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The Labor Market of Nurses: A Cobweb Model

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Abstract

The labor market of nurses has been plagued by reports of persistent shortages, which raise concerns about the quality of health care. The formulation of appropriate policy intervention requires knowledge of the factors shifting the demand and supply of nurses. This paper develops a model of the nursing labor market, in which the demand and supply curves are identified from the observed employment and wages using econometric techniques. It is found that the short term wage elasticity of supply is not significantly different from zero, and hence the employment trends in the nursing labor market follow a cobweb pattern, where the quantity supplied adjusts to exogenous increases in demand, but with a lag, causing shortage in the meanwhile. An appropriate policy instrument would be to subsidize nursing education, which would increase supply in anticipation of increased future demand.

1. Introduction

Stories of a nursing shortage abound in the news media: "Nursing shortage is raising worries on patients' care" (*New York Times*, 2001); "How to lessen the impact of nursing shortage on your hospital stay" (*Wall Street Journal*, 2001); "Nursing mistakes kill, injure thousands" (*Chicago Tribune*, 2000); "When the hospital staff isn't enough" (*Washington Post*, 2001); "How hospitals are gambling with your life" (*Reader's Digest*, 2001). Such discussions of the nursing shortage are not recent. For at least the past 50 years, registered nurse (RN) shortages have been one of the most talked about subjects in health manpower (e.g. see Devine, 1969; Yett, 1975; Link and Settle, 1985; Lane and Gohmann, 1995).

On the other hand, figures show that nursing employment has been increasing very rapidly. From 1983 to 2002, the number of full-time nurses increased by 79 % while the total labor force grew by only 38 % (Bureau of Labor Statistics). If shortages still continue, it must mean that this increase in employment is not sufficient to satisfy the *even higher* increases in demand. The employment growth, after all, is constrained by the growth rate of the supply of nurses. What is driving up the demand so fast? And what is causing the supply to lag behind?

This paper attempts to answer these questions by analyzing the nursing labor market. It uses the cobweb model, which Freeman has successfully used in the past to analyze the markets for lawyers (1975) and engineers (1976). For most professional occupations like nursing, there is a fixed delay between the time workers observe an increase in wages and the time they are able to enter the profession. Hence the short run supply curve of such professionals is fairly inelastic. The cobweb model predicts that due to this inelastic short run supply curve, an increase in demand sets off a series of shortages and surpluses, accompanied by fluctuations in wages, which can go on for a while before the market settles into equilibrium. This paper finds that the employment and wage trends of the nursing labor market are consistent with the cobweb model, especially if we consider that the demand for nurses is increasing continuously. Hence, the dynamics of the cobweb model can be used to provide some explanation about the occurrence of the nursing shortages.

The following section delves more deeply into this phenomenon of a nursing shortage. Section 3 reviews the literature on the nursing labor market and the shortage. Section 4 discusses the cobweb model and what it predicts about the market for nurses. Section 5 translates the theoretical model into an empirical model that can be tested with data. The data themselves are described in section 6. Section 7 presents the results, while section 8 explains what the model tells us about the shortage of nurses.

2. Does a nursing shortage really exist?

Before undertaking academic research on a phenomenon that is motivated by newspaper reports, it is worthwhile to consider how "real" the phenomenon is. Fortunately, in the case of the nursing shortage, the evidence is not just anecdotal. An empirical project undertaken by Lane and Gohmann (1995) attempted to identify the nursing shortage at the county level in the United States using economic and non-economic definitions of shortage. In the non-economic definition, a fixed need for nurses is identified based on the judgments of medical experts about how many nurses are required to perform certain tasks for a certain population size. When the quantity in the market falls short of that needed number, a shortage is said to exist. This approach to defining a shortage is often used by policymakers in setting targets for their policies.

According to the economic definition, a shortage exists when the quantity demanded is greater than the quantity supplied at the prevailing price. This approach to defining a shortage allows for the market pricing mechanisms, substitution of other inputs and technological change. Instances of both these kinds of shortages are illustrated in Figures 1 and 2.

