licensure permits "only persons holding a license...to practice the occupation [with] unlicensed persons prohibited from working in the field." Permissive licensure specifies "that only persons holding a license are authorized to use a particular title or official designation; unlicensed persons are not prohibited from working in this field but they may not used the protected title."[31] The distinction offers what I believe are testable implications regarding both demand and supply for allied health labor (AHL).

The emergence of licensure in the health field has necessitated attempts to clarify the scope of practice for each category of allied health labor. However, the prevailing definitions are vague, and "in general...the most clouded areas in the legal regulation of health manpower, since they have not been adequately resolved by the licensure statutes or related court decisions."[32] Indeed, as one

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[31]Maryland Y. Pennell and Paula A. Stewart, State Licensing of Health Occupations, (Washington D.C.: U.S. Department of Health, Education and Welfare, Public Health Service, 1968), p.3.

[32]"Legal Regulation of Health Personnel in the United States," p. 413.

observer has noted, "/it/ is questionable whether /the/ broad and general statutory definitions of allied and auxiliary professions and occupations provide usable guides for the health professions, licensing agencies, legal authorities, and the public."[33] Despite these deficiencies, state governments, by classifying their laws as mandatory or permissive, have behaved as if these "scopes" of practice are clearly defined. However, as the above statements imply, quite often the boundaries are not clearly specified.

The mandatory-permissive distinction does, however, suggest certain implications for the utilization of AHL which seem to be in accord with interpretations made by various writers in the health law field. Mandatory licensure is believed by one writer "as making criminal any action within the scope of a licensed profession by one not licensed in that profession."[34] These mandatory provisions are viewed as having the advantage of "establish/ing/ minimum standards of qualifications for all who practice the profession or occupation.../and/ assur/ing/ universal application of definitions of practice, thus providing a uniform basis for resolving problems of scope of

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[33]"Legal Regulation of Health Personnel in the United States," p. 423. The "prevailing generality" of these laws is defended on the grounds that it allows sufficient "flexibility" in the interpretation of nursing practice acts.

[34]Rick Carlson, "Health Manpower Licensing and the Emerging Institutional Responsibility for the Quality of Care," Law and Contemporary Problems, Vol. XXXV, 2, Pt. 2 (Spring 1970), 849.

practice and delegation."[35] Thus, mandatory licensure, which requires all individuals in an occupation to be licensed, seems to suggest that the ability to utilize non-licensed personnel to perform tasks normally assigned to licensed individuals could be constrained by the legal interpretation and implications of the nature of the license.

Permissive licensure, on the other hand, implies greater latitude in the utilization of health manpower since unlicensed individuals are not barred from working in various occupational settings. As the American Medical Association Committee on Nursing notes:

> In a permissive act, the titles "registered nurse" and "licensed practical nurse" are protected. The practice of either level of nursing is not prohibited in a permissive act, but an unlicensed person is not entitled to represent himself as an "RN" or an "LPN". In other words, one may, whether licensed or not practice nursing as long as the unlicensed individual does not call himself an RN or an LPN.[36]

Thus, this seems to suggest that jurisdictions with permissive licensure are able to allow unlicensed individuals to work in an occupational setting since the legal constraints are less rigid. Therefore, the ability to utilize

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[35]Roemer, 441. This indication of mandatory licensure is also found in "Legal Regulation...", p. 413.

[36]AMA Committee on Nursing, "Mandatory vs. Permissive Licensure for Nurses", Journal of the American Medical Association, February 7, 1966, Vol. 195, 6, 202.

a practical nurse or nursing aide, to perform tasks normally assigned to a more expensive registered nurse input would be enhanced.

The implications of a mandatory licensure law may be seen by a brief review of a 1966 negligence suit against a physician and his practical nurse: the case of Barber v. Reiking.[37] The circumstances resulting in this suit concerned the administration of an injection by a practical nurse to a small child. The injection resulted in injury to the child when the needle was broken. As a result, both nurse and physician were named defendants in a suit.[38] Although both were declared innocent in a first trial, a subsequent appeal was decided in favor of the plaintiff.[39] As Hershey notes, the plaintiff based its case upon "specific language in the mandatory licensing for professional nurses of Washington State...."[40] In legal terms, the nature of the mandatory Registered Nurse Licensing Law resulted in a finding of an "inference of negligence"[41] which although not conclu-

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[37]Barber v. Reiking, 411 P. 2d 861 (1966). For a summary of this case see Nathan Hershey, "A Court's View of Mandatory Licensure," American Journal of Nursing, Vol. 66, 11, November 1966, 2461-2462.

[38]It is not clear, from both sources in note 37, whether the physician explicitly instructed his practical nurse to perform the task, or whether the PN did so or her own volition.

[39]The appeals judge ruled that during the initial trial, the jury had been improperly instructed by the trial judge. The trial judge had failed to instruct the jury, upon request of the plaintiff, that violation of the licensing statute constituted an inference of negligence. See Barber v. Reiking, 68 Wn. 2d. (March 1966), pp. 139-145.

[40]Hershey, 2461.

[41]Carlson, 852.

sive, presents a barrier that the defendants must overcome. Had the nursing statute been permissive, we should note, the above act of the practical nurse (administering the innoculation) would not have been considered a violation of the license law. Translating the above into an economic context, the use of the practical nurse resulted in increased costs for her employer: legal fees, time lost preparing for and during the trial, adverse publicity, and possible psychic costs. Thus, the implications of a mandatory act may well give rise to notions by employers of the potential costs from employing various types of personnel. But before I present a more systematic way of viewing the effects of the mandatory-permissive licensure distinction, I want to comment briefly on the trend in nursing licensure and reasons for its implementation.

II.3 Trends in Nursing Licensure and Reasons for Licensure

The first nursing licensure laws were passed by New Jersey, New York, North Carolina, and Virginia in 1903.[42] By 1923, all states had licenses of a permissive nature, requiring anyone desiring to use the title "registered nurse" to become licensed. The general trend has been for states to introduce permissive licensure, followed by changes which make the law mandatory. Thus by 1971, approximately all but two jurisdictions (District of Columbia

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[42]Pennell and Stewart, pp. 72-73.

and Georgia) had passed mandatory licensure for registered nurses. Table II.1 (a and b) describes the years of passage and change of license for both registered and practical nurses.[43]

Much of the writing describing the forces which resulted in the initial passage of nursing licensure, has usually been left in the hands of the nursing profession. As a result, the reasons provided have been sympathetic to the aims of the nursing profession and are expressed in terms of the general rationales for occupational licensure: concern with providing a standard quality of care and protecting the public from low-skilled practitioners. There has been very little attempt to empirically verify these reasons or to determine whether these motives might disguise more immediate self-interest of existing nurses.

Following a framework employed by George Stigler[44], we can attempt to quantify those forces contributing to the

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[43]It should be noted that efforts to change the laws from a permissive to a mandatory nature have been generated primarily by state registered nursing associations. A reading of the bulletins of these associations just prior to the year of change, finds statements urging nurses and legislators to actively work for and support mandatory licensure. For example, the Indiana State Nurses Association bulletin, The Indiana Nurse (September 1968), pp. 17-18 declares: "If we are to achieve Mandatory Licensure for registered nurses and practical nurses which will safeguard the life and health of the citizens of the state, the cooperative effort of all nurses will be urgently needed." (emphasis in original)

[44]George Stigler, "The Theory of Economic Regulation," Bell Journal of Economics and Management Science, Vol. 2, 1 (Spring 1971), 3-21.

Table II.1 a

Year of Licensure

Registered Nurses

State	Year First Passed	Year Mandatory	Status 1960	Status 1970
Alabama	1915	1967	P	M
Alaska	1941	1957	M	M
Arizona	1921	1953	M	M
Arkansas	1913	1947	M	M
California	1905	1939	M	M
Colorado	1905	1957	M	M
Connecticut	1905	1956	M	M
Delaware	1909	1963	P	M
District of Columbia	1907	----	P	P
Florida	1913	1952	M	M
Georgia	1907	----	P	P
Hawaii	1917	1959*	P	M
Idaho	1911	1951	M	M
Illinois	1907	1951	M	M
Indiana	1905	1971	P	P
Iowa	1907	1963	P	M
Kansas	1913	1949	M	M
Kentucky	1914	1966	P	M
Louisiana	1912	Before 1951	M	M
Maine	1915	1959*	P	M
Maryland	1904	1967	P	M
Massachusetts	1910	----+	P	P
Michigan	1909	1967	P	M
Minnesota	1907	1959*	P	M
Mississippi	1914	1970*	P	P
Missouri	1909	1953	M	M
Montana	1913	1947	M	M
Nebraska	1909	1953	M	M

Table II.1 a (continued)

State	Year First Passed	Year Mandatory	Status 1960	Status 1970
Nevada	1923	1953	M	M
New Hampshire	1907	1959*	P	M
New Jersey	1903	1955	M	M
New Mexico	1923	1953	M	M
New York	1903	1949	M	M
North Carolina	1903	1965	P	M
North Dakota	1915	1963	P	M
Ohio	1915	1967	P	M
Oklahoma	1909	1967	P	M
Oregon	1911	1957	P	M
Pennsylvania	1909	1951	M	M
Rhode Island	1912	1952	M	M
South Carolina	1910	1969*	P	P
South Dakota	1917	1955	M	M
Tennessee	1911	1967	P	M
Texas	1909	1969*	P	P
Utah	1917	1963	P	M
Vermont	1911	1962	P	M
Virginia	1903	1970*	P	P
Washington	1909	1961	P	M
West Virginia	1907	1965	P	M
Wisconsin	1911	1955	M	M
Wyoming	1909	1955	M	M

Key: ---- No change to Mandatory licensure

* States having passed Mandatory laws in 1959 or 1960 are considered Permissive in our analysis. Similarly, states having passed Mandatory laws in 1969 or 1970 are treated as Permissive states in 1970. This permits for adjustment lags and for any disparity between passage date and effective date.

\+ The Massachusetts law is reported as Permissive in Pennell and Stewart. However, correspondence with the Massachusetts Board of Registration in Nursing indicates that the law is

Table II.1 a (continued)

viewed as Permissive with regard to personnel in nursing and convalescent homes, a large group of consumers or nursing services. In addition, statements in the Massachusetts Nursing Association Bulletin (Winter 1967, Summer 1968), view the nursing law as Permissive. Therefore, the Massachusetts law is treated as Permissive throughout, for both registered and practical nurses.

Sources: Maryland Y. Pennell and Paula A. Stewart, State Licensing of Health Occupations, (Washington D.C.: U.S. Department of Health Education and Welfare, Public Health Service, 1968), pp. 65, 73; "Legislative Notes", American Journal of Nursing, various issues; correspondence with various state nursing associations.

Table II.1 b

Year of Licensure

Practical Nurses

State	Year First Passed	Year Mandatory	Status 1960	Status 1970
Alabama	1945	1971	P	P
Alaska	1953	1957	M	M
Arizona	1952	----	P	P
Arkansas	1947	1947	M	M
California	1951	----	P	P
Colorado	1957	1957	M	M
Connecticut	1935	1956	M	M
Delaware	1955	1963	P	M
District of Columbia	1960	----	P	P
Florida	1913	1952	M	M
Georgia	1953	----	P	P
Hawaii	1947	1959*	P	P
Idaho	1947	1947	M	M
Illinois	1951	1965	P	M
Indiana	1921	1971	P	P
Iowa	1949	1963	P	M
Kansas	1949	----	P	P
Kentucky	1950	1966	P	M
Louisiana	1948	1948	M	M
Maine	1945	1967	P	M
Maryland	1922	1967	P	M
Massachusetts	1941	----+	P	P
Michigan	1952	----	P	P
Minnesota	1947	----	P	P
Mississippi	1954	1970*	P	P
Missouri	1953	----	P	P
Montana	1953	1967	P	M
Nebraska	1955	----	P	P

Table II.1 b (continued)

State	Year First Passed	Year Mandatory	Status 1960	Status 1970
Nevada	1949	1949	M	M
New Hampshire	1951	1967	P	M
New Jersey	1947	1959	M	M
New Mexico	1953	1968	P	M
New York	1938	1949	M	M
North Carolina	1947	1965	P	M
North Dakota	1947	----	P	P
Ohio	1956	1971	P	P
Oklahoma	1953	1967	P	M
Oregon	1949	1973	P	P
Pennsylvania	1919	1966	P	M
Rhode Island	1948	1952	M	M
South Carolina	1947	1969	P	P
South Dakota	1955	1967	P	M
Tennessee	1945	1967	P	M
Texas	1951	----	P	P
Utah	1949	1963	P	M
Vermont	1951	1962	P	M
Virginia	1946	1970*	P	M
Washington	1949	----	P	P
West Virginia	1957	1967	P	M
Wisconsin	1943	----	P	P
Wyoming	1955	1967	P	M

Symbols and sources are the same as in Table II.1 a.

introduction of nursing licensure. The ability of an occupational group to obtain a license, Stigler argues, will depend upon the size of the occupation (more votes available), its per capita income ("rewards" for successful political action), concentration of the occupation in large cities, and the presence of cohesive opposition to licensure. The latter two points are said to reflect the "costs" of licensure. Costs of solicitation and communication will be lower the greater the concentration of a group in a geographic area. In addition, if the occupation serves the "public at large", the costs imposed on any one individual will be small. As a result, Stigler asserts, "it will not be economic for that consumer or industry to combat the drive for licensure."[45]

Stigler attempted to test these assertions by use of regression analysis. For a number of different occupations and using states as units of observation, he regressed year of license in each state against two measures of concentration in the median year in which the particular occupation was licensed: size of the occupation relative to labor force, and urbanization. Both variables were expected to have negative signs, reflecting the greater ease of licensure (i.e., earlier year of licensure) in those states in which relative size and urbanization were large. For registered nurses, Stigler found both variables to be negative, with relative size highly significant.

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[45]Stigler, 13-14.

Stigler's regression results for nurses may be expanded by noting some characteristics of nursing at the turn of the century. Observers of nursing education have noted that hospital affiliated nursing schools provided most of the available training programs. The existing group of trained (graduate) nurses became increasingly alarmed at the quality of training offered in these institutions, their proliferation, and their utilization of cheap student labor in nursing tasks:

> Since the supply of trained nurses was short and finances were skimpy, and since hospital administrators were often laymen or physicians of no great education themselves, the great majority of these newly founded hospitals disregarded Nightingale [training] precepts.... The increase in the founding of hospital affiliated schools for nurses was phenomenal. But these schools did not give the training that...nurses required; rather they were designed to supply the hospitals' needs for steady help at a reasonable price. This is the most generous construction that can be put upon the rise of 'hospital schools'. A less generous one, which surely fitted some schools, is that through them cheap, exploitable female labor was fed into the hospitals.[46]

As the above statement suggests, quality as well as economic considerations may have played an important role in attempts to regulate entry into the nursing profession. While most writers emphasize the "quality" of training aspects, there is some reason to recognize the economic

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[46]Anselm Strauss, "The Structure and Ideology of American Nursing: An Interpretation," The Nursing Profession, Five Sociological Essays, ed. Fred Davis (New York: John Wiley and Sons, 1966), pp. 67-68. The above impression was obtained from speeches made in 1893 by nurses conferring at Chicago's Columbian Exhibition.

aspects. As the description indicates, the nursing labor market in this period was characterized by excess demand. As a result, employers attempted to create their own supply sources by developing training programs and utilizing inexpensive student labor in nursing tasks. As Stuart Altman notes, 73 per cent of such institutions in the late 1920's employed no graduate nurses.[47] One could hardly expect an occupation, no matter how concerned with upgrading training quality, to view the above practice as conducive to the economic well-being of its members.

To account for the above considerations, I have expanded Stigler's regression framework to include the number of training schools in the state (NS) and the ratio of enrolled to trained nurses in the state (EDT). The former variable is used to reflect the "quality" considerations that motivated existing members of the nursing profession to push for licensure. We might surmise that the growth of such facilities "diluted" quality of training by relying on unqualified nursing instructors or by over-utilizing the existing stock of competent instructors and supervisors. The latter variable, enrolled to trained nurses in the state is viewed primarily as a proxy to measure the threat of potential substitutes for existing trained nurses.

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[47]Stuart Altman, Present and Future Supply of Registered Nurses (Washington: U.S. Department of Health, Education and Welfare, National Institute of Health, Division of Nursing, 1971), p. 66.

The larger the ratio, the more potential nurses available for existing nursing positions. We expect both variables to be negatively related to the year of initial nursing licensure in the state (our dependent variable): the greater the level of each variable, the more eager existing nurses would be to protect the status of their profession (in terms of quality and employment) and hence, the earlier attempts would be made to obtain licensure.[48]

The remaining independent variables in our regressions included:

MDY: year of physician licensure in the state. (Source: Pennell and Stewart, op. cit., p. 111). MDY was primarily included as a proxy for legislative attitudes toward granting occupational licensure. States which granted licensure for one group of health practitioners at an earlier date may have had an atmosphere conducive for other groups (i.e., nurses) to obtain protection. If this is the case, we expect a positive relationship (earlier MD licensure in a state associated with early professional nursing licensure). A negative result could be interpreted

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[48] We wish at this point to note our awareness of the difficulties and limitations of using these variables. Both NS and EDT may be measuring the same phenomenon: either quality or potential substitution. By including both, however, we may be able to partially separate these effects. For example, as we hold the ratio of enrolled to trained nurses constant, and allow nursing schools to vary, we compare states with more programs but perhaps fewer students per program. However, this does not necessarily imply improved quality since the existing stock of qualified teachers must still be "spread" out. Alternatively, holding the number of nursing schools constant, and varying the enrolled to trained nurse ratio involves comparisons of states with larger numbers of students per program. However, this may not imply quality deterioration since there may be some economies of scale (up to a point) in training and limited qualified instructional personnel can now reach more students. We should also note that the simple correlation between EDT and NS is not overbearing, approximately .37. Thus, for want of better measures and recognizing these limitations, we utilize this approach.

as reflecting physician control over the ability of allied health occupations to obtain licensure, since if nurses were to acquire licenses, physicians could stand to lose a low cost source of labor.

PY: median personal income in the state. (Source: Richard Easterlin, "State Income Estimates", Population Redistribution and Economic Growth, United States, 1870-1950, Simon S. Kuznets and Dorothy S. Thomas, eds., Vol. I, (Philadelphia: American Philosophical Society, 1957). PY is used as a standardizing variable, reflecting influences such as urbanization, education and health of population.

TLFT: ratio of trained nurses to labor force in thousands. (Source: U.S. Census). TLFT reflects influences suggested by Stigler: greater voting ability by members of the occupation, lower costs of obtaining a license. We expect a negative sign: greater TLFT, earlier year of license.

All independent variables were defined for 1900, a year prior to any state nursing licensure law.

Table II.2 presents the year of nursing licensure regressions. In our initial specifications, equations (1) through (3), both NS and EDT have the expected negative signs. This provides support for our assertion that "quality" and substitution considerations may well have been a factor in speeding the introduction of nursing licensure in some states. In equation (3), in which both variables are included, NS appears to be the more significant variable. Both the marginal contributions of NS and EDT are reduced in equation (3), below their individual contributions in equations (1) and (2), suggesting that neither interpretation should be considered exclusive. There does seem to be greater support for NS, however, based on both its significance, and the improvement in the adjusted R^2 ($\bar{R}^2$) when it is included. It should be noted that MDY has the positive

Table II.2

Year of Professional Nursing Licensure Regressions

	Dependent Variables				
	(1)	(2)	(3)	(4)	(5)
	RNY	RNY	RNY	RNY	RNY
Independent Variables					
MDY	.02 (.51)	.03 (.74)	.023 (.69)	.03 (.91)	.03 (.94)
PY	.005 (.60)	.002 (.25)	.01 (.74)	.02 (1.80)*	.02 (1.80)*
NS	-.11 (-2.57)***		-.09 (-2.02)**	-.02 (-.44)	
EDT		-2.06 (-2.06)**	-1.40 (-1.36)+	-1.73 (-1.83)*	-1.87 (-2.11)**
TLFT				-10.97 (-3.01)***	-11.76 (-3.74)***
CONSTANT	1878	1863	1867	1859	1858
$\bar{R}^2$	.08	.03	.09	.24	.25

t-ratios in parentheses

\+ significant at .10 level

* significant at .05 level

** significant at .025 level

*** significant at .01 level

All for one-tail test

Number of observations: 48 states.

sign although its significance is low throughout.

Equation (4) adds TLFT to the regression. This variable has the expected negative sign, reflecting reduced costs of obtaining licensure as TLFT grows larger as well as greater potential votes to support legislation. The inclusion of this variable greatly improves the explanatory power of the model ($\bar{R}^2$ now .24) but at the same time reduces the significance and contribution of NS. This latter effect may be due to collinearity between NS and TLFT since their simple correlation is .55. This may also suggest that the numerical level of nursing schools is not the appropriate form for a "quality" measure. Perhaps an alternative form such as the rate of growth in these schools would be a better specification. Finally, when NS is deleted (equation 5), both EDT and TLFT increase in significance. These variables may be partially capturing the "quality" considerations attributed to NS, along with their original interpretations.

The above results are not meant to be exhaustive, but rather suggestive. From the analysis, it appears that quality, substitution, and cost considerations (of obtaining licensure) may all be important factors in leading to the introduction of nursing licensure. While the results point to the difficulty of isolating these individual effects, they indicate that further research and more precise variables are required before stronger statements may be made. We therefore present these results as an extension of Stigler's work and for the support of the historical data that they offer.

II.3 The Effects of Nursing Licensure on the Demand for Nursing Labor

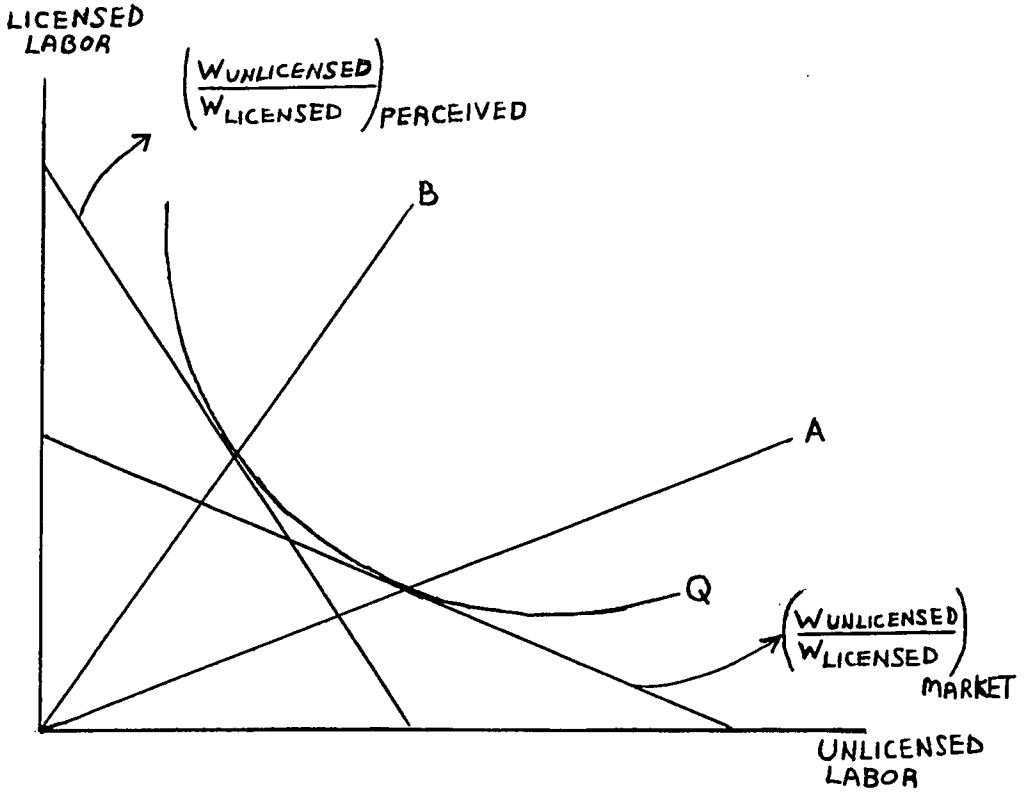
As I have alluded to above, the mandatory-permissive distinction found in health licensure laws suggests that utilization of various types of personnel may result in additional costs imposed upon employers. Since licensure imposes a rigid occupational setting, it interferes with attempts by employers to operate efficiently by equating marginal rates of substitution with relative wages of various types of labor. That is, if employers desire to economize by using an unlicensed lower priced input (whom employers believe could successfully perform a particular tasks falling within the scope of licensed labor) in place of licensed labor, the nature of a mandatory act would impose potential costs for this action and distort the decision made on the basis of relative market wages. The relevant costs might include penalties faced by employers for violations of the law (fines, adverse publicity, time spent in litigation) as well as additions they must make to the wage of unlicensed labor which are required to induce the latter to engage in this activity (since these workers will also be subject to possible penalties). As a result, the "perceived" relative wage rate (in contrast to the market relative wage) would be viewed as having increased, discouraging the utilization of relatively more unlicensed labor deemed capable of performing the task in question.[49]

[49]Section III.4 in Chapter III more fully develops the relationship between "perceived" and market relative wages as well as the underlying behavior of employers.

Thus, the imposition and nature of mandatory licensure may prevent employers from utilizing classes of labor in accord with what relative market wages and marginal productivities might dictate. In particular, as Figure II.1 indicates, a factor ratio such as B may be utilized when one such as A (at a lower cost) might be feasible had the effects of licensure been absent.

Figure II.1

Effects of Licensure on Factor Ratios



The above analysis can be applied specifically to nursing, and the effects of mandatory licensure on relative numbers of registered nurses to practical nurses, (RN/PN), and relative wages, (W_{RN}/W_{PN}), may be predicted. That

employers may react in a manner described above has been noted by several writers who observe that "objections to making a licensure law mandatory come from those who find it cheaper and less restrictive to use unlicensed personnel...[50] Thus, in jurisdictions in which licensing is mandatory for registered nurses, utilization of practical nurses to perform RN tasks may be associated with possible added costs facing employers. In permissive jurisdictions, in which these costs are not relevant (since only the title and not the scope of activity is protected), presumably producers could adjust their RN/PN ratios to one dictated by market wages and marginal productivities. Therefore, we might expect firms to alter their RN/PN ratios as we move from permissive to mandatory jurisdictions. In the labor market for all firms, moving from permissive to mandatory jurisdictions, we might expect to view both higher relative wages (W_{RN}/W_{PN}) and numbers employed (RN/PN), assuming a stable supply schedule of RN/PN. Thus, in Figure II.2, demand schedule DD and supply schedule SS are specified for a labor market in which each hiring unit is assumed to face permissive licensure. Imposition of a mandatory licensure,

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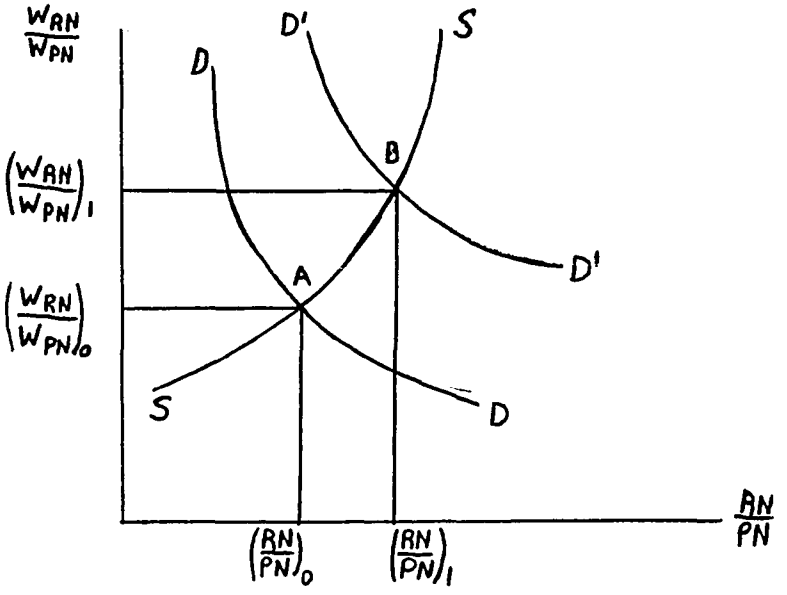
[50]Lucie Young Kelly, "Nursing Practice Acts", American Journal of Nursing, Vol. 74, 7 (July 1974), 1314. See also AMA Committee on Nursing, "Mandatory vs. Permissive Licensure for Nurses", op. cit., 203. The committee notes that "some hospital administrators object on the basis that mandatory licensure will regulate their...employment practices." Conversations with members of the nursing profession indicated that under permissive acts, employers would try to economize by utilizing relatively more PNs.

Figure II.2

Effects of Mandatory Licensure
On Relative Nursing Demand



by raising the "perceived" costs of using PNs relative to RNs, shifts the demand schedule to D'D', resulting in increased relative wages and numbers (equilibrium position A to B).[51] Note that these results hold if the relative supply schedule is stable. As the next section argues, however, there are strong reasons to expect that the imposition of a mandatory license will effect the relative supply schedule as well as relative demand.

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[51]Supply schedule SS describes the distribution of the given stock of nurses between registered and practical nursing. That is, it relates the occupational choice to relative wages. At any equilibrium point, we assume that the given nursing stock has been distributed between registered and practical nursing so that when the relative numbers supplied and demanded are equal, so are the <u>actual</u> numbers supplied and demanded in each category.

II.4 The Effects of Mandatory Licensure on the Relative Supply of Nursing Labor

Up to this point, we have restricted our discussion of the effects of mandatory licensure to the demand side. However, the mandatory-permissive licensure distinction can be seen to affect the RN-PN occupational decision by the way it influences the supply of labor to various nursing tasks. The general effects of health licensing on career mobility have been described in the following manner:

> Licensure laws have boxed in the very groups supporting them. Employees seeking advancement soon are stymied by education and examination requirements--even though those requirements may include courses and clinical experience they already have completed. The licensed practical nurse is a prime example. Despite her years of formal training and her hospital work, she usually cannot receive placement into an education program for registered nurses.[52]

It should be noted that although a permissive licensing law has the above effect concerning the full promotion of an unlicensed employee to another occupational category, it does not prevent employees from performing tasks of another occupational group. Thus, pay-offs to on-the-job training and experience exist for unlicensed personnel, since they may be utilized in areas of greater responsibility as long as they do not assume the occupational title.[53]

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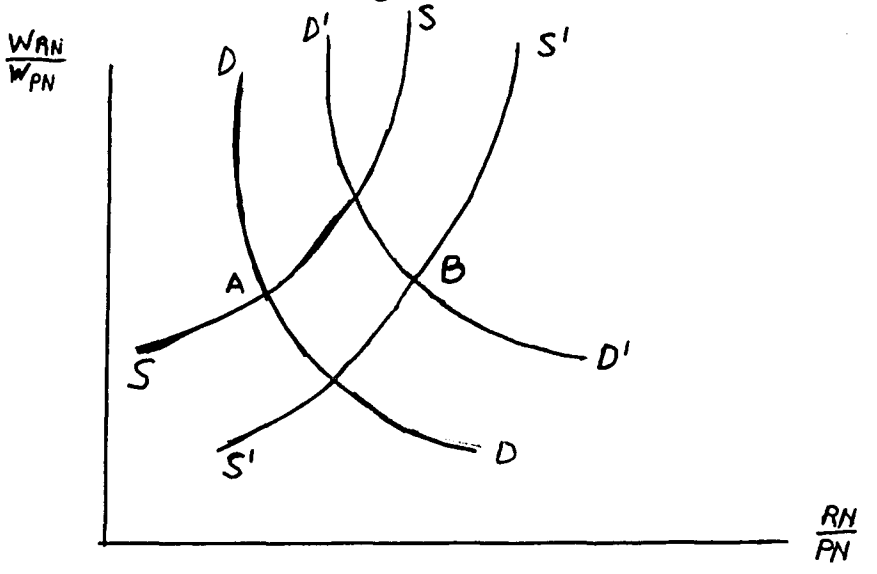
[52] E. Martin Egelston and Thomas Kinser, "Licensure of Hospital Personnel", Hospitals, Journal of the American Hospital Association, Vol. 44 (November 16, 1970), 37.

[53] A return (in the form of higher earnings) from on-the-job training will exist for both unlicensed personnel and firm in a permissive setting, since the training is not completely general in the following sense. An unlicensed individual could not perform such tasks in a mandatory setting, and since there is always the threat of licensure changing from permissive to mandatory, unlicensed personnel will have little incentive to finance the full training.

Under mandatory licensure, however, the performance of such tasks by unlicensed personnel is prohibited by the nature of the licensing law. Thus, ability to gain higher earnings, through use in more responsible tasks, is limited, as are the returns to on-the-job training and experience. If potential nursing entrants in a mandatory registered nurse regime are aware of this implication of the license, there may be greater incentives to enter a registered nursing program. The mandatory nature of the license reduces the ability

Figure II.3

Effect of Mandatory RN Licensure
On Relative Wages and Numbers



to obtain increments to earnings by entering the occupation through (less costly) PN training and progressing via on-the-job training and experience. In the context of our supply-demand framework, then, we might expect the imposition of a mandatory license to shift relative supply schedule to the <u>right</u>, reflecting the limitations of PN training. As a

result, taking both supply and demand considerations into account, we would observe an increase in relative numbers employed, with the effect of the mandatory RN license on relative wages (RN to PN) depending upon the magnitude of the supply-demand shifts (this is displayed in Figure II.3).

II.5 The Effect of Mandatory Practical Nurse Licensure

The discussion thus far has not considered the potential effects of mandatory PN licensure. As has been noted in Table II.1 b, there is also variation in the nature of practical nurse licensure. Hence, any analysis regarding the effect of mandatory RN licensure on relative wages and numbers (RN to PN) must consider the effect of mandatory PN licensure. The latter will influence the determination of relative wages and numbers through its effect on the decision to employ PNs vis-avis nursing aides, and on the decision to supply labor as a PN or nursing aide. These effects may be seen through the following example.

Consider the imposition of a mandatory RN license in a jurisdiction heretofore permissive. Assuming the relative supply schedule to remain stable, our above analysis suggests that RN/PN wages and numbers employed will increase. However, if at the same time practical nurse licensure has also changed from permissive to mandatory, there will be an increase in demand for PNs relative to other types of nursing labor, such as nursing aides. Thus, practical nurse wages and numbers employed may increase, due to the mandatory PN

license. As a result, the effect upon RN/PN relative wages and numbers would be understated, since they would partially reflect the effects of mandatory PN licensure. The desired measure of the effect of mandatory RN licensure would be distorted.[54] Therefore, in order to measure the effect of mandatory RN licensure on RN/PN wages and numbers, we must devise an empirical strategy which will eliminate the varying nature of practical nurse licensure. It is to the development of that strategy that we now turn.

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[54]The effects of mandatory PN licensure on the relative supply of RNs to PNs will be discussed in detail in Chapter III.

Chapter III

An Empirical Test of the Effects of Nursing Licensure

> It is not now possible to determine the extent to which the economic status of the registered nurse is affected by the employment of practitioners of lesser skills as interchangeable substitutes for qualified nurses. However, it is reasonable to suppose that adherence to professional and legal controls on practice would elevate the status of nursing and provide a firm base from which the profession could deal with its serious economic problems.
>
> Committee on the Resolution of Nursing Practice Report, American Nurses Association, May 1960.

III.1 Empirical Strategy

In order to discern whether the varying nature of nursing licensure has had any effect on the utilization of nursing labor, in the manner described in Chapter II, we develop and test a simultaneous equation model in which relative numbers (registered to practical nurses) and relative wages (registered to practical nurses) are treated as endogenous variables. The level of these variables is viewed as being determined simultaneously, as is the case in any market, through the interaction of supply and demand. Nursing licensure is viewed in this model as leading to potential changes in relative wages and numbers through shifts in demand and/or supply.

The model consists of the following two structural equations:

$$\text{(III.1)}\quad RELW^{*} = a_0 + a_1 RELR^{*} + a_2 LRN + a_3 LPN + \sum_{i=4}^{k} a_i x_i$$

$$\text{(III.2)}\quad RELR^{*} = b_0 + b_1 RELW^{*} + b_2 LRN + b_3 LPN + \sum_{i=4}^{J} b_i z_i$$

Equation III.1 is a relative demand equation (RNs to PNs) expressed inversely[55] with relative wages (RELW) treated as a dependent variable. A primary rationale for this "inverse" treatment (to be developed below) is that estimation of this equation allows us to examine the "direct" effects of licensure on relative wages, independently of supply effects that the licensure may lead to. This direct effect can be used to approximate the "perceived" costs employers believe are associated with violation of the license. The remaining variables in equation III.1 include relative numbers (RELR), licensure variables (LRN and LPN), and other exogenous variables (variables with an asterisk are endogenous). Structural equation III.2 represents a relative supply equation in which the effects of the nature of nursing licensure on the supply of registered to practical nurses is tested. As in the demand equation, this equation will present estimates of the "direct" effect of licensure on relative numbers. A more complete description and interpretation of the structural equations and their reduced form counterparts will be

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[55]The inverse form of the demand function can be directly derived from a CES form of the production function. See note 62 and Appendix III. This "inverse" specification (wages as the dependent variable) also appears in a number of works. See for example Lee Benham, "The Labor Market for Registered Nurses: A Three Equation Model", Review of Economics and Statistics, LIII, 3 (August 1971); William M. Landes, "The Economics of Fair Employment Laws", Journal of Political Economy, Vol. 76 (July/August 1968); and Sherwin Rosen, "On the Interindustry Wage and Hours Structure", Journal of Political Economy, Vol. 77, 2 (March/April 1969).

presented after a brief discussion of the data comprising the variables included in our equation system.

III.2 The Data

Part of the difficulty involved in testing the effect of various legal sanctions is finding a period for which both data and sufficient variation in the laws exists. Fortunately, for nursing licensure, 1960 provides such a period. Data on wages and numbers is available and there is sufficient variation in the distribution of mandatory and permissive licensing provisions.[56]

Since the power to license nursing personnel is vested with state governments, the state is used as our basic unit of observation. Thus, the wages and numbers[57] data used were taken from the 1960 Census. The wage data, more specifically, was taken from a 1/100 sample tape of annual earnings from the 1960 Census[58] and was transformed into hourly wages[59] (RELW* in the above equations).

[56] As Tables II.1 a and b indicate, by 1970 most RN licensure was mandatory while there was some variation in PN licensure. The necessity to group jurisdictions, described below, eliminates variation in RN licensure for 1970.

[57] Although manhours might be a more appropriate variable to measure numbers in our demand equation, it would needlessly complicate the equation system. An equation system using relative manhours as a measure of RN and PN labor was tested, but did not improve our empirical results.

[58] I am indebted to Professor V. Fuchs for making the data available.

[59] Hourly wages were obtained for each group of nurses in each state by dividing annual earnings by annual hours of work (weeks worked times hours per week).

Since variations in observed relative wages may reflect differences in relative nursing quality (RN to PN) across jurisdictions, we indlude the ratio of "expected" nursing wages in the jurisdiction,[60] as an exogenous variable. Thus RELW* represents the ratio of hourly observed wages (unadjusted for labor quality) and the expected wage ratio falls within the set of exogenous variables included in equation III.1.