Figure 1: A non-economic Shortage

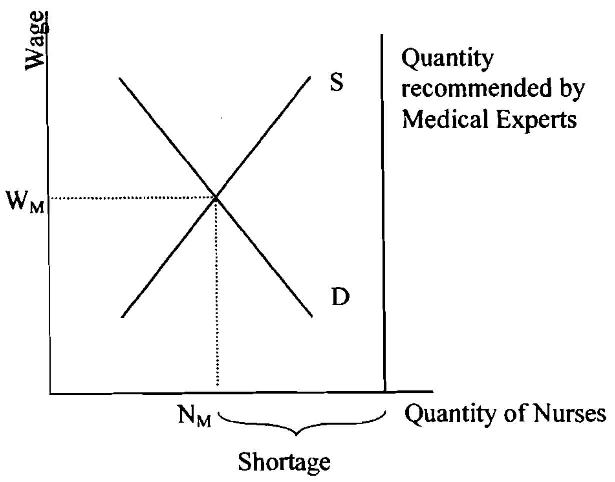
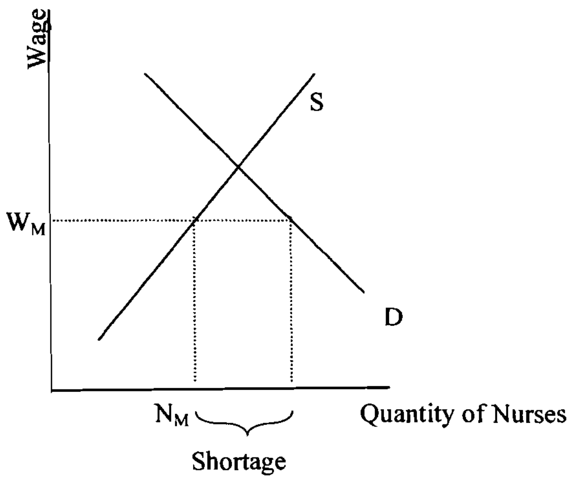


Figure 2: An economic Shortage



Using 1991 data for 1885 US counties, Lane and Gohmann found that the non-economic approach identified a nursing shortage in 565 counties, while the economic approach identified shortage in 423 counties. Both approaches concurred on the issue for only 133 counties, which speaks more about the divergence of the two approaches than the non-existence of a shortage; for the question posed in the title of this section, it is sufficient to know that a substantial shortage exists no matter what approach one is using to identify it.

However, one's explanation for the occurrence of the shortage depends on the kind of shortage – economic or non-economic – that one is trying to explain. Someone trying to explain a "non-economic" shortage will point to the *functioning of the market mechanism* that keeps the quantity of nurses from reaching the level desired by medical experts. In Figure 1, the quantity determined by the market (N_M) is lesser than the quantity desired by medical experts. A person explaining an "economic" shortage will point to the *non-functioning of the market mechanism* (wage rigidity, unionization etc) that keeps demand and supply from equating. Hence it is important to decide at the onset what kind of shortage one is trying to explain.

This paper takes a third approach to defining a shortage. According to this approach, a shortage is said to exist when the quantity of a short run equilibrium is less than the quantity that would be in the long run equilibrium, given a fixed long run supply curve. Intuitively, it makes sense to consider that this is a shortage because people at a given point in time have to make do with less than the potential quantity that is available to them in the long run. Figure 3 illustrates this kind of a shortage.

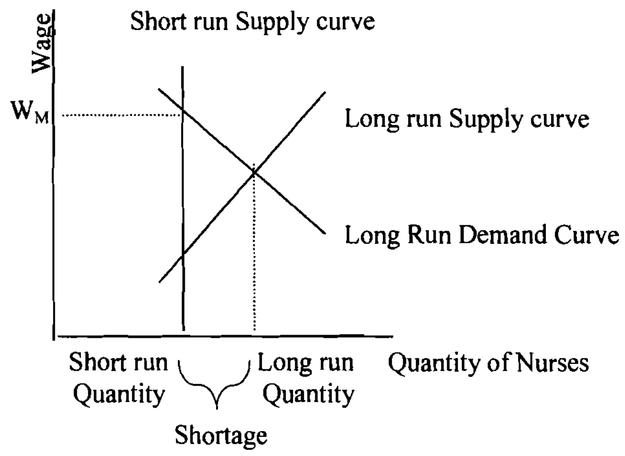


Figure 3: An alternative approach to identifying a shortage

This definition is motivated out of econometric necessity. This is because, in order to trace out the demand and supply curves from the observed quantities in the market using basic econometric techniques, it is necessary to assume that those quantities represent some kind of equilibrium (see the empirical model section for more on this). However if it is assumed that the market is in equilibrium, then it cannot be said that there is a shortage in the "economic" sense. This definition gets around that dilemma without violating the intuitive notion of what a shortage is.

With this definition of shortage in mind, we now examine the theories that have been put forth to explain the shortage of nurses.

3. Literature Review

Nursing associations speculate that the image of nursing leads to shortages (Friss 1994) or that shortages are a function of job dissatisfaction (Johnston 1997, Prescott 1989; Relf 1995). Many attribute it to the aging nursing workforce (Buerhaus et al, 2000a) or an increase in other career opportunities for women (Buerhaus et al, 2000b). Yet others look towards demand side factors, arguing that an aging population and increased acuity of in-hospital patients is leading to the shortage of nurses (Buerhaus, 1998). However, those using the "economic" definition of shortage argue that these changes *per se* should not lead to shortages, they would simply cause shifts in the demand or the supply curves, and the market would adjust to a new equilibrium (Adhia, 2002). Hence those espousing the "economic" definition look for the explanation of a shortage in some kind of *disequilibrium* model- a model where the markets do not adjust, where the quantity demanded does not equal the quantity supplied.

One such model is the "equilibrium vacancies" model or the "monopsony" model, first proposed by Archibald (1954). It shows that if an employer in a labor market is monopsonistic or has substantial market power, then chronically high vacancies can result. Sullivan (1989) summarizes the model aptly.

"Owing to this imperfect competition (monopsony), an individual hospital faces an upward sloping supply curve for nurses, and, thus at its optimal level of employment, pays below the relevant marginal product. As a result, the hospital would be willing to hire additional nurses at its current wage (and so might report vacancies) but would not be willing to raise that wage since the benefits would be outweighed by the increase in wages paid to its existing workforce."

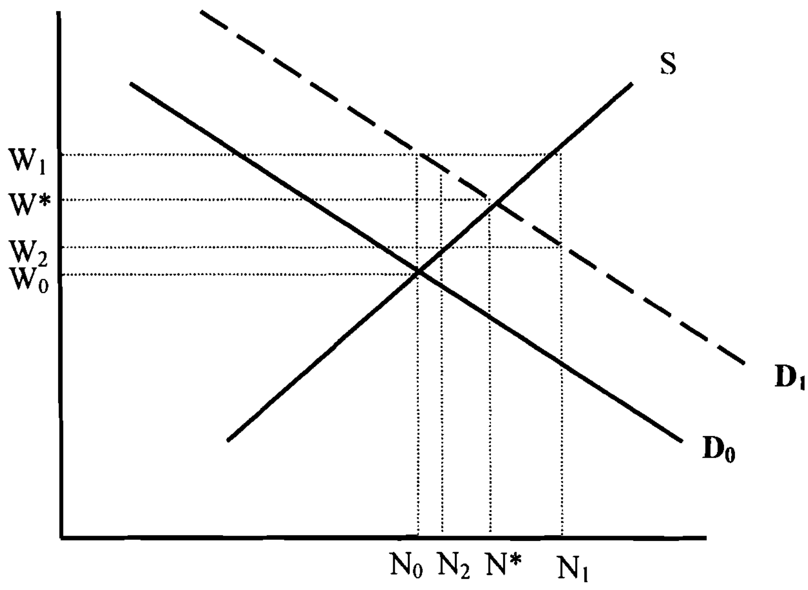
Since these vacancies would not be corrected by the normal market forces, a chronic shortage or "equilibrium vacancies" would result. See Appendix A for a more detailed theoretical explanation of this model.