The use of the expected wage ratio variable has both an empirical and theoretical basis. Empirically, we avoid biases in estimates of the effect of licensure on relative demand (wages) which may be associated with relative qualify differences. Thus, if quality may be approximated by education, race, age and sex differences, and if the ability to secure mandatory licensure is related to these measures (i.e., more highly educated RNs across jurisdictions are better able to articulate the need for such licensure), we may overstate

[60]The "expected" wage rate for each nursing group is obtained following a technique developed by Fuchs. This variable is defined as "expected" earnings divided by annual hours of work (for each nursing group in the state). Expected earnings are obtained by multiplying the national wage rate for each worker of a particular age, sex, race and schooling cell by hours of work of a particular nurse in the state with those characteristics, and summing over all workers in the nursing group. The "expected" wage for the nursing group in the state is then obtained by dividing the expected earnings by the annual hours of work of the nursing group in the state. The ratio of these expected wages serves as an index of RN to PN quality across jurisdictions. For a complete description, see Victor Fuchs, Differentials in Hourly Earnings by Region and City Size, Occasional Paper 101, (New York: National Bureau of Economic Research, 1967), pp. 4-5.

the effect of licensure on market relative wages. Furthermore, since the number of observations we deal with is small (31),[61] the use of this relative quality variable enables us to preserve degrees of freedom. Finally, the specifications of our inverse demand function, with observed relative wages as our dependent variable (and endogenous variable in III.2) and relative expected wages as an exogenous variable, has a theoretical basis. It is consistent with a cost minimizing process in which the production function is of the CES variety and relies upon inputs measured in <u>efficiency</u> units as its arguments.[62] As we show below, this is strictly the case

[61]The 31 observations used were reduced from the original 50 states because of small samples of registered and practical nurses (less than 10) in the earnings data in some of the states. Where possible, these states were grouped with larger neighboring states having the same type of RN-PN licensure. If this was not possible, the states were omitted. The grouped states consisted of Arkansas-Louisiana, Delaware-District of Columbia-Maryland, Maine-New Hampshire-Vermont, Alabama-Mississippi, Minnesota-North Dakota-Iowa, Rhode Island-Connecticut, North Carolina-South Carolina, Nebraska-South Dakota, Virginia-West Virginia, Arizona-New Mexico. Those states omitted were Alaska, Hawaii, Nevada, Idaho, Montana, Wyoming and Utah.

[62]Allow the production function for hospital output or nursing services to take the following CES form:

$$(1)\quad x = \left[\alpha_1 H_1^{-\beta} + \alpha_2 H_2^{-\beta} + \alpha_3 Z^{-\beta}\right]^{-\frac{1}{\beta}}$$

where H_1 is registered nurse input in efficiency units, H_2 is the practical nurse input in efficiency units, Z represents other inputs, and σ is the constant elasticity of substitution between any two inputs. Let:

$$(2)\ H_1 = a_1 N_1 \qquad (4)\ W_1 = a_1 \hat{W}_1$$

$$(3)\ H_2 = a_2 N_2 \qquad (5)\ W_2 = a_2 \hat{W}_2$$

where N_1 and N_2 are numbers of registered and practical nurses, a_1 and a_2 are indexes of quality or efficiency

if σ, the constant elasticity of substitution between inputs, is greater than 1.

Our other endogenous variable in these equations, RELR, relative numbers employed (RNs to PNs) in each state, was obtained from data in state census books.

The exogenous variables included for testing in relative demand and supply equations consisted of the following:[63]

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[62](continued) per registered and practical nurse, W_1 and W_2 are the actual wages of registered and practical nurses, and $\hat{W}_1$ and $\hat{W}_2$ are the quality-adjusted wages for registered and practical nurses. Note that a_1/a_2 may be viewed as the "expected" wage ratio and W_1/W_2 as the actual wage ratio. Assuming the price of Z to be one dollar, we can express total cost as

$$(6)\quad C = Z + \hat{W}_1 H_1 + \hat{W}_2 H_2.$$

By minimizing (6) subject to the production function in (1), we are able to obtain the inverse demand curve for H_1 relative to H_2. Substituting definitions in (2) through (5) results in the inverse demand schedule which is the basis of our empirical testing.

$$(7)\quad \ln (W_1/W_2) = \ln (\alpha_1/\alpha_2) - \frac{1}{\sigma} \ln (N_1/N_2) + (1 - \frac{1}{\sigma}) \ln (a_1/a_2).$$

Note that if $\sigma > 1$ actual wages will be positively related to expected wages. We may empirically test for this effect. See Appendix III for a proof of these results.

[63]The inclusion of several of the following exogenous variables in our relative demand equation may be derived by examining the term $\ln (\alpha_1/\alpha_2)$ in equation (7) of note 62. This term measures the portion of relative demand (RELW) independent of our slope variable, expected wage ratio, and licensure variables. $\ln (\alpha_1/\alpha_2)$ itself may therefore be dependent upon variables such as the physician, population ratio, average length of stay, etc. Thus, these variables may be included in its place. The remaining exogenous variables, as argued above, are inserted to avoid biasing our licensure variables.

Demand Equation:

LRN: a dummy variable taking a value of 1 if a state has mandatory RN licensure; 0 if the licensure is permissive.

LPN: a dummy variable taking a value of 1 if a state has mandatory PN licensure; 0 if the licensure is permissive.

Source for both: Pennell and Stewart, State Licensing of Health Occupations, pp. 65, 73; American Journal of Nursing, "Legislative Notes", various issues; correspondence with various state nursing associations.

An interpretation of these dummy variables will be presented below.

PPR: ratio of employed physicians in the state per 1000 state population. (Source: 1960 Census, for physicians; 1970 Statistical Abstract, for population.)

PPR is used to control for possible greater demand for RNs in locations in which physicians may be scarce. If this potential substitution exists, we would expect the coefficient of PPR to have a negative sign (as physicians become scarce, greater utilization of registered nurses is made, and with relative numbers constant, relative wages increase). A positive sign could reflect the possibility of complementarity between RNs and physicians.

AVLOS: average length of stay in short-term and other special hospitals in the state, 1960. (Source: Hospitals, Journal of the American Hospital Association (August 1961).)

AVLOS is used as a proxy for variations in case-mix across states. Longer lengths of stay may reflect a more serious mix of illnesses in the state, and hence, a greater demand for more highly trained nursing personnel (with PPR held constant). Using this interpretation, we expect a positive

relationship.

It should be noted that there are obvious problems involved with the above interpretations of AVLOS. AVLOS may reflect variations in individual physician philosophy regarding the length of hospitalization for various illnesses and will certainly reflect bed availability in the state. While there is little we can do to control for the former, we can control for the latter by including, in various regressions, the following variables:

BC: short-term hospital beds per thousand population in the state.

OCR: occupancy-rate in short-term general hospitals.

(Source for both: Hospitals, op. cit.)

By holding these variables constant, we can eliminate that part of physician decisions regarding length of stay which depend upon bed availability, and hopefully obtain results which more accurately reflect variations in case-mix.

The remaining variables used included the following:

GB: government hospital beds (all types of government) as a per cent of all beds in the state in 1960. (Source: Hospitals, op. cit.)

This variable is included to reflect the influence of government in the utilization of nursing labor. Government staffing requirements may be more rigid than those in non-governmental institutions, with less latitude for RN-PN substitution. In addition, government employers may have little incentive to minimize or economize on labor costs. As a result, we might expect relatively more RN to PN utilization as the influence of government employment expands across

states.[64] Thus we might expect a positive relationship in our RELW (demand) equation between GB and RELW. However, there may be some reason to expect a negative relation if government employment narrows wage differentials within an occupation for different skill groups. As a result, we offer no a priori predictions as to the resultant sign of GB.

AVBS: average bed-size of short-term general hospitals in the state. (Source: Hospitals, op. cit.)

AVBS is included to obtain an idea as to whether the physical scale of hospitals influences the ability to "police" possible violations of the license. That is, the larger the physical scale of the hopsital, the more difficult (i.e., costly) it becomes to ascertain possible licensure violations. Hence, the expected costs of violation decline (as the probability of detection diminishes with increased hospital size). As a result, we would expect relative demand to decline as hospital size rises, and therefore a negative relationship between RELW and AVBS. By holding the size of hospitals constant, then, we may be able to obtain a clearer idea of the effect of the license, one not distorted by the difficulty inherent in monitoring the activity of labor in large scale enterprises.[65]

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[64]The notion that government-administered hospitals may be constrained by "more rigid staffing requirements" is provided by Eherenberg as a reason for the insignificant relationship between the ratio of RNs to PNs employed in government hospitals and their relative wages. See Ronald G. Eherenberg, "Organizational Control and the Economic Efficiency of Hospitals: The Production of Nursing Services", Journal of Human Resources, IX, 1 (1974), 25.

[65]Ibid., 30. Eherenberg suggests this interpretation of size on the ability to police.

The above variables comprise the final set included in various specifications of our "demand" equation. Although other variables were included in the testing, they were omitted in the final version either because of their low significance or because the above variables were better representatives of the effects we attempted to measure.

Supply Equation:

LRN and LPN[66] are also included in the supply equation and once again, their interpretation will be discussed below. Other variables include:

TP: ratio of RN to PN training programs in the state, 1960. (Source: Facts About Nursing, American Nursing Association, 1961)

We include TP for two reasons. First, since employment opportunities presumably come easier (i.e., lower information costs) in states in which the nursing degree was taken, the relative supply (RN/PN) should be positively related to training facilities. Secondly, TP may be viewed as a policy variable through which states may alter their nursing labor mix and its skill level (once again, a positive relationship expected).[67] To account for these possibilities, we there-

[66] We should note at this point that LRN and LPN could be considered endogenous variables in the context of a larger model in which an explanation of the "demand" and "supply" for each type of licensure was included. However, such a framework would in general be difficult to implement and is beyond the scope of this essay.

[67] The inclusion of TP for possible "policy" reasons follows work by Benham, op. cit. Benham, in estimating a stock of registered nurses equation, includes lagged graduates as his policy variable, using increases in this variable to reflect the potential effect of new training facilities. We also

fore include the variable.

BDRN: per cent of registered nurses on the registered nurse licensing board in the state. (Source: Pennell and Stewart, State Licensing of Health Occupations, 1967. It should be noted that for some states, the data does not correspond to the 1960 board membership but for membership before 1966).

A priori, the relationship of BDRN to RELR is not clear. It is tempting to suggest a negative relationship, since the greater the degree to which RNs exert control over their licensing board, the greater the ease with which they can control the entry of new RNs. However, since RNs and PNs do compete to some degree for nursing positions and for leadership in the nursing profession,[68] RNs may use their

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[67](continued) tested a lagged training program ratio and RN/PN graduate ratio (5 year lag). In each case, these variables did not perform well. One problem with using TP is that it may represent an alternative measure of nursing supply in the state, and thus be correlated with our remaining independent variables.

[68]"The practical nursing occupation is to a great extent controlled by registered nurses." Benjamin Shimberg, Barbara S. Esser, Daniel H. Kruger, Occupational Licensing: Practices and Policies (Washington D.C.: Public Affairs Press, 1972), p. 19. The authors noted that the nursing board officials and PN training program administrators in their interviews were primarily RNs. They drew the following impression from an interview with a PN member of a state nursing (PN) board and a PN officer of a state PN association: "The picture that emerged from these discussions was that PNs perceived the RNs as dominating their profession. The PN who was a state nursing board member said that the RNs on the board usually caucused prior to each meeting and decided in advance what action they would take on each issue, including matters that involved practical nurses. If this report is accurate, the antagonism between the groups is understandable." pp. 21-22.

role on RN licensing boards to encourage the growth of their profession. Hence, the sign of this variable is not entirely obvious.

BDPN: per cent of PNs on the PN licensing board in the state. (Source: same as BDRN).

Since in some states, PNs have their own licensing board, of have a different composition of membership, we include this variable. Its interpretation, as with BDRN, is not a priori obvious. If practical nurses desire to improve their positions at the expense of potential PN entrants, then we would expect a positive relationship between BDPN and RELR. If however, practical nurses desire to expand their influence in nursing policy in the state, then increasing their membership represents one way of doing so. Hence the possibility of a negative relationship between BDPN and RELR is likewise possible.

FY: median family income in the state, 1960. (Source: Statistical Abstract, 1970).

FY enters the supply equation as a variable reflecting the ability or ease of financing nursing education. Since registered nursing generally requires several more years of education than practical nursing, the relative supply of RNs to PNs may be influenced by the ability to finance the additional years of schooling necessary. A more complete indication of the importance of family income as a financing device could be obtained if data on the family income and family size of student RNs and PNs were available. However, this alternative was not possible.

There may be some argument for including FY among our demand variables, since FY may be a reflection of the overall demand for medical care from which the demand for RNs and PNs is derived. However, one could expect PPR to reflect some of the influence of FY on the demand for medical care, due to the strong correlation between PPR and FY. Furthermore, a variable such as AVLOS probably reflects a more direct measure of medical care utilization and hence the demand for RNs relative to PNs.

Given this discussion of the nature of the data and variables used to estimate our model, we now proceed to discuss the interpretation of the license dummy variables.

III.3 An Interpretation of the Licensure Dummy Variables[69]

When two or more sets of dummy variables are included in a regression equation, care must be exercised in their interpretation. LRN and LPN both enter demand and supply equations, taking values of 1 if the particular nursing licensure is mandatory, 0 if it is permissive. As is indicated in Table III.1, there are three combinations of licensure that existed in 1960 in various jurisdictions: mandatory licensure for both RNs and PNs (LRN = 1, LPN = 1); mandatory licensure for RNs, permissive licensure for PNs (LRN = 1, LPN = 0); and permissive licensure for both RNs and PNs (LRN = 0, LPN = 0). There were no states or jurisdictions

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[69] I wish to thank Professor M. Grossman for assistance in this interpretation. See also J. Johnston, Econometric Methods, 2nd edition, (New York: McGraw-Hill, 1972), pp. 180-81.

for which RN licensure was permissive and PN licensure was mandatory. We will refer to the first group of states as MM states, the second group as MP states, and the third group as PP states. Hence the correct interpretation of the effect of licensure on RELW or RELR consists of the differential effects of comparisons between MM states, MP states, and PP states. The comparison between MP and PP states most closely resembles the simulation of the imposition of a mandatory license on registered nurses, and for our purposes is perhaps the most interesting.

Table III.1

Licensure Combinations By Ungrouped and Grouped States, 1960

Ungrouped States

PN \ RN	M	P
M	11	0
P	13	27

Ungrouped states sum to 51 since the District of Columbia is included.

Grouped States

PN \ RN	M	P
M	6	0
P	9	16

The above comparisons may be seen by writing out our regression model where x_i stands for all other exogenous

variables. For RELW we obtain:

$$(III.1') \quad RELW^{*} = a_0 + a_1 RELR^{*} + a_2 LRN + a_3 LPN + \sum_i a_i x_i$$

If our observation is a PP state, equation (III.1') is reduced to:

$$(III.2') \quad RELW^{*} = a_0 + a_1 RELR^{*} + \sum_i a_i x_i .$$

If our observation is an MP state, equation (III.1') becomes:

$$(III.3') \quad RELW^{*} = a_0 + a_1 RELR^{*} + a_2 + \sum_i a_i x_i .$$

Similarly, if our observation is an MM state, equation (III.1') becomes:

$$(III.4') \quad RELW^{*} = a_0 + a_1 RELR^{*} + a_2 + a_3 + \sum_i a_i x_i .$$

The differential effect on RELW, for each type of licensure, can be obtained by subtracting the relevant equations.[70] Therefore:

Table III.2

Interpretation of Licensure Coefficients

Effect on RELW	Equations	Appropriate Coefficient
MM vs. PP	(III.4') - (III.2')	$a_2 + a_3$
MP vs. PP	(III.3') - (III.2')	a_2
MM vs. MP	(III.4') - (III.3')	a_3

Thus, the effect on RELW of movements from PP to MP states, or the imposition of mandatory RN licensure (holding permissive PN licensure constant), is given by the regression

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[70] Note that the exogenous variables and right-hand endogenous variables do not enter into the derived expressions since these variables are in effect being held constant.

coefficient a_2. We expect $a_2 > 0$ based on the argument made in Chapter II. Movements from MP to MM states, which simulates the change to mandatory licensure for practical nurses (holding the nature of RN licensure constant), is given by a_3. a_3 is expected to have a negative sign since imposition of PN licensure would increase the demand for PNs relative to such nursing personnel as aides. With RN licensure constant, this would be translated into a decline in relative demand or in RELW. Finally, the effect of altering both RN and PN licensure from permissive to mandatory will depend upon the relative impact of mandatory licensure on the use of each type of nurse. Since a_2 and a_3 are expected to have opposing signs (a_2 positive, a_3 negative), a prediction is not possible.

With regard to the supply side, the imposition of mandatory RN licensure (with permissive licensure for PNs held constant) can be shown to be given by b_2 in a regression such as III.2 above. b_2, as the above discussion suggests, will show the differential effect of movements from PP to MP jurisdictions and has two possible interpretations. As we have noted in Chapter II, the licensure may inhibit the process of achieving greater earnings on-the-job, since the possibility of working in areas of greater responsibility may be limited.[71] Hence, benefits from on-the-job training

[71]Referring to the "vertical (career) mobility" of health manpower, Laurence R. Tancredi and John Woods in "The Social Control of Medical Practice: Licensure vs. Output Monitoring", Milbank Memorial Fund Quarterly, Vol. L, 1, Pt. 1

may not be readily forthcoming to non-RN nursing labor. Thus, if potential nursing entrants are aware of this consequence of the license, there may be some incentive to pursue more advanced schooling (i.e., RN training as opposed to PN training). If this hypothesis is correct, we would expect $b_2 > 0$.[72]

Coefficient b_3 describes the effect of mandatory PN licensure on relative supply. This effect simulates comparisons between MP and MM states, with mandatory RN licensure held constant. Mandatory PN licensure may impose greater costs on potential PN entrants by requiring formal schooling. In addition, since practical nursing programs have more flexibility regarding the technical nature of such programs (i.e., whether or not to include aspects of RN training), costs of entry may be adjusted by altering training requirements. The costs of entry to this <u>level</u> of nursing may be lower in permissive states, where presumably non-PN nursing labor (i.e.,

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[71](continued) (January 1972), 102, write: "Each licensed category of health personnel has its own set of formal educational requirements. The unlicensed aspirant, or the already-licensed worker wishing to move up to a more responsible position, may well find that his own education or experience is deemed inadequate or irrelevant to the new position, and that therefore he must undertake a costly and time consuming formal education program to qualify."

[72]Another interpretation of the effects of mandatory RN licensure is possible. If such licensure raises the relative costs of entering RN training as opposed to PN training, then we could expect a <u>negative</u> b_2 reflecting added costs of entry in mandatory states. This is a more difficult proposition to deal with empirically, since state cost of training estimates for RNs and PNs in 1960 do not appear to be published. However, a casual glance at requirements (age of entry, length of training published in Pennell and Stewart, op. cit., pp. 69, 77) for RNs and PNs across all

aides) could acquire the skills to perform PN tasks via on-the-job training and experience. If individuals desiring to attain the skill-level of PNs can be considered to have a "marginal" interest in nursing[73], the imposition of a mandatory PN licensing requirement may be sufficient to "discourage" their entry. Hence, the RN/PN ratio would rise ($b_3 > 0$) as a consequence of a decline in PN supply.[74]

There may be, however, some reasons for $b_3 < 0$. As in the case of RN licensure, mandatory PN licensure will prevent vertical career mobility of potential nursing entrants who hope to obtain the skills to perform PN tasks via on-the-job training (for example, beginning as a nursing aide). If this is the case, potential entrants may decide to enter formal PN training programs, resulting in a decline in the RN/PN ratio as the PN supply increases. Thus, mandatory PN licensure could conceivably cause the RN/PN ratio to decline.

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[72](continued) states does not suggest much variation. In addition, since registered nursing training encompasses all aspects of nursing, one might expect training content to be quite uniform across states. Hence, it appears that if mandatory RN licensure is to affect the relative supply of RNs and PNs, it may be expected to do so through the first means described.

[73]"Marginal" in the sense that they have not made the commitment to obtain full professional nursing status by choosing to undergo RN training.

[74]As we will discuss below, the movement in this ratio may not reflect a "discouragement" effect, but perhaps a "switching" effect. That is, since working as a PN requires a commitment to training (with mandatory PN licensure), there may be an incentive to "switch" to full RN training once the realization that nursing (at any level) requires formal training.

In addition, we offer no prediction as to the effect of imposition of both RN and PN mandatory licensure (MM-PP comparison). This effect is measured by $b_2 + b_3$ and since the signs of the individual coefficients are not a priori obvious, neither is their sum.