Though some studies found support for this model (see Yett, 1975; Sullivan 1989; Link and Landon, 1975), a large number have questioned it both empirically (see Adhia, 2002; Adamanche and Sloan, 1982) and theoretically (Rosen, 1970; Lin, 2002). The most contention has been over the assumption that the nursing labor market is monopsonistic. Rosen (1970) suggests that job opportunities in the competitive fringe of non-hospital employers are sufficient to eliminate any tendency toward the exertion of monopsony power. Hence, he contends, the nursing labor market is competitive. If that is the case, then a model being used to explain a nursing shortage should assume a competitive market. The cobweb model is one such model. It shows how shortages can arise even in a perfectly competitive market.

4. The Cobweb Model - Theory

The Cobweb model, which can be found in most Microeconomics or Labor Economics Textbooks (see Ehrenberg and Smith), works just like the model of a competitive market, with a critical condition that the supply in the short run is inelastic (the quantity in the short run is fixed). This is very likely to be true in a market for professionals like nurses, because there is a time lag between the decision to enter a field and the actual entry in the professional labor force. Figure 4 depicts how the cobweb model would describe the nursing market.

Figure 4 A Cobweb Model
for the nursing labor market



D_0 and S are the long run demand and supply curves respectively. Suppose the market is initially in equilibrium, where the wage is W_0 and the employment level is N_0.

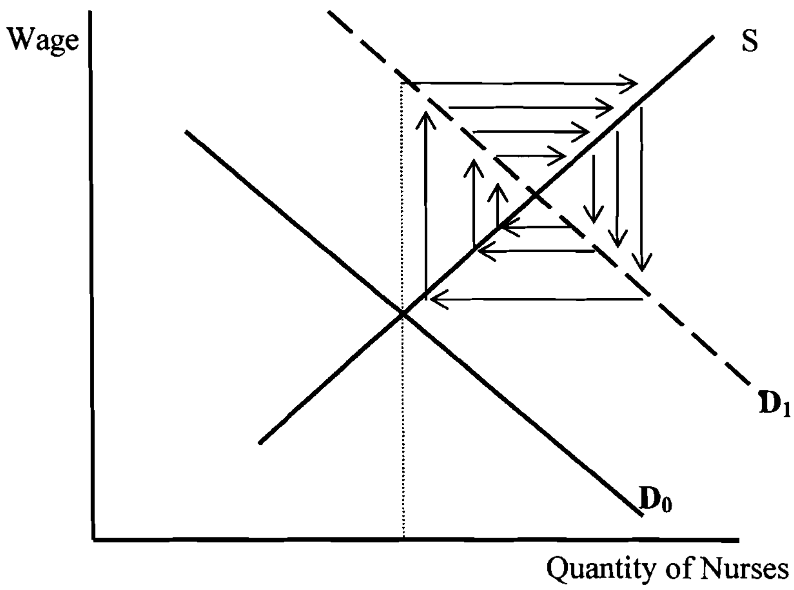
Now suppose there is an outward shift of demand from D_0 to D_1. This can happen due to many reasons: an aging populace, an increase in population or an increase in government subsidy of health care - all increase the quantity of healthcare utilized, which in turn shift out the demand for nurses. This shift causes the new long run equilibrium point to be (N^*, W^*).