III.4 Interpretation of Coefficient a_2 as the "Perceived" Costs of Licensure Violation

In this section, we show that the coefficient of LRN (a_2) in our relative demand equation can be interpreted as approximating the "perceived" costs employers view violation of the licensure may impose. Under licensure, employers view the wage of unlicensed labor used in licensed tasks as differing from the market wage of unlicensed labor, W_u, with the disparity representing the "perceived" costs of violating the license. These costs may include legal or psychic costs, or sums which must be paid to unlicensed labor to entice them to perform "illegal" tasks. Thus, the "perceived" wage paid to unlicensed labor assigned to licensed tasks, $W_{u,p} = W_u(1 + c)$ where c is the per cent of W_u viewed as added costs for employing unlicensed labor. Therefore, employers view the relative wage of licensed to unlicensed labor as having declined, to the level $\frac{W_L}{W_u(1 + c)}$ from the observed or market level $\frac{W_L}{W_u}$ (where W_L is the wage of licensed labor). Thus, while the market wage ratio may suggest a more "unlicensed" labor intensive ratio, employers may desire to alter the ratio to one more "licensed" labor intensive, in light of these "perceived" costs. It is the

result of employers' actions to alter this labor ratio that we wish to examine, since the interpretation of the coefficient of LRN in structural equation III.1 depends on this.

In Figure III.1, two classes of labor, U and L, are employed at point A in the ratio $(\frac{U}{L})_1$, given the market wage ratio $(\frac{W_L}{W_u})$. Imposition of a license for class L, imposing potential penalties for the use of U in this activity, results in disparity between the existing market wage ratio and the "perceived" wage ratio, $(\frac{W_L}{W_u(1 + c)})$. From an employer's point of view, therefore, B now becomes the optimal employment ratio. Since, at a particular point in time, with the supply of each type of labor perfectly inelastic, each firm cannot react to their perceptions of the wage change without there being some effect in the labor market. All firms desiring to alter their $\frac{U}{L}$ ratios to B will necessarily bid market relative wages, $\frac{W_L}{W_u}$, up. A new equilibrium market wage will result at a level which just offsets the advantage of moving from A to B. As Figure III.2 shows, with a given market $\frac{U}{L}$ ratio, the shift in demand due to licensure will result in <u>observed</u> market relative wages rising. The new equilibrium wage ratio will be one that will induce firms to employ $\frac{U}{L}$ in their original proportions. That is, wages will rise by an amount equal to the "perceived" costs of using unlicensed labor.

More specifically, if the market relative wage $\frac{W_L}{W_u}$ is perceived as $\frac{W_L}{W_u(1 + c)}$, firms, by desiring to employ more of

Figure III.1

Effects of Licensure on Factor Ratios

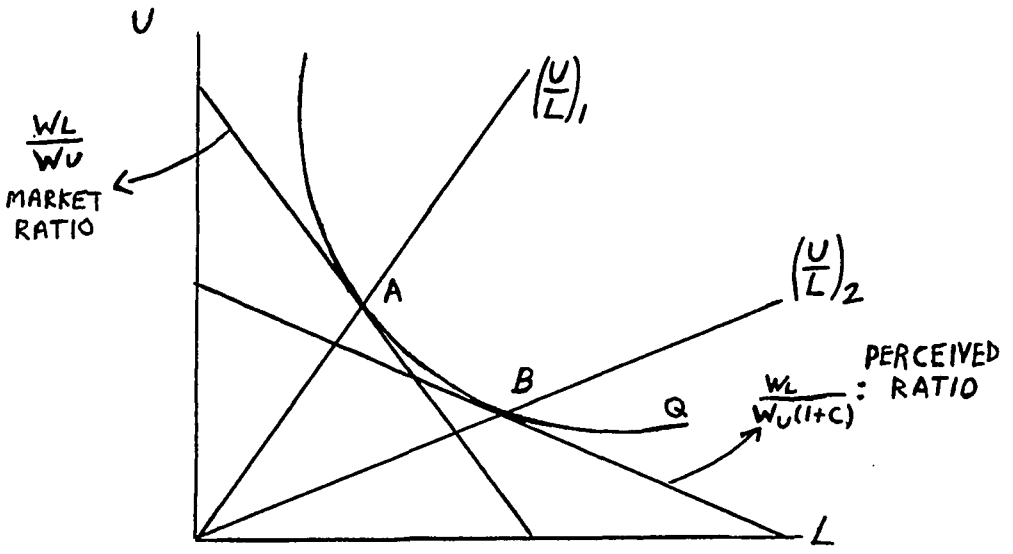
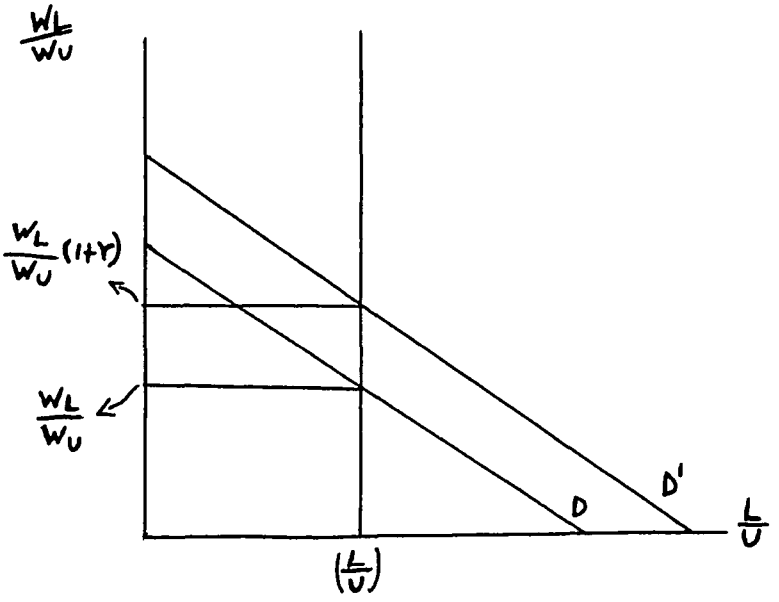


Figure III.2

Effect of Licensure on L/U Demand When L/U Supply Held Constant



L, will bid market relative wages up by $\frac{W_L}{W_u} \cdot (1 + r)$. This ratio will be perceived by firms as $\frac{W_L\ (1 + r)}{W_u\ (1 + c)}$. Since all firms are identical, and with a given $\frac{U}{L}$ supply in the market, the best any one firm can do is to employ its original $\frac{U}{L}$ at A. This is because all firms are willing to pay the same wage premium to L, hence no one firm, ceteris paribus, can gain an advantage in employing L. Thus, market relative wages will rise by $\frac{W_L\ (1 + r)}{W_u}$, resulting in perceived wages of $\frac{W_L\ (1 + r)}{W_u\ (1 + c)}$. This will be consistent with a firm employment ratio of A only if $(1 + r) = (1 + c)$ or r, the per cent rise in market relative wages is equal to c, the per cent of W_u perceived as an extra cost.

Thus, the above digression provides an interpretation of the coefficient of LRN in structural equation III.1. Since relative numbers are held constant in this equation, this coefficient can be used as an approximation of the "perceived" costs of licensure. We are able to do this because the shift associated with LRN measures the change in relative wages due to the imposition of mandatory RN licensure, or the direct effect of RN licensure.

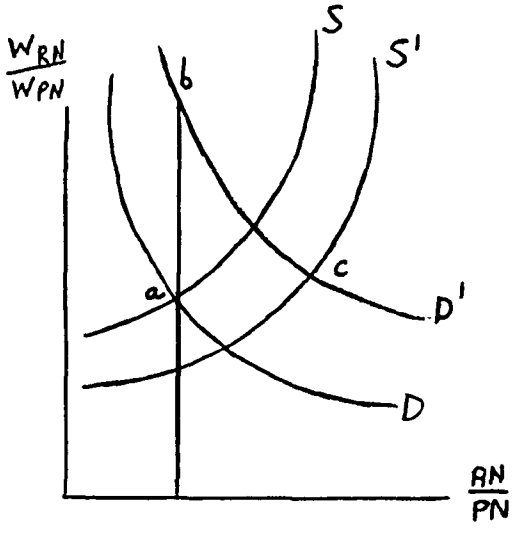
III.5 The Total Effect of Licensure: Reduced Form Equations

Up to this point, we have only considered the "direct" effects of licensure on the demand and supply of nursing labor. These "direct" effects measure the impact of licensure by holding relative numbers (in our demand equation) and

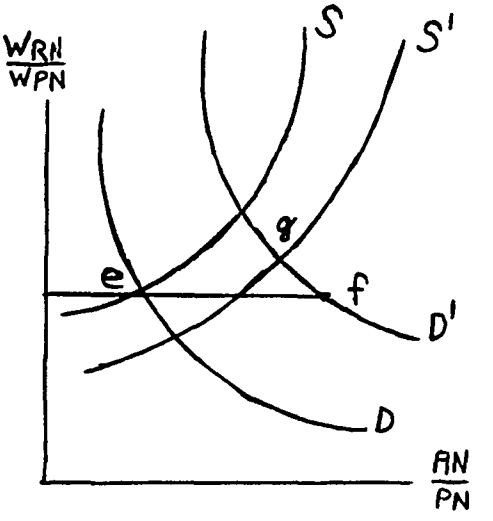
relative wages (in our supply equation) constant. Thus, the effect of licensure on relative wages, due to shifts in supply, has not been considered. Similarly, the impact of licensure on relative numbers has not considered the shift in demand which also occurs when licensure is altered. That is, the <u>total</u> effect consists of a <u>direct</u> effect, in which the endogenous variable is held constant, plus an <u>indirect</u> effect which measures the effect on our dependent variable from shifts in the other schedule which arise when the nature of the license is altered. These effects are illustrated in Figure III.3 for the case in which mandatory RN licensure is imposed.

Figure III.3

Total Effects of Mandatory RN Licensure



Total Effect on RELW = (a-c) = Direct Effect (a-b) + Indirect Effect (b-c)



Total Effect on RELR = (e-g) = Direct Effect (e-f) + Indirect Effect (f-g)

The reduced form coefficients of the licensure variable in our demand and supply schedules are obtained by substituting structural equation III.2 for RELR in equation III.1, and structural equation III.1 for RELW in equation III.2. The resulting coefficients of the licensure variables in each reduced form equation will provide estimates of the total effect of licensure (as it pertains to changes in RN or PN licensure) on relative wages and numbers employed. The reduced form coefficients will take the following form:

Table III.3

Reduced Form Licensure Coefficients

Licensure Variable	Interpretation	R.F. Coefficient
LRN in Demand	Change from PP to MP states.	$\frac{a_2 + a_1 b_2}{1 - a_1 b_1}$
LRN in Supply	Change from PP to MP states.	$\frac{b_2 + b_1 a_2}{1 - a_1 b_1}$
LPN in Demand	Changes from MP to MM states.	$\frac{a_3 + a_1 b_3}{1 - a_1 b_1}$
LPN in Supply	Change from MP to MM states.	$\frac{b_3 + b_1 a_3}{1 - a_1 b_1}$

Note that a reduced form expression, for a change in both LRN and LPN from permissive to mandatory, can also be obtained. The expression for the change in relative wages, requires an addition of the coefficients in lines 1 and 3. A similar expression for the effect on relative numbers employed, due to a simultaneous change in both LRN and LPN,

can be obtained from an addition of lines 2 and 4. These expressions will represent the changes on relative wages and numbers by moving from PP to MM jurisdictions.

As can be seen, the resulting reduced form coefficients consist of <u>direct</u> reduced form effect coefficients (interpreted above) and combinations of coefficients which provide a measure of <u>indirect</u> reduced form effects. For example, the reduced form coefficient of LRN in the demand equation is comprised of a_2, the <u>direct</u> effect coefficient in structural equation III.1, which measures the effect of imposing mandatory RN licensure with relative numbers held constant, and $a_1 b_2$. The latter coefficient product is an <u>indirect</u> effect consisting of $\frac{\partial RELW}{\partial RELR} \cdot \frac{\partial RELR}{\partial LRN}$: that is, the effect of licensure on relative wages through the shift in relative supply. The <u>total</u> effect $\frac{a_2 + a_1 b_2}{1 - a_1 b_1}$, takes the sum of these effects into consideration. The other reduced form coefficients have similar interpretations. Estimates of the reduced form coefficients, as derived from the estimated structural equations, will be presented below. With the empirical strategy outlines, we now turn to a discussion of the results obtained.

Chapter IV

Empirical Results: The Effects of Licensure on the Utilization of Nursing Labor

IV.1 Estimation Technique

The results of the regression strategy outlined in Chapter III are presented in Table IV.1. All variables (with the exception of the licensure dummy variables and BDPN) have been transformed into natural logarithms. The coefficients of the logarithmic variables may be interpreted as elasticities while the coefficients of the dummy variables and BDPN can be interpreted as percentage changes.[75] The equations have been estimated by two-stage least squares (TSLS) and have been weighted by the square-root of the state or geographic area's population.[76] Table IV.2 presents the licensure coefficients in the appropriate configurations described above. Table IV.3 provides estimates of the reduced form licensure coefficients.

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[75]Summary statistics for the data used may be found in Appendix IV.

[76]The square root of population is the appropriate weight to use for dealing with heteroskedastic disturbances when running per capita data. For relative numbers, in which each number in the ratio is obtained by aggregating individual observations in a state and averaging over the state's population, it can be shown that the appropriate weight is also the square root of the jurisdiction's population. For consistency, both relative demand and relative supply are weighted. Unweighted regressions showed similar results as those in Table IV.1 and are presented in Appendix IV. I am indebted to Professor M. Grossman for insight on this point.

In Table IV.1, regression coefficients for a number of alternative specifications of the structural equations are presented. Before describing the results obtained, however, we wish to comment on a particular feature of the TSLS estimating procedure which must be considered when interpreting the significance of the estimated coefficients. The "t-statistics" presented (in parentheses) must be interpreted with great care since the TSLS technique used provides a statistic whose asymptotic distribution is that of a t-distribution, but whose small sample distribution is unknown.[77] The reported "t-ratio adjustment factor" may be used to transform the reported t-statistic into one based upon a distribution which is asymptotically standard normal (multiply reported t-statistic by the adjustment factor to obtain the latter).[78] We therefore present both the

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[77]The Regression Analysis Program for Economists (RAPE) was used. The TSLS procedure and the reported statistics are those developed by Dhrymes. Dhrymes' "alternative" significance tests are used, which for TSLS, are based on an asymptotic t-distribution. Note that the degrees of freedom for the t-statistics are the degree to which the equation is overidentified. See for example, William J. Raduchel, The Regression Analysis Program for Economists, Reference Guide, Technical Paper No. 10, revised, (Cambridge: Harvard Institute of Economic Research, 1974), p. 15; P.J. Dhrymes, "Alternative Asymptotic Tests of Significance and Related Aspects of 2SLS and 3SLS Estimated Parameters", Review of Economic Studies, XXXVI, (April 1969); and P.J. Dhrymes, Econometrics, section 5.7. The coefficient of determination is not presented since with the Dhrymes' technique, this does not provide a goodness-of-fit criteria for the structural equations.

[78]For use of the t-ratio adjustment factor see, J.P. Newhouse and C.E. Phelps, "Price and Income Elasticities for Medical Care Services", The Economics of Health and Medical Care, Mark Perlman, ed., (New York: John Wiley and Sons, 1974), p. 156, note 1.

Dhrymes' t-statistic as well as the asymptotic standard normal statistic (Z-statistic) in Table IV.1, and will discuss the significance of our independent variables with respect to both criteria. We caution, however, that the small number of observations used (31) would tend to discourage a strict interpretation of significance tests based on either distribution. As a result, therefore, assertions regarding significance based on conventional levels must be made with care since the above statistics are defined in an asymptotic framework.

IV.2 Empirical Results

In Table IV.1, equations (1) and (2) provide the general demand-supply framework used. The remaining equations consist of systems in which the demand equation has been altered. Thus, in equation (1), the slope variable (RELR) has the correct negative sign with a t-ratio above unity. However, by conventional standards (with 2 degrees of freedom, the degree of overidentification for this equation), its significance is low. Applying the t-ratio adjustment factor results in a transformation to a Z-statistic significant at the .025 level (one-tail test). This result, as well as the transformations in demand equations (3) and (5), should be taken with caution because of the large size of the adjustment factor (2.47).[79] RWEX, the ratio of expected RN/PN wages, has the correct positive sign based upon our

[79]Phelps and Newhouse report adjustment factors ranging from .6 to just above unity.

derivation in Chapter III (note 62) and upon the notion that high observed relative wages may reflect higher relative quality between RNs and PNs. However, the relationship is not significant under either statistic.[80]

The licensure variable, LRN, which reflects movements from PP to MP states (i.e., permissive PN licensure held constant) has the hypothesized positive sign, reflecting an increase in relative demand fcr RNs to PNs as mandatory licensure is imposed. This provides some evidence for our notion that employers may "perceive" costs for violation of mandatory licensure provisions. These costs, and hence the effect of mandatory RN licensure on relative wages, raise relative wages by approximately 9.5 percent. Although its t-ratio does exceed unity, by conventional standards its level does not allow us to assert this result with a large degree of confidence. The reported Z-statistic is highly significant but again, we stress caution in interpreting this result given the magnitude of the adjustment factor. The correct sign and reasonable magnitude of the coefficient suggest that mandatory licensure may exert some small influence on behavior in the manner described.

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[80] It may be that this variable is subject to reporting errors and therefore biased. For example, the education measure used in its construction is based upon highest grade of schooling completed, and if vocational training is not reported, there will be an error in the measure of quality. Thus, nurses may have received much of their training in hospital-affiliated programs and may have commited such reporting errors.

The licensure variable LPN describes the effects of mandatory PN licensure, or movements from MP to MM states. While the negative sign obtained in this specification meets our a priori expectations (that is, imposing "costs" on employers for utilizing lower priced inputs, such as aides, in place of PN inputs), the low t and Z statistics and low coefficient indicate that these effects are not significant, both in a statistical or economic sense. Hence, it appears that the effect of licensure in this demand specification has its impact on RN utilization through mandatory RN licensure.

The remaining variables in the demand equation, AVLOS and PPR, have signs which meet our previous expectations. AVLOS is a proxy for case-mix in short-term hospitals, with reservations mentioned in Chapter III. Its positive sign suggests that the demand for RNs relative to PNs reflects a demand for higher quality nursing inputs in areas where case-mix is more serious. In subsequent equations, discussed below, we attempt to isolate this interpretation more completely. In doing so, we are able to increase the t-statistic (1.13) closer to conventional levels of significance (note that the Z-statistic is significant). PPR, the physician-population ratio (per thousand population), has a negative sign which suggests that RNs may serve as substitutes for physicians in areas where physician availability is scarce. That is, holding the RN/PN ratio constant, the RN-PN relative wage increases (as PPR declines), suggesting an increase in demand for RNs relative to PNs. A plausible

explanation for this behavior is that more intensive use of RNs is made in physician-scarce areas to ease the demands on existing physician services. The fact that its t-ratio is above 2.00 and significant at the .10 level provides credibility for the importance of this variable.

In equation (2), our relative supply equation, the slope coefficient of RELW (unadjusted or observed relative wages) is positive although both the t and Z statistics are below unity. Note that in this equation, the t-ratio adjustment factor is a more reasonable 1.57. The licensure variables now measure the supply effects of the imposition of mandatory licensure. LRN measures the impact of mandatory RN licensure compared to permissive RN licensure, or the movement from PP to MP states. In equation (2), this effect is positive, suggesting that rather than serve as a barrier to entry, the licensure may provide incentives to enter registered nursing since alternative nursing careers (i.e., PNs or aides) may be dead-ended. This, as has been noted above, may result because of the difficulty of occupational mobility in mandatory jurisdictions. While the sign of the coefficient suggests this interpretation, its magnitude (less than 1 per cent) and statistical significance indicate that the effect is extremely small, if present at all. In subsequent equations, we are able to increase the significance, although its level remains well below unity.