However, as discussed before, the quantity supplied is fixed in the short run. It cannot immediately increase to N^*; it remains fixed at N_0. So, for the market to clear, the wage increases from W_0 to W_1. The short run equilibrium now is (N_0, W_1). Note that N_0 (the short run equilibrium quantity) is less than N^* (the long run equilibrium quantity), and so we have a shortage according to the definition of shortage adopted in this paper.

At this point, N_0 nurses are obtaining the wage of W_1. On the long run supply curve, the quantity corresponding to the wage W_1 is N_1. So in the long run - when enough time has passed for the new entrants into the profession to have obtained their training, there will be a total of N_1 nurses. But this quantity is far more than what is demanded at the current wage W_1. Thus we will now have a surplus of nurses.

But the quantity of nurses is fixed in the short run, and so for the markets to clear, the wage will fall this time-*all the way* to W_2, because the demand curve tells us that the wages have to fall to W_2 for all the N_1 nurses to be employed. This wage is below the long run equilibrium W^*, resulting in some people moving out of the profession, but the effect will not be felt for a few years. When the supply does adjust, it will again adjust too much, all the way to N_2. This will once again cause a shortage, and the cycle will be repeated all over again. Over time, the swings between shortages and supply (shown in figure 5) become smaller, and eventually the long run equilibrium is reached. A more complete adjustment process is shown in Figure 5. Because it looks somewhat like a cobweb, the model is called the cobweb model.

Figure 5 The Cobweb
Adjustment Process



5. Empirical Model

In order to show that the cobweb model described above is applicable to the nursing labor market, three things need to be shown:

(1) the short run supply of nurses is inelastic,

(2) when there are outward shifts in demand, wages rise instantaneously

(3) the quantity supplied responds positively to this changes in the wage, but with a lag.

This section develops a model to test the validity of each of these statements.

(1) The short run supply of nurses is inelastic

Though this would be a reasonable assertion to make for most other professions, it is immediately not clear whether this is true in the case of nurses because of the large percentage of nurses who are inactive in the profession at any given point in time. In 2000, of the 2 million plus people living in the US that are licensed to practice as RNs, 18.3% were not practicing nursing (US Dept of Health and Human Services). If the wages rise enough, some of these nurses might be enticed into nursing jobs within a short time period. Thus the short term supply curve might exhibit a modicum of elasticity. To explore this possibility, I construct a demand and supply model where the quantity supplied was allowed to vary both with the current wage and the wage 4 years ago. (see Appendix B for a detailed description of this). The current wage is not found to significantly effect the current supplied; whereas the wage 4 years ago is found to positively and significantly affect the quantity supplied. Thus, it is reasonable to assume that the short run nursing supply is inelastic.

(2) When there are outward shifts in demand, wages rise instantaneously

(3) The quantity supplied responds positively to this change in the wage, but with a lag.

In order to validate the above two statements, I construct the following mathematical model, which can be tested with empirical data.

1) $\mathbf{WAGE}_t = b_{11} + b_{12}\,\mathbf{Q^D}_t + b_{13}\,\mathbf{HEALTHEXP}_t$

2) $\mathbf{Q^S}_t = b_{21} + b_{22}\,\mathbf{WAGE}_{t-4} + b_{23}\,\mathbf{AWAGE}_{t-4} + b_{24}\,\mathbf{FEMENGINEER}_{t-4} + b_{25}\,\mathbf{FEMLABOR}_t$

3) $\mathbf{Q^S}_t = \mathbf{Q^D}_t = \mathbf{Q}_t$

where

$\mathbf{Q^S}_t$ is the quantity supplied of full time nurses in time period t
$\mathbf{Q^D}_t$ is the quantity demanded of full time nurses in time period t
$\mathbf{Q}_t$ is the total quantity of nurses employed full time in the market in time period t
$\mathbf{WAGE}_t$ is the weekly median wage of full time nurses in time period t
$\mathbf{WAGE}_{t-4}$ is the weekly median wage of full time nurses in time period t-4
$\mathbf{AWAGE}_{t-4}$ is the weekly median wage of all full time Managerial and Professional workers in time period t-4
$\mathbf{FEMENGINEER}_{t-4}$ is the percentage of engineers that are female in time period t-4
$\mathbf{FEMLABOR}_t$ is the total female labor force in time period t.
$\mathbf{HEALTHEXP}_t$ is the Real National Health Expenditure in time period t.