The impact of licensure on the supply side seems to

Table IV.1

TSLS Estimates of Relative Demand and Supply Equations

	Dependent Variables			
Independent Variables	(1) RELW	(2) RELR	(3) RELW	(4) RELR
RELR	-.23 (-1.10)*** (-2.72)***		-.09 (-.57)* (-1.73)*	
RELW		.71 (.53) (.83)		1.66 (1.28) (1.64)
LRN	.095 (1.54)*** (3.80)***	.002 (.13) (.20)	.073 (1.48)*** (4.45)***	-.06 (-.40) (-.52)
LPN	-.013 (-.20) (-.48)	.25 (1.52)*** (2.38)***	-.03 (-.06) (-1.53)	.33 (1.97)* (2.53)***
RWEX	.25 (.54) (1.33)		.24 (.63)* (1.90)*	
AVLOS	.38 (1.13)*** (2.78)***		.39 (1.39)*** (4.21)***	
PPR	-.32 (-2.41)* (-5.95)***		-.32 (-2.89)* (-8.72)***	
GB			.091 (1.67)*** (5.04)***	
FY		.65 (1.30)** (2.04)**		.97 (1.94)* (2.50)***
TP		.08 (1.06)* (1.67)*		.09 (1.00) (1.29)
BDPN		-.27 (-1.16)* (-1.82)*		-.23 (-.86) (-1.01)
INTERCEPT	-.12 (-.22) (-.54)	-4.92 (-1.03) (-1.62)	-.16 (-.35) (-1.06)	-8.03 (-1.7)* (-2.19)**

Table IV.1 (continued)

Equations (1) to (4)

	(1)	(2)	(3)	(4)
T-RATIO ADJUST-MENT FACTOR	2.47	1.57	3.02	1.29
DEGREES OF FREEDOM (DEGREE OF OVERIDENTIFICATION)	2	2	2	3

Note: First row of figures in parentheses are Dhrymes' t-statistics; second row contains adjusted t or Z-statistics. All variables except LRN, LPN, and BDPN are in natural logarithms. All regressions are weighted by square root of jurisdiction's population.

* significant at .10 level

** significant at .05 level

*** significant at .025 level

All for one-tail test.

Table IV.1 (continued)

Equations (5) to (8)

Independent Variables	Dependent Variables (5) RELW	(6) RELR	(7) RELW	(8) RELR
RELR	-.09 (-.54) (-.49)		-.13 (-.77) (-.96)	
RELW		.98 (.96) (1.09)		.95 (1.22) (1.40)
LRN	.064 (1.15)*** (3.16)***	-.004 (-.03) (-.03)	.091* (1.82)*** (2.25)***	-.001 (-.01) (-.02)
LPN	-.023 (-.40) (-1.09)	.27* (1.91)** (2.15)**	-.043 (-.79) (-.98)	.27* (2.10)*** (2.41)***
RWEX	.40 (.88)*** (2.43)***		.24 (.63) (.79)	
AVLOS	.51 (1.56)*** (4.29)***		.57* (1.88)*** (2.34)***	
PPR	-.28* (-2.15)*** (-5.90)***		-.31 (-2.81)*** (-3.48)***	
AVBS	-.08 (-.71)* (-1.95)*			
BC			-.26 (-1.71)** (-2.12)**	
OCR	.12 (.22) (.61)			
GB	.09 (1.63)*** (4.47)***		.08 (1.41)* (1.75)*	

Table IV.1 (continued)

Equations (5) to (8)

Independent Variables	Dependent Variables (5) RELW	(6) RELR	(7) RELW	(8) RELR
FY		.74 * (1.83) ** (2.07)		.73 ** (2.16) *** (2.48)
TP		.08 (1.07) (1.20)		.08 (1.07) (1.23)
BDPN		-.26 (-1.10) (-1.24)		-.26 (-1.12) (-1.28)
INTERCEPT	-.53 (-.23) (-.63)	-5.80 * (-1.52) ** (-1.72)	-.19 (-.41) (-.51)	-5.72 * (-1.82) ** (-2.09)
T-RATIO ADJUSTMENT FACTOR	2.75	1.13	1.24	1.15
DEGREES OF FREEDOM (DEGREE OF OVERIDENTIFICATION)	2	5	2	4

See page 84 for symbols and description of table.

Table IV.1 (continued)

Equations (9) to (12)

Independent Variables	Dependent Variables (9) RELW	(10) RELR	(11) RELW	(12) RELR
RELR	-.16 (-1.02) (-1.30)		-.17 (-1.01) (-1.05)	
RELW		.95 * (1.52) * (1.91) *		.98 * (1.56) * (1.83) *
LRN	.080 * (1.64) ** (2.08) **		.081 (1.63) ** (2.05) **	
LPN		.27 *** (2.89) *** (3.63) ***		.26 *** (2.81) *** (3.29) ***
RWEX	.28 (.71) (.91)		.28 (.71) (.90)	
AVLOS	.61 * (2.05) *** (2.61) ***		.62 * (2.03) *** (2.55) ***	
PPR	-.33 ** (-2.99) *** (-3.81) ***		-.33 ** (-2.98) *** (-3.75) ***	
BC	-.25 (-1.60) ** (-2.04) **		-.25 (-1.60) ** (-2.01) **	
GB	.08 (1.47) * (1.87) *		.08 (1.46) * (1.84) *	
FY		.73 *** (2.73) *** (3.44) ***		.82 *** (3.13) *** (3.68) ***
TP		.08 (1.10) (1.39)		

Table IV.1 (continued)

Equations (9) to (12)

Independent Variables	(9) RELW	(10) RELR	(11) RELW	(12) RELR
		Dependent Variables		
BDPN		-.26 (-1.14) (-1.44)		-.41 ** (-2.25) *** (-2.63)
INTERCEPT	-.26 (-.58) (-.74)	-5.69 ** (-2.31) *** (-2.91)	-.27 (-.59) (-.61)	-6.34 *** (-2.61) *** (-3.05)
T-RATIO ADJUSTMENT FACTOR	1.27	1.26	1.04	1.17
DEGREES OF FREEDOM (DEGREE OF OVERIDENTIFICATION)	3	5	2	5

See page 84 for symbols and description of table.

Table IV.2

Licensure Dummy Variables from Structural Equations (7) and (8)

		Dependent Variables: (7) RELW		Dependent Variables: (8) RELR	
(1) LRN (PP to MP)	a_2:	.091	*	b_2: -.001	
		(1.82)	+	(-.013)	
		(2.25)		(-.015)	
(2) LPN (MP to MM)	a_3:	-.043		b_3: .27	**
		(-.79)		(2.10)	+
		(-.98)		(2.41)	
(3) LRN and LPN (PP to MM)	a_2+a_3:	.048		b_2+b_3: .27	***
		(.65)		(2.76)	

Note: Parentheses on first line below coefficients contain t-ratios; those on second line contain transformed Z-statistics.

* approaches significance at .10 level for t-test
** approaches significance at .05 level for t-test
*** approaches significance at .025 level for t-test
\+ approaches significance at .025 level for Z-test

All the above for one-tail test.

Standard error to compute t-ratio for line (3) is:

$$S = \sqrt{\text{Var. } a_2 + \text{Var. } a_3 + 2 \text{ Cov. } (a_2, a_3)}$$

Table IV.3

Reduced Form Licensure Coefficients

	Dependent Variables: (7') RELW	(8') RELR	(9') RELW	(10') RELR	(11') RELW	(12') RELR
LRN	.081	.076	.069		.069	
LPN	-.070	.203		.234		.231

have its greatest impact through the variable LPN. Its positive sign indicates that as mandatory practical nurse licensure is imposed (i.e., comparing MP to MM states), relative numbers (RN/PN) increase. This suggests that the mandatory license may discourage entry into practical nursing, perhaps in the following manner. As described in Chapter III, individuals planning to enter practical nursing may have only a "marginal" interest in nursing and are attempting to seek information as to whether nursing suits their occupational aims (one might conjecture that individuals seeking to become RNs have more than a "marginal" interest in nursing due to the longer period of training required). If this is the case, the imposition of a mandatory license, requiring formal training (as opposed to informal, on-the-job training leading to the ability to perform PN tasks in permissive states) may be sufficient to discourage those entrants and hence reduce the supply of PNs and raise the RN/PN ratio in the state. Alternatively, the costs of training in mandatory states may exceed training costs in permissive PN states (since PN training may be adjusted to include aspects of RN training), and therefore also discourage entry. In the former, training to perform PN tasks requires incurring the full costs of obtaining a license. In the latter, training to perform PN tasks may be obtained through informal channels (on-the-job training) and the associated investment costs may be less.

While the effect of mandatory PN licensure is to increase

the RN/PN ratio, both explanations are restricted to effects solely on PN supply. However, since the ratio is increasing, it may be that the RN component is primarily affected by LPN: that is, LPN results in an increased RN supply. A plausible explanation for this effect may be grounded in the notion that a more efficient way to train is to concentrate one's training in one or two "lumps" rather than to spread that training over one's working life. Thus, if potential nursing entrants must undertake formal training to obtain a license to practice, some may be persuaded to "switch" from PN training to RN training. For example, if a commitment to formal training must be made, even to enter the lower rung of professional nursing, and if entrants realize that occupational mobility can only be obtained through further education (since in this comparison the RN licensure is mandatory), there may be some incentive to extend training to obtain RN qualifications.[81] Thus, the positive relationship between LPN and RELR may reflect this "switching" behavior rather than discouraging PN entry. Some empirical results to distinguish between these alternative explanations will be presented below when we discuss our "best" specification, equations (7) and (8).

With regard to the remaining supply variables, FY, median family income in the state, has the expected positive sign. This reflects the notion that states with higher

[81]Note that we are holding the ability to finance further training, as measured by family income, constant.

family incomes may have a greater ability to finance the additional training required to become a RN. Although its t-ratio exceeds unity (1.30) and its transformed t (i.e., its Z-statistic) is significant, such a variable may play a limited role in making the decision to seek additional training or continue training once having entered a program.[82]

BDPN, a variable used to measure the influence of PN membership on the PN nursing board on entry to practical nursing, has a negative sign with a t-ratio just above unity, 1.16, (its Z-statistic is significant at the .10 level). This negative relationship suggests that PNs, rather than attempting to strictly curtail entry, given the nature of PN licensing in the state, may try to encourage entry in their attempts to secure their professional status vis-a-vis RNs. That is, the competition (described in Chapter III) that may exist between RNs and PNs, in providing both nursing services and exerting their professional positions regarding nursing policy, may result in PNs attempting to strengthen their position. While there

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[82]Altman, pp. 39-48, suggests that "ability" and "family income" play a role in determining the choice of nursing programs RNs select (i.e., two-year associate degree, three-year diploma, four-year B.A. degree). Ability seems to be the primary determinant of training success. Low income does not appear to affect the successful completion of programs for those with the requisite ability. However, for those of low ability, low income may be an additional factor preventing successful completion.

may seem to be some disparity between this interpretation and the positive sign obtained on LPN (suggesting perhaps, that licensure discourages entry), it may well be that the push for mandatory licensure comes largely through the efforts of other non-practical nursing members of the licensing board. The extremely low correlation between LPN and BDPN (.03) may support this assertion.[83]

Finally, TP, the ratio of RN/PN training programs in the state, has the expected sign, reflecting a positive association between training institutions and occupational nursing supply. However, the significance of this variable is not strong. Alternative specifications of TP, lagging by five years or using lagged graduates, did not improve the results.

The remaining equations presented are variants of the demand-supply system presented in equations (1) and (2). In particular, alternative specifications of the demand equation are presented with variables to account more clearly for case-mix, bed-availability, government employment, and "policing" effects. The use of these additional exogenous variables in the system, in some specifications, markedly improve our results. Equations (7) and (8) represent the most complete specification.

In equation (3), GB (per cent government hospital beds in the state, all types) is included to examine the influence

[83]BDRN, a similar variable for RN licensing board influence, was found to be of little influence on RELR and hence was not included.

of government hiring on the utilization of RNs and PNs. As was noted above, government standards regarding RN-PN utilization may provide less latitude for substitutability. If this is correct, we expect a positive sign on GB, reflecting an increase in relative demand (RELW) as the influence of government expands. We obtain this result, with a t-ratio substantially above unity (1.67). Note that the transformed t-statistic is highly significant although this is due to a large adjustment factor of 3.02. The inclusion of this variable slightly depresses both the influence and significance (with respect to the t-statistic) of LRN, suggesting that the impact of RN licensure, as presented in (1), may have been overstated. That is, government standards may sufficiently restrict task substitution between nurses of differing classes, so that when we hold the influence of government constant, the impact of licensure on relative demand (RELW) is reduced. The inclusion of GB does reduce the significance of slope coefficient of RELR (its negative sign remains). The significance of RWEX improves slightly and its positive sign is retained. Both AVLOS and PPR show some improvement in significance, with the latter approaching significance near the .05 level (in terms of its t-statistic). LPN remains statistically weak. On the supply side, the inclusion of GB as an exogenous variable in our system, provides an improvement in the relationship between endogenous RELR and RELW (both t and Z-statistics above unity). The variables LPN and FY improve in significance, with both their

t-statistics significant at the .10 level (both Z-statistics significant at .05 level). The t-ratio of BDPN, however, falls below unity. All signs are retained.

In the next system of equations (5) and (6), two variables are included to control for the influence of size in policing licensure violations, and also, to partly purge from AVLOS influences which may reflect bed-availability and hence, physician judgment as to the length of hospitalization. For the former, we include AVBS (average beds per short-term hospital) and expect a negative sign if size exerts an inability to effectively police (i.e., raising the costs of detection and hence providing incentives to lower the relative demand for RNs to PNs). As regards the latter, we include OCR (occupancy rate in short-term hospitals) which in combination with AVBS provides information about the level of bed availability in the state. A more direct measure, beds per capita (BC), is introduced in equation (7), but was omitted from the equation (5) due to the intercorrelation between AVBS, BC, AVLOS, and OCR.

Thus, in demand equation (5), the inclusion of these variables tends to diminish the effect of RN licensure on relative demand: both the coefficient and significance of LRN decline. The signs of all variables, however, are retained. The sign of AVBS is negative, suggesting that a "policing" effect may be present (although its t-ratio is weak). While OCR does not approach significance, holding it constant along with AVBS improves the significance of

AVLOS. This may reflect a more direct linkage between case-mix variations and demand for more highly-skilled nursing personnel (as reflected in RELW). In addition, the above specification results in a decline in the significance of PPR. A basic problem which may be influencing this specification is that the variables AVBS, OCR, AVLOS and PPR are strongly correlated.[84] Thus, while there is some indication that the "policing" effect may enter and that AVLOS may more accurately reflect case-mix, once bed availability is controlled for, we will attempt to emphasize the latter point in an alternative specification. This will hopefully reduce the potential multicollinearity problem.

Equations (7) and (8) represent a final specification of our demand-supply system. In place of AVBS and OCR, we include BC (described above) to measure bed-availability. As a result, in this specification, LRN rises in our demand

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[84] The correlation among AVBS, OCR, AVLOS and PPR is as follows:

	AVLOS	PPR	AVBS	OCR
AVLOS	1.00	.69	.75	.67
PPR		1.00	.68	.42
AVBS			1.00	.71
OCR				1.00

Note that with more than two independent variables, high simple correlation coefficients are sufficient but not necessary for multicollinearity to exist. See, for a demonstration, Jan Kmenta, Elements of Econometrics (New York: MacMillan, 1971), pp. 382-384. The strong correlation between OCR and AVLOS is to be expected since AVLOS is used to construct OCR. That is,

$$OCR = \frac{ADM \cdot AVLOS}{BR \cdot 365} = \frac{\text{Patient days}}{\text{Bed days}}$$

where ADM = admissions per thousand population
BR = beds per thousand population.

equation, its t-ratio of 1.82 is higher than in other specifications. Note that the t-ratio adjustment factor of 1.24 seems more reasonable and the Z-statistic for LRN is significant at the .025 level. The t-ratio of PPR rises back to 2.81, significant at the .10 level for this statistic, and above the .025 level when the transformation to a standard normal variable is obtained. AVLOS attains a t-ratio significant at the .10 level (its Z-statistic is significant at the .025 level). BC acts as a good proxy for AVBS in that its sign is negative and its t-ratio exceeds unity (its Z-statistic is significant at the .05 level). Here BC serves to provide a measure of bed availability to maintain constant, as well as to provide some indirect indication of policing: the more beds per capita, the greater the difficulty in supervising the "inputs" utilized in producing care.

The inclusion of BC as an exogenous variable in this system also improves the estimation of supply equation (8). RELW retains its positive sign and its t-ratio returns to a level above unity (1.22). LRN is once again low in significance, but the t-ratio of LPN improves to a level of 2.10. The significance of FY also rises, suggesting that family income may play more than a "limited" role in determining the ability to enter more extensive training programs. BDPN retains its sign and magnitude as well as its t-ratio. No improvement in the significance of TP is obtained. Thus, a fairly well-specified supply relationship is estimated.

At this point we should comment about the coefficients of RELR and RWEX in our relative demand equation. We will do so with respect to equation (7). As was pointed out in note 62, Chapter III (see also Appendix IV), the reciprocal of the coefficient of RELR serves as an estimate of the elasticity of substitution between RNs and PNs. While we have included RWEX in our demand equation to control for variations in observed RELW due to relative qualify differences (thus purging such influences from estimates of the coefficient of LRN), we noted that this would follow from the CES framework only if σ was >1. If this were the case, then $1 - \frac{1}{\sigma}$, the coefficient of RWEX would be positive, describing a direct relationship between RELW and RWEX. From equation (7), we see that σ, estimated from the coefficient of RELR is approximately 7.7,[85] thus providing a rationale for our specification. However, we may also estimate from the coefficient of RWEX. Obtaining σ in this manner, we estimate it to equal 1.32.[86] While both estimates exceed unity, thus providing the theoretical rationale for our results, the difference in their magnitudes is quite large. This apparent inconsistency may be resolved in the following manner. As we have noted above, our use of RWEX may be plagued with reporting errors (see note 80) which may bias

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[85] $-\frac{1}{\sigma} = -.13$, $\sigma = 7.69$.

[86] $1 - \frac{1}{\sigma} = .24$, $\sigma = 1.32$.

the estimated coefficient. In addition, both the coefficients of RELR and RWEX are point estimates from a distribution of coefficients. Given their standard errors (.16 for the coefficient of RELR, .38 for that of RWEX), it is possible to construct 95 per cent confidence intervals for both which contain these values.[87]

As the above regression results indicate, the impact of mandatory licensure is not the same for both RNs and PNs in each equation. Mandatory RN licensure (i.e., the comparison between PP and MP states) is much stronger than the effect of mandatory PN licensure in our demand equation, both in terms of its coefficient and significance. In equation (7), we estimate that mandatory RN licensure results in an increase in RELW of about 9.1 per cent, which is also an estimate of the perceived costs imposed upon employers for violation. In supply equation (8), the impact of mandatory PN licensure is far more important than that of mandatory RN licensure. The coefficient and strong significance suggest that the RN/PN ratio is quite strongly affected by mandatory PN licensure, rising by 27 per cent when other supply influences are held constant. We shall below offer some possible reasons for these results. First, however, we want to discuss in more detail the interpretation of LPN in supply.

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[87] With 2 degrees of freedom (degree of overidentification of equation (7)), the confidence intervals are:

$$(-.82 \leq a_{RELR} \leq .56) = .95$$

$$(-1.40 \leq a_{RWEX} \leq 1.88) = .95$$

IV.3 The Effect of LPN on Relative Nursing Supply: the "Discouragement" Effect vs. the "Switching" Effect

As was mentioned above, the fact that mandatory PN licensure results in an increase in the RN/PN ratio does not distinguish which nursing group is being directly affected by the licensure. That is, does mandatory PN licensure discourage potential PN entrants or cause them to switch to RN training once the realization that a commitment to formal nursing training is required. Either "discouragement" or "switching" hypothesis is consistent with an increase in the RN/PN ratio due to mandatory PN licensure.

To distinguish between these results, a regression framework was used in which RNs per capita (per thousand population) and PNs per capita were run against the above supply variables. In each of these equations, unadjusted relative wages were treated as an endogenous variable. The regressions were run in both OLS (ordinary least-squares) and TSLS form. The sign of LPN in the regressions was used to distinguish between these competing hypotheses. The TSLS results are presented in Table IV.4. In equation (2), in which PNs per capita was our dependent variable, LPN had a negative sign and was significant at the .10 level, using the Dhrymes' t-statistic, and at the .05 level when applying the transformation to a standard normal variate. In equation (1), the effect of LPN on the per capita supply of RNs has a negative sign and is insignificant, and does not therefore, lend support to a process in which potential PNs

Table IV.4

Effects of LPN on Relative Nursing Supply

Independent Variables	Dependent Variables (1) RNs per thousand population	(2) PNs per thousand population
RELW	-1.45 ** (-2.14) *** (-2.57)	-2.56 ** (-2.39) *** (-2.82)
LRN	.10 (1.04) (1.25)	.10 (.63) (.74)
LPN	-.09 (-.77) (-.92)	-.34 * (-1.98) *** (-2.34)
LFY	.31 (1.05) (1.26)	-.49 (-1.05) (-1.24)
LTP	-.03 (-.39) (-.47)	-.12 (-1.11) (-1.31)
BDPN	-.24 (-1.20) (-1.44)	.03 (.09) (.11)
INTERCEPT	-.90 (-.33) (-.40)	5.43 (1.26) (1.49)
T-RATIO ADJUSTMENT FACTOR	1.20	1.18
DEGREES OF FREEDOM	4	4

Note: See page 84 for weight used and description of table. Significance (all for one-tail test): * .10 level for t-test; ** .05 level for t-test; *** .025 level for Z-test.

"switch" to RN training when mandatory PN licensure is imposed. These results strongly suggest that the effect of mandatory PN licensure is to "discourage" entry to this level of nursing.

IV.4 Remaining Regression Results

The remaining regression results presented in Table IV.1 consist of equation systems in which certain variables have been deleted. In equation (9), LPN has been removed while in (10), LRN has been removed. Both these licensure variables were previously found to be of low significance in prior specifications and their removal does not appear to greatly bias the estimates. LRN in (9) declines slightly in both magnitude and significance, the the significance of LPN in (10) rises dramatically. In the last equation set, we estimate our demand and supply equations with TP deleted. TP has been removed in response to the reservations in note 67. In doing so, our estimates of the demand parameters are unchanged, but there is an improvement in the significance of FY and BDPN.[88] However, in both equations, the significance and magnitude of the licensure variables remain essentially the same as in (9) and (10).

In Table IV.2, we present the licensure coefficients for equations (7) and (8) (in Table IV.1) in configurations

[88]The improvement in these variables may point to another problem regarding inclusion of TP: that of multicollinearity. The simple correlation between TP and FY and BDPN is .35 and -.66 respectively. This reservation was expressed in note 67 above.

which permit us to compare the imposition of both mandatory RN and PN licensure, that is the movement from PP to MM states. This is given by line 3 which represents the sum of the appropriate licensure coefficients. As is apparent, the effect of this comparison is greatest on the supply side, primarily due to the dominating effect of PN licensure. On the demand side, two opposing forces are acting upon relative wages (i.e., relative demand). The imposition of mandatory RN licensure causes an increase in relative demand for RNs or a positive relation between LRN and RELW occurs. On the other hand, the imposition of mandatory PN licensure results in an increase in relative demand for PNs, causing a decline in RELW. The outcome, a 4.8 per cent rise in relative wages is the net effect. However, the effect of mandatory licensure on relative demand does not appear to be significant in this PP-MM comparison.

IV.5 The "Significance" of the Licensure Variables

In this section, we wish to comment and provide some explanation for the significance of the licensure coefficients in our structural equations. As we had expected, the LRN variable, reflecting the imposition of mandatory RN licensure (PP-MP comparison) has a stronger effect in our demand equation. Its sign is correct and its magnitude is reasonable (9.1 percent in equation (7)). Although its t-ratio approaches significance at the .10 level (its transformed Z-statistic is significant at the .025 level), its magnitude suggests that the effect of licensure (in

this PP-MP comparison) may be moderate. Several reasons, however, may be posited for this mild licensure effect. As Pennell and Stewart note in their 1967 survey of health licensure,[89] state enforcement and regulation of health licensure is not performed on the basis of rigid inspection procedures:

> In general, licensing agencies follow the policy of investigating a practitioner's compliance with the law only when a complaint is filed. To a marked degree, the enforcement of licensing laws depends on the voluntary compliance of individual practitioners and the efforts of occupational associations.

If this is the case, there is strong reason to suspect that employers may pay "lip service" to the license since they may view the expected penalties as being quite low.[90]

A theoretical rationale for the weak effect of licensure on the demand side may also exist. Applying results from Chapter I, we may note:

$$\frac{E\,\frac{Lg1}{Lg2}}{E(Wg1)} = S_{Q,g} \cdot S_{g,Lg1}\left[\sigma_{Lg1,Lg1} - \sigma_{Lg1,Lg2}\right]$$

where the above denotes an expression for the elasticity of substitution between licensed and unlicensed labor (Lg2 and Lg1 respectively) in a licensed labor task, g. The degree to which employers will alter their input ratios

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[89] Pennell and Stewart, op. cit., p. 11

[90] The view that employers in institutions in mandatory states may merely pay "lip service" to licensure was suggested by Professor Nathan Hershey, Professor of Health Law, Graduate School of Public Health, University of Pittsburgh, in correspondence with the author.

(of unlicensed to licensed labor) in response to a perceived penalty may be determined by the magnitude of the terms in the above elasticity. As was emphasized in Chapter I, the responsiveness of employers to a "perceived" change in wages will depend upon the size of the share expressions as well as the level of the Allen partial elasticities of substitution. Thus, even if the Allen cross-partial was of sufficient magnitude to suggest potential substitution, the share of the prohibitive task ($S_{Q,g}$), or PNs (say Lgl) in that task, may be sufficiently small so as to weaken the effect of the license.[91] Remembering the fact that nursing licensure (along with most health licensure) is quite vague (see discussion in Chapter II), it may well be that employers themselves view the prohibitive tasks as constituting a small portion of nursing services. Thus, it is possible that the shares of prohibitive tasks in nursing services are not of sufficiently great importance to cause the licensure effect to be strong. Although empirical measures of these "shares" are quite probably unquantifiable, perhaps discussions with members of the nursing profession can provide some impressions.

Finally, the restrictive effects of licensure on utilization of nursing labor may hinge on conflicting aims of the nursing profession. As one author notes:

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[91] In the above discussion, we refer to our framework in which two tasks, g and f, comprise production. The point regarding the role of "shares" in production applies to the production of nursing services in which many "tasks" may be involved.

> It appears that the position of an occupational association toward manpower substitution and the upgrading of its own functions will be somewhat ambivalent. There is a trade-off between the benefits of increased "professionalism" and increased economic benefits. For example, if registered nurses allow practical nurses and aides to perform many of the less-skilled functions nurses now perform, the professional prestige of nursing will increase. However, as these functions are relinquished the demand for registered nurses will decline while the demand for practical nurses and aides will increase. This situation is not conducive to economic gains for registered nurses.92

Thus, the willingness of nurses to self-police violations and support the aims of the license may conflict with broader professional aims for the status of the entire nursing occupation.

On the supply side, the strong results obtained for LPN suggest that mandatory practical nurse licensure may "discourage" potential practical nursing entrants. An alternative interpretation (consistent with the empirical findings), that "switching" to RN training may take place, was found to be statistically weak. The "discouragement" effect seems reasonable since some potential practical nursing entrants may have a "marginal" interest in nursing and may not be willing to enter the requisite training that a mandatory license imposes. In addition, since practical nursing is on the lower rung of the nursing profession, the requirements across jurisdictions can be made to vary. In

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92 Myron D. Fottler, Manpower Substitution in the Hospital Industry: A Study of New York City Voluntary and Municipal Hospital Systems, (New York: Praeger Publishers, 1972), p.6.

particular, if the purpose of a mandatory PN license is to discourage entry, these states can upgrade their curriculum or requirements to include more difficult RN related activities. The fact that the "discouragement" effect in mandatory RN licensure does not seem to exist (extremely low magnitude of coefficient and significance of LRN in RELR) may reflect the fact that those individuals deciding upon registered nursing as a career, just as those deciding upon medicine, make the commitment with awareness of the rigors involved and a strong intention to overcome them.

IV.6 Reduced Form Coefficients

In Table IV.3, reduced form coefficients are presented from the coefficients estimated in structural equations (7) through (12) in Table IV.1. The reduced form coefficients of LRN and LPN in 7' and 8' incorporate both direct and indirect effects discussed in Chapter III. The coefficient of LPN in structural equation (7) and LRN in structural equation (8) (both in Table IV.1) were included in the estimation of these reduced form coefficients despite their low significance. In equations (9') through (12'), the reduced form coefficients of LRN (in RELW) and LPN (in RELR) have been estimated by deleting LPN from demand and LRN from supply. Equations (11') and (12') also omit the variable TP in the estimation of the reduced form coefficients.

These deletions may appear to eliminate the indirect effects since the effect of LRN in (9') and (11') only occurs through shifts in demand and the effect of LPN in

(10') and (12') through shifts in supply. However, the effect is present in the form of a supply response when demand shifts along a stable supply schedule (as in 9' and 11') or in a demand response when supply shifts along a stable demand schedule (as in 10' and 12').

Therefore, we estimate that the overall or total effect on relative wages of mandatory RN licensure (comparing PP and MP states) is to raise relative wages between 6.9 to 8.1 per cent. The upper bound is obtained with shifts in both supply and demand schedules, in response to mandatory RN licensure, considered (that is, including the low significance variable LRN in our structural supply schedule). This result represents the outcome of an upward shift in demand and a slight leftward shift in supply. The lower bound results from an upward shift in demand along a stable supply schedule. In both cases, our results are as expected, below the direct effect of mandatory RN licensure in equation (7) of Table IV.1, in which relative numbers are held constant. Similarly, the effect of our most significant licensure variable, LPN in supply (reflecting a comparison between MP and MM states) ranges between 20 and 23 per cent. The lower bound includes the downward shift in demand (which was found to be insignificant) along with the rightward shift in relative supply, while the upper bound represents the effect of a rightward shift in relative supply along a stable demand schedule. This result eliminates the insignificant effect of LPN obtained in the

demand estimation.

Finally, the reduced form coefficients of LPN in demand (-.070) and LRN in supply (.076) are also presented. We should again note that the coefficients were found to be quite low in significance in structural equations (7) and (8). These two reduced form coefficients are, then, results which may be obtained from our system but with little confidence attributable to them. The imposition of mandatory LPN licensure results in a decline in relative wages of 7 per cent. This is consistent with a downward shift in relative demand, reflecting costs of violating the PN license, but the primary reduced form effect on relative wages from LPN comes from the shift in relative supply. Similarly, we find the effect of mandatory RN licensure to result in an increase in relative numbers employed (7.6 per cent), but that this effect stems primarily from the upward shift in demand rather than the rightward shift in relative supply.

IV.7 Conclusion

To conclude, it appears as if the effects of mandatory nursing licensure operate most strongly on the demand side for registered nursing licensure, and on the supply side for practical nursing licensure. Our reduced form results suggest that mandatory RN licensure may have had some positive effect on both relative wages and numbers (in MP vs. PP states) primarily through a shift in relative demand. Mandatory practical nursing licensure may have improved the

economic and professional status of PNs (in MM vs. MP states) by perhaps "discouraging" potential entrants through a differentiation of training in mandatory states. Given these results, we will now briefly examine the extent to which a similar interpretation may be obtained during the period of the 1960-1970 decade, in which many states changed licensure from permissive to mandatory.

Chapter V

Decade Analysis: The Effect of Changes in Nursing Licensure Between 1960 and 1970

V.1 Introduction

As Tables II.1 a and b in Chapter II indicate, the decade of the 1960's saw attempts by states to alter the nature of both registered and practical nurse licensure from permissive to mandatory. Indeed, by 1971, all but two jurisdictions had adopted mandatory RN licensure, while 13 states (including the District of Columbia) retained permissive PN licensure. In this chapter, we investigate whether the changes in the nature of state licensing led to discernible changes in relative wages and numbers (RN to PN) over the decade, in accord with what out cross-section findings suggest. As we shall note, severe data limitations place constraints on the degree to which the analysis can be carried. Therefore, this chapter should be treated as an initial attempt to investigate the effect of these inter-decade changes.

V.2 Empirical Strategy

Since the data on numbers and wages that we wish to use are available only from the 1960 and 1970 Census, we are unable to conduct a time series study in which state observations could be utilized from each year of the decade. As a result, we examine changes in the ratio of relative wages and relative numbers between 1960 and 1970. Once

again, a system of dummy variables is used to measure the separate effects of mandatory RN and PN licensure. Thus, as in Chapter III, care must be exercised in their interpretation.

The equations utilized consist of an equation describing changes in the ratio of relative wages between 1960 and 1970, and one describing changes in relative numbers for the same period.[93] Dummy variable LRN now receives a value of 1 if over the decade RN licensure in the jurisdiction[94] changed from permissive to mandatory, 0 if there was no change over the decade (i.e., if the jurisdiction remained permissive or remained mandatory). Similarly, LPN now receives a value of 1 if practical nursing licensure changed from permissive to mandatory over the decade, 0 if no change occurred. In a manner similar to that in Chapter III, we can deduce the interpretation of each of the licensure variables.

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[93] As we note below, attempts to examine these interdecade changes in a simultaneous supply-demand framework were not fruitful. Therefore, we refrain from relying on such terminology to describe our equations.

[94] Since all states in some of our grouped 1960 observations did not alter their licensure in the same manner, we have been forced to alter the original 1960 groupings. The grouped jurisdictions now include only Maryland-Delaware and Minnesota-North Dakota. Alabama, North Carolina, Nebraska, Virginia and Arizona are no longer grouped respectively with Mississippi, South Carolina, South Dakota, West Virginia and New Mexico. This latter group of states did not alter their licensure in the same manner as the states with which they were previously paired. In addition, they contained too few observations to include as separate states.

Thus, an equation describing changes in the ratio of relative wages, for an observation will be written as:

(V.1) $RELW = a_0 + a_1 RELR + a_2 LRN + a_3 LPN.$

If the observation is one for which neither type of licensure changed (i.e., if the jurisdiction was PP, MP or MM in both 1960 and 1970), it will take the form:

(V.2) $RELW = a_0 + a_1 RELR.$

An observation for which only RN licensure changed (a PP to MP observation) will be described as:

(V.3) $RELW = a_0 + a_1 RELR + a_2.$

Similarly, an observation in which only PN licensure changed (MP to MM observation) will be written as:

(V.4) $RELW = a_0 + a_1 RELR + a_3.$

Finally, an observation in which <u>both</u> types of licensure changed (PP to MM) takes the form:

(V.5) $RELW = a_0 + a_1 RELR + a_2 + a_3.$

Thus, the differential effects of the changes in licensure, as summarized by the licensure coefficients, may be obtained by inter-equation subtraction. Note, however, that the licensure coefficients now reflect comparisons between states that <u>did not change</u> and states which <u>changed in a particular manner</u>. These comparisons are presented in Table V.1.

Table V.1

Interpretation of Interdecade Licensure Coefficients

<u>Comparison</u>	<u>Equations</u>	<u>Coefficient</u>
Change in RELW between states not changing and those changing from PP to MP	(V.3)-(V.2)	a_2

Table V.1
(continued)

Comparison	Equations	Coefficient
Change in RELW between states not changing and those changing from MP to MM	(V.4)-(V.2)	a_3
Change in RELW between states not changing and those changing from PP to MM	(V.5)-(V.2)	a_2+a_3

Note also that the licensure coefficient of an equation describing changes in relative numbers over the decade, with dummy variables defined in the same manner, will make the same comparisons for changes in relative numbers.

V.3 The Form of the Regression Model

To control for other forces which may influence the change in relative wages and numbers over the decade, we should include a set of exogenous variables as we did in obtaining our cross-section results. Since our endogenous variables (RELW and RELR) are defined to reflect changes in levels, i.e., they are ratios of relative wages and numbers in 1970 to those in 1960, it appears that our exogenous variables should be defined in a similar manner: ratios of 1970 to 1960 levels. That is, a first specification which immediately suggests itself is to run the ratios of the dependent variables against the ratios of the independent variables.[95] This model, which we will refer to as the "change against change" model, was tested both in a TSLS and

OLS format. In either case, the regression results obtained showed little explanatory power. One a priori rationale for these poor results might be that we are asking too much of the data by specifying variables in this form. That is, over the decade, the change in these variables may not be of sufficient magnitude to provide enough variation, and hence sufficient explanatory power across jurisdictions. In Table V.2, coefficients of variation are presented in both linear and logarithmic form (in which the regressions were run). The linear coefficients of variation are low, although the logarithmic transformation does expand the variation. However, this expansion of the coefficients of variation is due to the transformation and the variables in logarithmic form are not significantly related to RELW or RELR.

Table V.2

Coefficients of Variation for Selected Exogenous Variables

Variable	C.V.(Linear)	C.V.(Logarithmic)
$\frac{\text{PPR 1970}}{\text{PPR 1960}}$	.05	.67
$\frac{\text{AVLOS 1970}}{\text{AVLOS 1960}}$	.07	.54
$\frac{\text{BC 1970}}{\text{BC 1960}}$	.09	.76
$\frac{\text{FY 1970}}{\text{FY 1960}}$	.05	.09

[95] As in our cross-section results, we use observed and expected wage ratios. The latter is included to adjust for changes in relative quality between RNs and PNs over the decade.

An alternative specification, however, is available. This model follows work by Benham, Maurizi and Reder (BMR)[96] on locational decisions of physicians and dentists. Using states as the unit of observation, these decisions were studied both in cross-section and between decades. In their interdecade analysis, BMR first examined changes in physicians and dentists per capita as a function of changes in such variables as personal income, training facilities, licensure exam failures and population.[97] For this specification, they obtained poor results, with t-ratios below two and low R^2s. As a result, BMR tested an alternative specification in which the change in the "medic" (physician or dentist) per capita variable over the decade was tested against initial levels of independent variables. Their results and rationale for this procedure are expressed as follows:

> It is striking that in the regressions involving /the change in "medics" per capita/, it is the initial condition rather than the change in the independent variable that exerts the major influence. We interpret this to mean that, on a per capita basis, the locational response of physicians has been to "correct" initial disequilibrium rather than adjust to changing equilibrium conditions.[98]

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[96]Lee Banham, Alex Maurizi, and Melvin Reder, "Migration, Location, and Remuneration of Medical Personnel: Physicians and Dentists", Review of Economics and Statistics, Vol. L, 3 (August 1968), 332-347.

[97]BMR specify their "change" model with observations as the difference between terminal and initial levels. Our specification is in terms of ratios, which in logarithmic form result in a similar specification.

[98]Benham, Maurizi, and Reder, op. cit., 340.

Thus BMR construct their interdecade framework in terms of a model which explains interdecade movements of medics as responses to initial disequilibrium conditions. The resulting signs obtained on initial level independent variables (numbers per capita, medic income) can be interpreted as eliciting supply responses of medics which correct initial disequilibria. More specifically, BMR run interdecade regressions of the form:

$$\Delta x_1^* = f(x_1^{*\prime}, x_7', \Delta x_7)$$

where Δx_1^* : change in medics per capita over the decade

$x_1^{*\prime}$: initial level of medics per capita

x_7' : initial average medic income

Δx_7 : change in average medic income

They argue that if <u>initially</u> x_7' is "high" (above an "equilibrium" level) in a state, the supply response over the decade should be <u>toward</u> that state, tending to <u>correct</u> the "disequilibrium". That is, a positive relationship should be obtained. Similarly, if $x_1^{*\prime}$ is below its "equilibrium" level, associated with initially high levels of x_7', then supply responses should be generated to correct this imbalance. Thus BMR expect a negative relationship between the <u>initial</u> number level and the change in that number over the decade. The change in x_7 (Δx_7 in this disequilibrium correcting framework) BMR hypothesize, is to be negatively

related to Δx_1^*, since "high" initial values of x_7 should be reduced as the obverse of increases in low initial levels of x_1.[99] Subsequent empirical testing confirmed the above "disequilibrium" hypothesis, although the relationship between Δx_1^* and x_7' is not significant.