The first equation is the demand equation. Freeman (1975) has noted that if the quantity in the market is predetermined (as we now assume), it makes sense to have the wage as the dependant variable in the demand equation. Hence the above demand equation relates the wage to the quantity and $\mathbf{HEALTHEXP}_t$, the Real National Health Expenditure, which serves a proxy for a host of factors that shift the demand for nurses, like an increasing population, an aging population, increased acuity of patients, increased health expenditures by the government etc. What I would like to observe is what happens to $Wage_t$ as $HEALTHEXP_t$ increases. If it increases too, then it lends support to statement (2) above.

The second equation is the supply equation that relates the quantity supplied to the wage of nurses 4 years ago ($WAGE_{t-4}$) and a host of supply shift factors. Since I am trying to show that supply responds with a lag, my hypothesis is that the quantity supplied today (Q_t) is positively related to wages 4 years ago($WAGE_{t-4}$). I have used the 4 year lag because most nursing programs are either two-year or four-year programs, and so the four year lag will capture the cumulative effect of both these programs.

AWAGE is the median wage people in alternative occupations (all managerial and professional occupations) receive, and is taken to be an indicator of the wage that a nurse can receive if he/she enters an alternative occupation. I believe that as the median wage for people in alternative occupations increases, all else being equal, the number of people choosing nursing as an occupation will decline.

Nursing is still female dominated occupation; 94.6% of the nurses in 2000 were women (U.S. Dept. of Health and Human Services). So I suspect that as the female labor force (**FEMLABOR** $_t$) expands, all else being equal, the number of new entrants into the nursing profession will increase.

FEMENGINEER $_{t-4}$, the percentage of engineers that are female, is a proxy for the societal changes that allow women to enter previously male-dominated occupations. I suspect that as more career opportunities open up for women, the number of women choosing nursing- a traditional female occupation, will decline.

The third equation is the *market clearing* or the equilibrium condition. We cannot observe the quantity demanded or quantity supplied; we can only observe the quantity in the market. However, if the quantity in the market is an equilibrium quantity, then it represents both the quantity demanded and quantity supplied at that price. Thus we assume that the market is in equilibrium, so that we can trace out the demand and supply curves from the observed quantities. This assumption of market clearing is not a far-fetched one; in fact, it forms the basis of most economic models.

Substituting the equilibrium quantity ($\mathbf{Q}_t$) for the quantity demanded ($\mathbf{Q}^D{}_t$) and quantity supplied ($\mathbf{Q}^S{}_t$), the model to be estimated becomes –

1) $\mathbf{WAGE}_t = b_{11} + b_{12}\,\mathbf{Q}_t + b_{13}\,\mathbf{HEALTHEXP}_t$

$$2)\ \mathbf{Q}_t = b_{21} + b_{22}\,\mathbf{WAGE}_{t-4} + b_{23}\,\mathbf{AWAGE}_{t-4} + b_{24}\,\mathbf{FEMENGINEER}_{t-4} + b_{25}\,\mathbf{FEMLABOR}_t$$

6. Data

This study uses yearly data on the nursing labor market from 1983 – 2001. The two main sources of data for this study are *Employment and Earnings*, 1984 - 2002, a monthly publication of the Bureau of Labor Statistics and *The Statistical Abstract of the United States, 1984-2002,* a yearly publication of the US Census Bureau. The following table contains the variable definitions, information on how variables are measured and the source of data.

Table 1: Variables and their Definitions, Measurement and Sources

Variable	***Definition***	***The variable is measured by ..***	***Unit***	***Data Source***
Q	Quantity of Nurses	The total number of registered nurses employed full time in the United States	Thousands	Employment and Earnings, BLS
WAGE	Wage of nurses	The median real weekly earnings of full time Registered Nurses	Real Dollars (base year 1983)	Employment and Earnings, BLS
AWAGE	Wages of full time workers in all Managerial or Professional Occupations (white-collar jobs)	The median real weekly earnings (base year 1983) of workers in full-time Managerial or Professional Occupations (white-collar jobs)	Real Dollars (base year 1983)	Employment and Earnings, BLS
HEALTHEXP	Real National Health Expenditure	The total dollars spent on health care in the United States	Billion Real Dollars (base year 1983)	Statistical Abstract of the United States
FEMLABOR	Female Labor Force	Total number of Females working for pay in the United States	Millions	Statistical Abstract of the United States
FEMENGINEER	Percentage of Engineers that are Female	Percentage of Engineers that are Female	Percentage	Employment and Earnings, BLS

7. Results

The coefficients of equation 1 and 2 are estimated using OLS, and they are presented in the following tables, with the absolute t statistics values in parenthesis.

Table 1: Equation 1 Supply Equation
Dependent Variable: Number of Full time Employed Registered Nurses

Variable	Coefficient
$WAGE_{t-4}$	1.68
	(1.839)*
$AWAGE_{t-4}$	-2.307
	(1.056)
$FEMENGINEER_{t-4}$	3.956
	(0.118)
$FEMLABOR_{t}$	34.88
	(4.809)**
	Adj. R^2 = .953**

* indicates significance at 5%, ** at 1%

Table 2: Equation 2 Wage (Demand) Equation
Dependent Variable: Median Weekly Real wages of Full Time Wages

Variable	Coefficient
Q_t	-0.25
	(2.81)**
HEALTHEXP t	0.518
	(3.755)**
	Adj. R2 = .662**

* indicates significance at 5%, ** at 1%

On the demand side, it is found that a billion dollar increase in real health care expenditure causes the median weekly real earnings of nurses to rise by about 50 cents. Recall that the real health care expenditure was our demand shift variable. Hence, we find that an outward shift of demand indeed causes an increase in wage, which is consistent with the cobweb model.

On the supply side, it is found that an increase of a dollar in the nursing wage today leads to about 1600 more nurses four years later after controlling for other supply shift factors. This provides evidence that there is a lagged effect on the quantity of nurses supplied.

All the control variables of the supply equation have the expected sign, but only FEMLABOR is significant. Hence, when the overall female labor force increases by a million, the nursing labor force increases by about 34,000. FEMENGINEER is a proxy variable for occupational integration by gender. As many occupations open up to women, it is reasonable to assume that the nursing occupation might be opening up to more men as well. Thus such integration might not have any net effect on the quantity of nurses, causing the sign of the coefficient of FEMENGINEER to be indeterminate in the model.

The evidence obtained above lends support to the following two statements, which we had set out validate in the empirical model section of this paper.