BMR attempt to provide more credibility for their hypothesis by alternatively running Δx_7 against $x_1^{*'}$, Δx_1^*, and x_7'. While Δx_7 is used as an endogenous variable in this version, no attempt is made to expand the model by making it simultaneous.[100] The results obtained support a process in which physicians were being led away from states with above equilibrium numbers and hence with below equilibrium wages. The low t-ratios obtained in this variant are viewed as being consistent with "a moderate degree of short-run disequilibrium (friction) in each of the various initial years".[101] BMR conclude that this moderate response of physician income over the decades reflects the fact that inter-decade physician movement was largely in response to population changes, and that these movements took place without strong effects on average physician income (given a decade for adjustment).[102] In our interdecade analysis, in which

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[99] Benham, Maurizi and Reder, 340.

[100] Perhaps BMR were faced with the same data limitations that constrain the scope of our interdecade analysis.

[101] BMR have fitted cross-section regressions with x_7 as the dependent variable. BMR, op. cit., 343.

[102] Ibid., 344.

we are primarily interested in the effect of changes in licensure on relative wages and numbers employed, we will make use of the BMR technique of including initial decade levels of price and numbers.

V.4 Empirical Results

Given the above mentioned limitations on data and methodology, we present a regression framework in which our equations describing changes in relative numbers and wages are estimated by ordinary least squares. These results, equations (1) and (2) in Table V.2, are specified in the BMR framework in which we include initial levels (1960) of relative wages (unadjusted) and numbers. Following BMR, the expected signs on the variables are as follows. In equation (1), describing changes in relative numbers over the decade, RELW 60 is expected to have a positive sign, suggesting that "above equilibrium" relative wages will attract an increase in the RN/PN ratio supplied over the decade. RELR 60 is expected to be negative since "below equilibrium" relative numbers jurisdictions will be associated with higher relative wages, and therefore be able to attract greater relative numbers. RELW, the change in relative wages, is also expected to bear a negative relationship to RELR since changes in numbers will be associated with opposite movements in wages over the decade (see the BMR interpretation above).

In equation (2), RELR 60 is expected to be positively related to RELW, reflecting an adjustment in RELW to an excess or above equilibrium initial supply. That is, below

Table V.2

Interdecade Regressions

Dependent Variables

Independent Variables	(1) RELR	(2) RELW
RELR		.07 (.86)
RELW	.37 (.74)	
LRN	-.091 (-1.20)	-.03 (-.85)
LPN	.024 (.30)	.02 (.62)
RELR 60	-.24 (-1.84)**	-.11 (-1.96)**
RELW 60	.16 (.33)	-.78 (-6.10)***
RWEX		-.17 (-1.01)
INTERCEPT	.50 (2.05)**	.29 (3.12)**
$\bar{R}^2$	.05	.55
DEGREES OF FREEDOM	25	24

Note: All variables except LRN and LPN are expressed in natural logarithms. All regressions were weighted by square root of 1970 jurisdiction's population.

** significant at .05 level
*** significant at .025 level
All for one-tail test.

equilibrium initial numbers will be associated with above equilibrium wages, resulting in a decline in wages over the decade as the RN-PN ratio in those states increase. RELW 60 is expected to have a negative sign, since where RELW 60 was low (below equilibrium) one would expect an excess supply of RNs to PNs. As this expected supply adjusted over the decade, RELW would rise. RWEX, the ratio of expected relative wages in 1970 to 1960, is expected to be positive. As relative quality increases over the decade, we would expect this to be reflected in an increase in the ratio of observed relative wages. Finally RELR is expected to have a negative sign. As relative numbers increased over the decade to high wage jurisdictions, we would expect to observe some decline in those relative wages.

The signs on the initial level wage and number variables do not entirely conform to predictions based on the BMR "disequilibrium" model, and not all the variables are significant. In equation (1), some support is found for the disequilibrium notion. RELR 60 is significant (at .05 level) and has the correct negative sign, suggesting a movement of RNs to PNs out of areas where relative numbers are in excess supply and to areas where the RN/PN ratio is below equilibrium. Although the positive sign of RELW 60 supports this interpretation, its t-ratio does not exceed unity. RELW fails to attain significance, nor does its sign agree with predictions based on the BMR model. In

equation (2) RELW 60 is negative and highly significant, correctly conforming to the BMR notion that "below" equilibrium initial relative wages result in increases over the decade. This would reflect greater relative numbers (RN/PN) moving from low to high earning areas.[103] However, the sign of RELR 60 is negative and does not support the notion that relative wages will fall over the decade when initial numbers are low, as BMR predict. Neither RELR nor RWEX has signs which conform to expectations previously stated. From the above, then, there appears to be some fragmentary evidence that these disequilibrium forces may contribute to changes in state relative numbers and wages of nursing labor.[104]

The results for the licensure coefficients in each equation are not particularly robust. If registered nurses were viewing the imposition of a mandatory license as a tool to improve their economic position (note the statement at the beginning of Chapter III), it does not appear to have done so.

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[103]It should be noted that licensure is not viewed as a considerable barrier to interstate mobility since most states have reciprocity and endorsement agreements.

[104]Caution must be taken in attributing the strong negative relationship of RELW 60 to RELW in equation (2), solely to these disequilibrium considerations. If measurement error is present in RELW 60 (as a result of reporting error in 1960 RN or PN earnings or hours of work), the coefficient of RELW 60 may have a negative bias. For example, if RELW 60 is overstated, then our dependent variable RELW (which is the ratio of RELW 70 to RELW 60) will be understated, building in a negative bias in our regression coefficient. A similar caveat is appropriate for RELR 60 in equation (1).

The sign of LRN in equation (2) is incorrect (comparing states that did not change to those changing from PP to MP) and its t-ratio is below unity. LPN also does not have the correct sign and its t-ratio is quite low. Given these weak results (with the data limitations of our analysis in mind), there does not appear to be much support that, over the decade, the imposition of a mandatory license had much effect in increasing the relative demand for RNs to PNs. Perhaps over time, employers in states are able to gain information as to the efforts made to detect violations and the probabilities of being prosecuted. Or, perhaps these weak effects reflect inertia or frictions in the adjustment process.

In equation (1), LRN is the only licensure variable with a t-ratio exceeding unity (its t = -1.20). Its negative sign, as well as its significance, is in contrast to results obtained in the cross-section, where the RN licensure variable was positive and quite low in significance. The negative effect in this variable in the interdecade context may suggest some deterrence to the growth of RNs to PNs, when states which did not change their form of licensure are compared to those changing from PP to MP. Perhaps this reflects a "discouragement" effect taking the form of a desire by nurses to constrain entry and thus upgrade their profession through more rigid requirements. For example, there has been a growing tendency in the (registered) nursing profession to push for continuing education requirements.[105] In any event, the limited statistical analysis

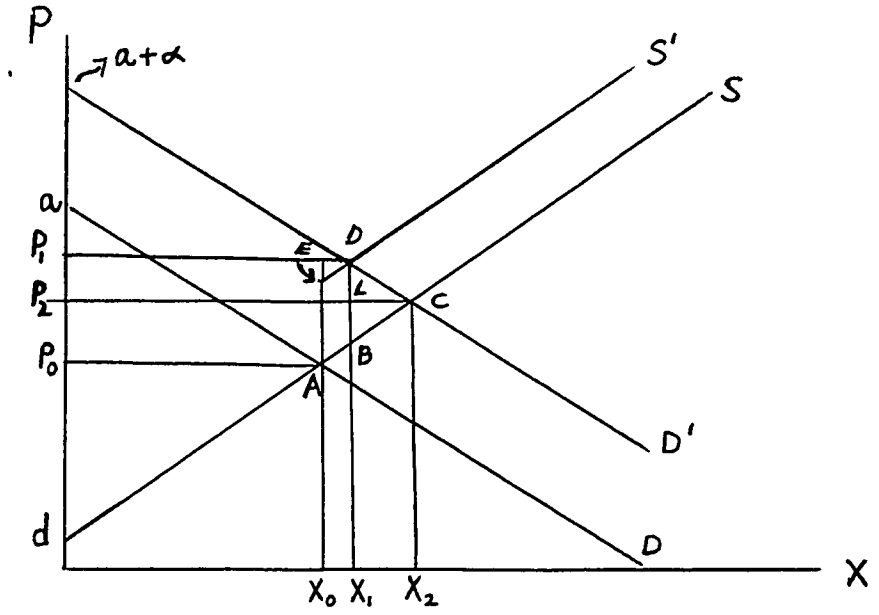
[105]See, for example, Kelly, "Nursing Practice Acts," 1318.

presented does not seem to warrant strong statements regarding the restrictive effects of licensure on either relative wages or numbers over this period.

Appendix I

A: Effects of Demand and Supply Schedule Slopes on Total Welfare Loss

The potential welfare loss to society, as was noted in Chapter I, consists of two components. Diagrammatically, this consists of the area bordered by ABCDE:



the sum of parallelogram ABDE and triangle DBC. This area may be represented by $\frac{1}{2}(DB)(LC) + (X_1-X_0)(EA)$ or in our notation $\frac{1}{2}t(X_2-X_1) + t(X_1-X_0)$ since $DB = EA = t$ and $X_2 - X_1 = LC$. We may observe the effects of changes in welfare resulting from changes in the slopes of demand and supply schedules by specifying the equation system resulting in the above equilibrium prices and quantities.

Consider the following basic model of the above market:

(1) $p = a-bX$ (Demand Schedule, D)
(2) $p = d+eX$ (Supply Schedule, S)
(3) $p_{Demand} = p_{Supply}$ (Equilibrium)

To solve for X_0 (point A in diagram), substitute (1) and (2) into (3):

$$(4) \qquad X_0 = \frac{a-d}{b+e}$$

Equilibrium quantity X_1 may be found by specifying the equation system to include the respective shift parameters:

(1') $p = a-bX+\alpha$ (Demand Schedule, D')
(2') $p = d+eX+t$ (Supply Schedule, S')
(3') $p_{Demand} = p_{Supply}$ (Equilibrium)

Note: $t > 0$ when $X \geq X_0$

To solve for X_1, substitute (1') and (2') into (3'):

$$(5) \qquad X_1 = \frac{a-d-t+\alpha}{b+e}$$

Similarly, X_2 may be found by noting that it is the equilibrium quantity resulting from intersection of (1') and (2). Therefore, equating (1') and (2), we obtain:

$$(6) \qquad X_2 = \frac{a-d+\alpha}{b+e}$$

Our expression for the area of welfare loss is

$$(7) \quad W = \tfrac{1}{2}t(X_2-X_1) + t(X_1-X_0).$$

X_1-X_0 may be found by subtracting (4) from (5):

$$X_1-X_0 = \frac{\alpha-t}{b+e}$$

Similarly, subtraction of (5) from (6) results in X_2-X_1:

$$X_2-X_1 = \frac{t}{b+e}$$

Substituting in (7) for welfare loss W, we obtain:

$$W = \tfrac{1}{2}t\left(\frac{t}{b+e}\right) + t\left(\frac{\alpha-t}{b+e}\right) \text{ or, } (8) \quad W = \frac{-\frac{1}{2}t^2+\alpha t}{(b+e)}$$

To find the effect of a change in the demand slope on welfare loss W, differentiate (8) with respect to b:

$$\frac{\partial W}{\partial b} = \frac{-t(\alpha-\frac{1}{2}t)}{(b+e)^2}$$

Since $\alpha > t$, it follows that $\frac{\partial W}{\partial b} < 0$. Therefore, as the slope of b (in absolute value) rises, the welfare loss resulting from licensure diminishes.

To find the effect of the supply slope e, on welfare loss W, differentiate (8) with respect to e:

$$\frac{\partial W}{\partial e} = \frac{-t(\alpha - \frac{1}{2}t)}{(b+e)^2} < 0, \text{ as before.}$$

Therefore, as supply slope e becomes larger, welfare loss diminishes. Hence the larger the slopes of demand and supply schedules, the smaller the welfare loss due to imposition of licensure.

B: Effects of Changes in Demand and Supply Slopes on Rent to Incumbents

The rents to incumbents generated by licensure consist of the area $(P_1-P_0)\cdot(X_0)$ in the above figure (page 125). To obtain the effect on this rent, of changes in the slopes of demand and supply schedules, we differentiate $R = (P_1-P_0)(X_0)$ with respect to demand slope b and then supply slope e. The differentiation takes the following general form:

$$\frac{\partial R}{\partial \text{ Slope}} = (X_0)\frac{\partial (P_1-P_0)}{\partial \text{ Slope}} + \frac{\partial (X_0)}{\partial \text{ Slope}} \cdot (P_1-P_0).$$

Note that since we are dealing with rents obtained by those <u>already</u> in the occupation (i.e., rents accruing to X_0), the term $\frac{\partial (X_0)}{\partial \text{Slope}} = 0$. Thus, the above differentiation reduces to:

$$\frac{\partial R}{\partial \text{ Slope}} = (X_0)\cdot\frac{\partial (P_1-P_0)}{\partial \text{Slope}} .$$

From the above, it was shown that $X_0 = \frac{a-d}{b+e}$. P_0 may be found by substituting the solution for X_0 in (4) above, in say, demand equation (1): $P_0 = a-b\left[\frac{a-d}{b+e}\right] = \frac{ae+bd}{b+e}$.

P_1 may be found by substituting the solution for X_1 in (5), in say, equation (1'):

$$P_1 = a-b\left[\frac{a-d-t+\alpha}{b+e}\right] + \alpha = \frac{ae+bd+bt+\alpha e}{b+e} \quad .$$

Subtracting P_0 from P_1, we obtain:

$$P_1-P_0 = \frac{ae+bd+bt+\alpha e-ae-bd}{b+e} = \frac{bt+\alpha e}{b+e} \quad .$$

Substituting the above results in the expression for R, we obtain: $R = (P_1-P_0)(X_0) = \frac{bt+\alpha e}{b+e} \cdot \frac{a-d}{b+e}$.

Differentiating with respect to demand slope b, we obtain:

$$\frac{\partial R}{\partial b} = \frac{\partial (P_1-P_0)}{\partial b} \cdot (X_0) = \frac{e(t-\alpha)}{(b+e)^2} \cdot X_0 \quad .$$

Since e, $(b+e)^2$, $X_0 > 0$, and $(t-\alpha) < 0$ (i.e., the demand shift exceeds the supply shift), $\frac{\partial R}{\partial b} < 0$. Therefore, as the demand slope increases (in absolute value), rents to incumbents <u>decline</u>.

To find the effect of a change in rents due to a change in supply slope e, differentiate R with respect to e:

$$\frac{\partial R}{\partial e} = \frac{\partial (P_1-P_0)}{\partial e} \cdot (X_0) = \frac{b(\alpha-t)}{(b+e)^2} \cdot (X_0) \quad .$$

Since $b, (b+e)^2, X_0 > 0$ and $(\alpha-t) > 0, \frac{\partial R}{\partial e} > 0$. Therefore, as supply slope e increases, rents to incumbents <u>rise</u>.

Appendix II

Derivation of Demand Elasticities from Output Maximization Process

Given the output maximizing process described on pp. 15-21, we totally differentiate the first order conditions (p.17) to obtain:

$$0+W_{g1}dL_{g1}+W_{g2}dL_{g2}+W_{f1}dL_{f1}+W_{f2}dL_{f2}=dC-\sum_i\sum_j L_{ij}dW_{ij}$$

$$W_{g1}d\ +Q_{gg}g_{Lg11}dL_{g1}+Q_{gg}g_{Lg12}dL_{g2}+Q_{gf}g_{Lg1f1}dL_{f1}+Q_{gf}g_{Lg1f2}=\lambda dW_{g1}$$

$$.....+.....+Q_{gg}g_{Lg22}dL_{g2}+.....+.....=\lambda dW_{g2}$$

$$.....+.....+.....+Q_{ff}f_{Lf11}dL_{f1}+.....=\lambda dW_{f1}$$

$$W_{f2}d\ +Q_{fg}f_{Lf2g1}dL_{g1}+.....+.....+Q_{ff}f_{Lf11}dL_{f1}=\lambda dW_{f2}$$

Substituting $W_{ij}=\frac{Q_i{}^iL_{ij}}{\lambda}$ $\quad i=(g,f)$ $\quad j=(1,2)$ from first-order conditions and rewriting the above, we obtain:

$$\begin{pmatrix} 0 & Q_gg_{Lg1} & Q_gg_{Lg2} & Q_ff_{Lf1} & Q_ff_{Lf2} \\ Q_gg_{Lg1} & Q_{gg}g_{Lg11} & \cdots & Q_{gf}L_{g1f2} & \\ Q_gg_{Lg2} & Q_{gg}g_{Lg12} & \cdots & & \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ Q_ff_{Lf2} & Q_{fg}f_{Lf2g1} & \cdots & Q_{ff}f_{Lf22} & \end{pmatrix} \begin{pmatrix} \frac{d\lambda}{-\lambda} \\ dL_{g1} \\ dL_{g2} \\ dL_{f1} \\ dL_{f2} \end{pmatrix} = \begin{pmatrix} \lambda\left[dC-\sum_i\sum_j L_{ij}dW_{ij}\right] \\ \lambda dW_{g1} \\ \lambda dW_{g2} \\ \lambda dW_{f1} \\ \lambda dW_{f2} \end{pmatrix}$$

The determinant of the first matrix on the left-hand side will be referred to as Δ. Therefore

using Cramer's rule and assuming

i) $dW_{g2} = dW_{f1} = dW_{f2} = 0$

ii) $dC - \sum_{ij}\sum L_{1j}W_{1j} = 0$

we obtain the result that $dL_{g1} = \frac{\lambda\, dW_{g1}\Delta_{11}}{\Delta}$

where Δ_{11} is the cofactor of dW_{g1} (second row, second column of matrix on last page). Substituting from first-order conditions (derived in Chapter I), $\lambda = \frac{Q_g g_{Lg1}}{W_{g1}}$, we obtain:

$$dL_{g1} = \frac{Q_g g_{Lg1}\Delta_{11} dW_{g1}}{W_{g1}\,\Delta} \qquad \text{or,}$$

$$\frac{dL_{g1}}{dW_{g1}} = \frac{Q_g g_{Lg1}\Delta_{11}}{W_{g1}\,\Delta}$$

as the compensated substitution effect on L_{g1} due to a perceived change in its wage, W_{g1}. In elasticity form,

$$(1)\eta_{Lg1,Wg1} = \frac{W_{g1}dL_{g1}}{L_{g1}dW_{g1}} = \frac{Q_g g_{Lg1}\Delta_{11}}{L_{g1}\Delta}\,.$$

Multiplying the last term of the expression by

$\frac{Q}{Q} \cdot \frac{g}{g} \cdot \frac{L_{g1}}{L_{g1}}$ we obtain:

$$(2)\eta_{Lg1,Wg1} = \frac{Q_g g}{Q} \cdot \frac{g_{Lg1}L_{g1}}{g} \cdot \frac{Q}{L_{g1}^2} \cdot \frac{\Delta_{11}}{\Delta} =$$

$$S_{Q,g} \cdot S_{gLg1} \cdot \frac{Q}{L_{g1}^2} \cdot \frac{\Delta_{11}}{\Delta}$$

where $S_{Q,g}$, $S_{g,Lg1}$ have been defined above in the text.

Note that from the text we have shown

$Q = Q_g g + Q_f f = Q_g g_{Lg1}L_{g1} + Q_g g_{Lg2}L_{g2} + Q_f f_{Lf1}L_{f1} + Q_f f_{Lf2}L_{f2}$.

Substituting in (2) we obtain:

$$(3)\ \eta_{Lg1,Wg1} = S_{Qg} \cdot S_{g,Lg1} \cdot \frac{Q_g g_{Lg1} L_{g1} + \ldots + Q_f f_{Lf1} L_{f1} \Delta_{11}}{L_{g1}^2 \quad \Delta}$$

where the last term is defined as the Allen "own" partial elasticity of substitution for L_{g1}, $\sigma_{Lg1,Lg1}$ within task g.

$$(4)\ \eta_{Lg1,Wg1} = S_{Q,g} \cdot S_{gLg1} \sigma_{Lg1,Lg1}$$

Cross elasticities may be obtained in the same manner:

$$(5)\ \eta_{Lg2,Wg1} = S_{Q,g} \cdot S_{gLg1} \cdot \sigma_{Lg1,Lg2}$$

where $\sigma_{Lg1,Lg2}$ is the Allen partial for the change in demand for L_{g2} due to a compensated change in W_{g1}. Using the above, an elasticity of substitution term may be obtained. Since $dL_{g1} = \frac{dW_{Lg1} \lambda \Delta_{11}}{\Delta} = \frac{dW_{Lg1} Q_g g_{Lg1} \Delta_{11}}{W_{Lg1} \Delta}$ and

$dL_{g2} = \frac{dW_{g1} \lambda \Delta_{12}}{\Delta} = \frac{dW_{Lg1} Q_g g_{Lg1} \Delta_{12}}{W_{Lg1} \Delta}$ we can obtain, using the same substitutions as before, (multiplying by $\frac{L_{g1}}{L_{g1}} \cdot \frac{Q}{Q} \cdot \frac{g}{g}$)

$$\frac{dL_{g1}}{L_{g1}} = \frac{dW_{g1}}{W_{g1}} \cdot \frac{Q_g g_{Lg1}}{L_{g.1}} \cdot \frac{\Delta_{11}}{\Delta} = \frac{dW_{g1}}{W_{g1}} \cdot S_{Q,g} \cdot S_{g,g_{Lg1}} \sigma_{Lg1,Lg1}$$

and noting that $\frac{dL_{g1}}{L_{g1}}$, $\frac{dW_{g1}}{W_{g1}}$ are percentage changes,

$$(6)\ E_{Lg1} = E_{Wg1} \cdot S_{Q,g} \cdot S_{g,Lg1} \sigma_{Lg1,Lg1}. \quad \text{Similarly,}$$

$$(7)\ E_{Lg2} = E_{Wg1} \cdot S_{Q,g} \cdot S_{g,Lg1} \sigma_{Lg1,Lg2}. \quad \text{Subtracting}$$

(7) from (6) we obtain:

$$(8)\ E_{Lg1} - E_{Lg2} = E_{Wg1} \cdot S_{Q,g} \cdot S_{g,Lg1} \left[\sigma_{Lg1,Lg1} - \sigma_{Lg1,Lg2}\right]$$

or, (9) $\frac{E\left(\frac{L_{g1}}{L_{g2}}\right)}{E(W_{g1})} = S_{Q,g} \cdot S_{g,L_{g1}} \left[\sigma_{L_{g1},L_{g1}} - \sigma_{L_{g1},L_{g2}}\right]$,

an expression for the elasticity of substitution (presented in the text) between L_{g1} and L_{g2} for a change in W_{g1}.

Proof of Footnote 26:

In footnote 26, we assert the following constraint on the Allen partial elasticities:

$$S_{Q,L_{g1}} \cdot \sigma_{L_{g1},L_{g1}} + S_{Q,L_{g2}} \cdot \sigma_{L_{g1},L_{g2}} + S_{Q,L_{f1}} \cdot \sigma_{L_{g1},L_{f1}} + S_{Q,L_{f2}} \cdot \sigma_{L_{g1},L_{f2}} = 0$$

As Allen shows, p. 504, this result is obtained by expanding the matrix of 1st and 2nd order marginal products by alien cofactors. That is, given the matrix of the total differentiation of first-order conditions (Appendix II, p. 130), we expand the cofactors of the 2nd row by elements of the first row:

(1) $Q_g g_{L_{g1}} \Delta_{L_{g11}} + Q_g g_{L_{g2}} \Delta_{L_{g12}} + Q_f f_{L_{f1}} \Delta_{L_{g1},L_{f1}} + Q_f f_{L_{f2}} \Delta_{L_{g1},L_{f2}} = 0.$

By definition, the Allen partial elasticity of substitution is, say for $\sigma_{L_{g1},L_{g1}}$ (2) $\sigma_{L_{g1},L_{g1}} = \frac{Q\Delta_{L_{g11}}}{L_{g1}L_{g1}\Delta}$.

Multiplying the right-hand side by $\frac{Q_g \cdot g_{L_{g1}}}{Q_g \cdot g_{L_{g1}}}$, the marginal product of L_{g1} in Q,[1] we obtain:

[1] Since $Q = Q(g,f)$, $\frac{Q}{L_{g1}} = \frac{\partial Q}{\partial g} \cdot \frac{\partial g}{\partial L_{g1}} = Q_g \cdot g_{L_{g1}}$.

(3) $\sigma_{L_{g1},L_{g1}} = \dfrac{Q_g \cdot g_{Lg1} \cdot Q \cdot \Delta_{Lg11}}{L_{g1} \cdot Q_g g_{Lg1} \cdot L_{g1} \Delta}$. Note that

$S_{Q,L_{g1}} = \dfrac{Q_g g_{Lg1} \cdot L_{g1}}{Q}$ since from the properties of linear homogeneous production functions and Euler's Theorem,

$Q = Q_g g + Q_f f = Q_g g_{Lg1} + Q_g g_{Lg2} L_{g2} + Q_f f_{Lf1} L_{f1} + Q_f f_{Lf2} L_{f2}$.

Therefore, (4) $\sigma_{L_{g1},L_{g1}} = \dfrac{Q_g g_{Lg1} \Delta_{Lg11}}{L_{g1} \cdot S_{Q,Lg1}}$

and (5) $S_{Q,Lg1}\,\sigma_{Lg1,Lg1} = \dfrac{Q_g g_{Lg1} \Delta_{Lg11}}{L_{g1} \Delta}$.

For the remaining Allen partials $\sigma_{Lg1,Lg2}$, $\sigma_{Lf1,Lg1}$, and $\sigma_{Lf2,Lg1}$ we can obtain similar results. For say $\sigma_{Lg1,Lf2}$,

(6) $\sigma_{Lg1,Lf2} = \dfrac{Q \Delta_{Lg1,Lf2}}{L_{g1} \cdot L_{f2} \Delta}$. Multiplying by $\dfrac{Q_f f_{Lf2}}{Q_f f_{Lf2}}$ we obtain, (7) $\sigma_{Lg1,Lf2} = \dfrac{Q_f f_{Lf2} \cdot Q \cdot \Delta_{Lg1,Lf2}}{L_{g1} \cdot L_{f2} \cdot Q_f f_{Lf2} \Delta} = \dfrac{Q_f f_{Lf2} \Delta_{Lg1,Lf2}}{L_{g1} \cdot S_{Q,Lf2} \Delta}$

so, (8) $S_{Q,Lf2}\,\sigma_{Lg1,Lf2} = \dfrac{Q_f f_{Lf2} \Delta_{Lg1,Lf2}}{L_{g1} \Delta}$. Similarly,

(9) $S_{Q,Lf1}\,\sigma_{Lg1,Lf1} = \dfrac{Q_f f_{Lf1} \Delta_{Lg1,Lf1}}{L_{g1} \Delta}$ and

(10) $S_{Q,Lg2}\,\sigma_{Lg1,Lg2} = \dfrac{Q_g g_{Lg2} \Delta_{Lg1,Lg2}}{L_{g1} \Delta}$.

Substituting for expressions in (1), we obtain:

(11) $L_{g1}\Delta S_{Q,Lg1}\sigma_{Lg1,Lg1}+L_{g1}\Delta S_{Q,Lg2}\sigma_{Lg1,Lg2}+$

$L_{g1}\Delta S_{Q,Lf1}\sigma_{Lg1,Lf1}+L_{g1}\Delta S_{Q,Lf2}\sigma_{Lf1,Lf2}=0.$

Dividing both sides by $L_{g1}\Delta$, we obtain:

(12) $S_{Q,Lg1}\sigma_{Lg1,Lg1}+S_{Q,Lg2}\sigma_{Lg1,Lg2}+S_{Q,Lf1}\sigma_{Lg1,Lf1}+$

$S_{Q,Lf2}\sigma_{Lg1,Lf2}=0.$

Note that the Allen partials incorporate substitution of labor within tasks(i.e., $\sigma_{Lg1,Lg2}$) as well as substitution of tasks (i.e., $\sigma_{Lg1,Lf1}$).

Appendix III

Derivation of Form of Relative Demand Schedule

In Chapter III, we obtain a relative demand function which is used to empirically test for the effects of nursing licensure. In this specification, relative wages are shown to be related to relative numbers, relative "expected" wages (defined in Chapter III) and other exogenous variables. This result may be obtained from the following cost minimization procedure.

Define the production function to be of the CES variety:

$$(1) \quad x = \left[\alpha_1 H_1^{-\beta} + \alpha_2 H_2^{-\beta} + \alpha_3 Z^{-\beta}\right]^{-\frac{1}{\beta}}$$

where x is either hospital output or nursing services, H_1 and H_2 are registered and practical nursing inputs in <u>efficiency</u> units, Z represents other inputs, and $\sigma = \frac{1}{1+\beta}$ is the constant elasticity of substitution between any two inputs, a standard result for a CES function. We also define the following relationships:

$$(2) \quad H_1 = a_1 N_1 \qquad (4) \quad W_1 = a_1 \hat{W}_1$$

$$(3) \quad H_2 = a_2 N_2 \qquad (5) \quad W_2 = a_2 \hat{W}_2$$

where N_1 and N_2 are numbers of registered and practical nurses, a_1 and a_2 are indexes of efficiency per registered and practical nurse, W_1 and W_2 are actual wages of registered and practical nurses, and $\hat{W}_1$ and $\hat{W}_2$ are the quality-adjusted wages for each nursing group. We assume the price of Z to be one dollar.

The total cost of utilizing these inputs can be expressed as:

$$(6)\quad C = Z + \hat{W}_1 H_1 + \hat{W}_2 H_2 \qquad \text{or}$$

$$(6a)\quad C = Z + W_1 N_1 + W_2 N_2$$

Minimizing (6) subject to (1), i.e., minimizing the following Lagrangian expression,

$$(7)\quad G = Z + \hat{W}_1 H_1 + \hat{W}_2 H_2 + \lambda \left(x - \left[\alpha_1 H_1^{-\beta} + \alpha_2 H_2^{-\beta} + \alpha_3 Z^{-\beta} \right]^{-\frac{1}{\beta}} \right)$$

results in the following first-order conditions for H_1 and H_2:

$$\frac{\partial G}{\partial H_1} = \hat{W}_1 - \lambda R^{-(1+\frac{1}{\beta})} \alpha_1 H_1^{-(1+\beta)} = 0$$

$$\frac{\partial G}{\partial H_2} = \hat{W}_2 - \lambda R^{-(1+\frac{1}{\beta})} \alpha_2 H_2^{-(1+\beta)} = 0$$

where R is the expression in brackets in (7).

Expressing the conditions in terms of the marginal rate of substitution between H_1 and H_2 yields:

$$\frac{\hat{W}_1}{\hat{W}_2} = \frac{\alpha_1 H_1^{-(1+\beta)}}{\alpha_2 H_2^{-(1+\beta)}} = \left(\frac{\alpha_1}{\alpha_2}\right) \left(\frac{H_1}{H_2}\right)^{-(1+\beta)}$$

Rewriting in natural logarithms, we obtain the following inverse demand expression:

$$\ln \left(\frac{\hat{W}_1}{\hat{W}_2}\right) = \ln \left(\frac{\alpha_1}{\alpha_2}\right) - (1+\beta) \ln \left(\frac{H_1}{H_2}\right).$$

Substituting $\sigma = \frac{1}{1+\beta}$, and definitions in (2), (3) and (4), we obtain:

$$\ln \left(\frac{W_1}{W_2}\right) = \ln \left(\frac{\alpha_1}{\alpha_2}\right) + \ln \left(\frac{a_1}{a_2}\right) - \frac{1}{\sigma} \ln \frac{a_1 N_1}{a_2 N_2} \qquad \text{or,}$$

$$\ln \left(\frac{W_1}{W_2}\right) = \ln \frac{\alpha_1}{\alpha_2} - \frac{1}{\sigma} \ln \left(\frac{N_1}{N_2}\right) + \left(1 - \frac{1}{\sigma}\right) \ln \frac{a_1}{a_2},$$

the form of our equation developed in Chapter III and tested in Chapter IV. Note that $\frac{a_1}{a_2}$ can be viewed as the ratio of "expected" wages. The rationale for inclusion of our other exogenous variables is based upon the fact that $\ln \frac{\alpha_1}{\alpha_2}$, which measures the portion of relative demand independent of our slope variable (relative numbers) and the expected wage ratio, may depend upon such factors as licensure, length of stay, physician-population ratio, etc.

Appendix IV

A. Summary Statistics, 1960 Cross-Section

1. Variables in Arithmetic (Linear) Form:

Variable	Mean	Standard Deviation	Coefficient of Variation
RELW	1.50	.17	.11
RWEX	1.20	.06	.05
RELR	2.77	.70	.25
LRN*	.48	.50	1.04
LPN*	.19	.40	2.11
PPR	1.20	.28	.23
TP	2.20	1.28	.58
FY	5367.40	950.90	.18
GB	.22	.08	.36
AVLOS	7.35	.95	.13
OCR	73.67	4.71	.06
BC	3.50	.54	.15
AVBS	120.52	48.08	.40
BDPN	.24	.21	.88

2. Variables in Natural Logarithms:

RELW	.40	.11	.28
RWEX	.18	.05	.28
RELR	.99	.25	.25
PPR	.16	.23	1.44
TP	.60	.65	1.08
FY	8.57+	.19	.02
GB	1.61+	.41	.25
AVLOS	1.99	.13	.07
OCR	4.30	.06	.01
BC	1.24	.16	.13
AVBS	4.72	.37	.08

* Binary variable

\+ Absolute value

B. Unweighted Regressions, 1960 Cross-Section

TSLS Estimates of Relative Demand and Supply Equations

	Dependent Variables			
Independent Variables	(1) RELW	(2) RELR	(3) RELW	(4) RELR
RELR	-.24 (-1.17)*** (-2.76)		-.08 (-.55)* (-1.79)	
RELW		1.99 (.99)*** (2.62)		2.53 (1.48)*** (4.41)
LRN	.089 (1.59)*** (3.75)	-.087 (-.45) (-1.19)	.069 (1.46)*** (4.76)	-.13 (-.69)** (-2.06)
LPN	-.017 (-.251) (-.59)	.34 (1.49)*** (3.95)	-.025 (-.46) (-1.50)	.38 (1.76)* (5.24)***
RWEX	.10 (.23) (.54)		.09 (.23) (.75)	
AVLOS	.37 (1.19)*** (2.81)		.38 (1.4)*** (4.56)	
PPR	-.36 (-2.72)* (-6.42)***		-.34 (-2.99)** (-9.78)***	
GB			.093 (1.79)*** (5.84)	
FY		1.13 (1.48)*** (3.92)		1.31 (1.93)* (5.75)***
TP		.078 (.78) (2.07)**		.082 (.72) (2.15)**
BDPN		-.26 (-.86)*** (-2.28)		-.24 (-.70) (-2.09)**

Equations (1) to (4) (continued)

	(1)	(2)	(3)	(4)
INTERCEPT	-.11 (-.20) (-.47)	-9.46 (-1.30)*** (-3.45)***	-.11 (-.25) (-.82)	-11.29 * (-1.75)*** (-5.22)***
T-RATIO ADJUST-MENT FACTOR	2.36	2.65	3.26	2.98
DEGREES OF FREEDOM (DEGREE OF OVERIDENTIFICATION)	2	2	2	3

Note: First row of figures in parentheses are Dhrymes' t-statistics; second row contains adjusted t or Z-statistics. All variables except LRN, LPN, and BDPN are in natural logarithms.

* significant at .10 level

** significant at .05 level

*** significant at .025 level

All for one-tail test.

Equations (5) to (8)

Independent Variables	Dependent Variables (5) RELW	(6) RELR	(7) RELW	(8) RELR
RELR	-.07 (-.51)* (-1.87)*		-.11 (-.74) (-1.03)	
RELW		1.10 (1.11) (1.21)		1.42 (1.55)*** (2.22)***
LRN	.049 (.91)*** (3.33)***	-.02 (-.14) (-.15)	.093* (1.91)*** (2.65)***	-.04 (-.34) (-.49)
LPN	-.01 (-.17) (-.63)	.26* (1.79)** (1.92)*	-.05 (-.88) (-1.22)	.28* (1.97)*** (2.82)***
RWEX	.33 (.73)*** (2.67)***		.08 (.21) (.29)	
AVLOS	.55 (1.78)*** (6.51)***		.51* (1.83)*** (2.54)***	
PPR	-.28 (-2.06)*** (-7.54)***		-.31* (-2.79)*** (-3.88)***	
AVBS	-.11 (-1.03)*** (-3.77)***			
BC			-.25 (-1.62)*** (-2.25)***	
OCR	.10 (.21) (.77)			
GB	.10* (1.84)*** (6.73)***		.08 (1.49)** (2.07)**	

Equations (5) to (8) (continued)

Independent Variables	(5) RELW	(6) RELR	(7) RELW	(8) RELW
		Dependent Variables		
FY		.81 (1.94)* (2.08)**		.92 (2.29)** (3.27)***
TP		.07 (.86) (.92)		.07 (.84) (1.20)
BDPN		-.30 (-1.22) (-1.31)		-.29 (-1.10) (-1.57)
INTERCEPT	-.43 (-.23) (-.84)	-6.41 (-1.65)* (-1.77)	-.08 (-.19) (-.26)	-7.50* (-2.01)*** (-2.87)
T-RATIO ADJUSTMENT FACTOR	3.66	1.07	1.39	1.43
DEGREES OF FREEDOM (DEGREE OF OVERIDENTIFICATION)	2	5	2	4

See page 140 for symbols and description of table.

Equations (9) to (12)

Independent Variables	(9) RELW	(10) RELR	(11) RELW	(12) RELR
		Dependent Variables		
RELR	-.14 (-.96) (-1.25)		-.15 (-.98) (-1.06)	
RELW		1.24 * (1.77) *** (2.60)		1.24 * (1.78) *** (2.47)
LRN	.077 * (1.69) *** (2.20)		.078 (1.69) * (1.83)	
LPN		.25 ** (2.48) *** (3.65)		.24 ** (2.42) *** (3.36)
RWEX	.14 (.38) (.49)		.15 (.39) (.42)	
AVLOS	.56 * (2.01) *** (2.61)		.57 * (2.02) ** (2.18)	
PPR	-.34 ** (-3.10) *** (-4.03)		-.34 ** (-3.09) *** (-3.34)	
BC	-.22 (-1.45) * (-1.89)		-.22 (-1.46) (-1.58)	
GB	.08 (1.60) ** (2.08)		.08 (1.59) * (1.72)	
FY		.84 *** (2.74) *** (4.03)		.89 *** (2.97) *** (4.13)
TP		.07 (.84) (1.23)		

Equations (9) to (12) (continued)

Independent Variables	(9) RELW	(10) RELR	(11) RELW	(12) RELR
		Dependent Variables		
BDPN		-.29 (-1.20)** (-1.76)		-.42 (-2.22)** (-3.09)***
INTERCEPT	-.18 (-.43) (-.56)	-6.74 (-2.37)** (-3.48)***	-.19 (-.44) (-.48)	-7.11 (-2.54)** (-3.53)***
T-RATIO ADJUSTMENT FACTOR	1.30	1.47	1.08	1.39
DEGREES OF FREEDOM (DEGREE OF OVERIDENTIFICATION)	3	5	2	5

See page 140 for symbols and description of table.

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