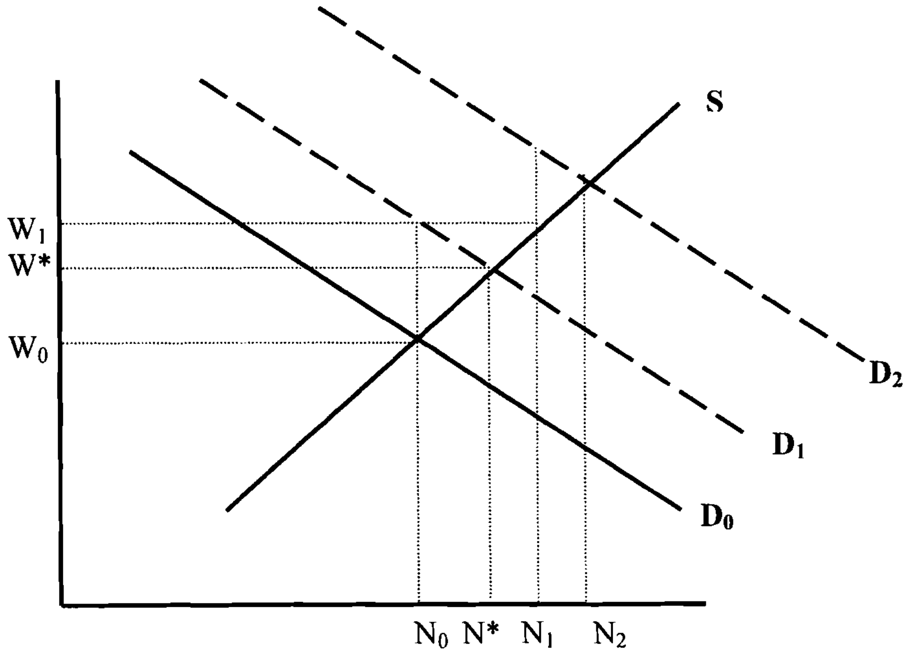
- *When there are outward shifts in demand for nurses, wages of nurses rise instantaneously*
- *The quantity supplied of nurses responds positively to such changes in the wage, but with a lag.*

Hence, the cobweb model is applicable to the nursing labor market.

8. What does this tell us about the nursing shortage?

The cobweb model explains the occurrence of nursing shortages in the following way – various factors increase the demand for nurses, but the quantity supplied increases with a lag, creating a shortage in the meanwhile. Though the model predicts that the market will eventually settle into long run equilibrium after going through alternating periods of surpluses and shortages, such swings are hardly observed in the nursing labor market. Instead, what we see most of the time are persistent shortages. This makes sense if we consider that the nursing labor market is not experiencing just a one time shift in demand – but a continuing shifting of demand. In fact, Real National Health Expenditure (our demand shift variable) has been growing at the average rate of 5% annually between 1983 and 2001 (Statistical Abstract of the United States, 1984-2001). So even though we may have a lagged supply response to shifts in demand, this increase in quantity supplied might not be adequate if the demand has shifted outward again, creating a new- long run equilibrium at a higher quantity. Consider the Figure 6, which is a reproduction of the cobweb model in Figure 5, but it shows an additional demand shift.

Figure 6: Continuous Demand shifts in the Cobweb Model



N_1 is the quantity supplied today in response to a shift in demand (D_0 to D_1) four years earlier. However, if the demand has shifted again (D_1 to D_2) then the long run equilibrium now is at N_2 and we will still have a shortage.

Whether the demand is shifting far enough every time to outpace quantity supplied is yet to be empirically determined, and would be an interesting avenue for further research. If it is indeed found to be the case, then we can say that nursing shortages occur because even though the quantity supplied four years later is determined today, the wages today do not reflect the demand conditions of four years later. Consequently, the quantity determined today may not be adequate to satisfy the demand increases 4 years later. One way for the policy makers to correct this is to "over stimulate" the quantity supply of nurses today, in anticipation of increased demand in the future. Increasing the subsidy on nursing education might be one way of doing this.

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Appendix A

This section gives theoretical explanation of how a monopsonistic labor market can give rise to "equilibrium vacancies." This explanation follows directly from the fact that at the optimal (cost minimizing level) of nursing employment, the marginal revenue product of nursing labor is higher than its wage.

Sullivan (1989) has shown how to set up an optimization problem for a monopsonist hospital. The wage (W) that the monopsonist has to pay is a function of the quantity of Nurses (N) hired by it. This $W(N)$ is its cost function for nurses. It employs other inputs X that have prices r. Thus the cost function of hospital under monopsony is

$$W(N) + Xr$$

Suppose that the hospital is required to service the needs of a certain exogenously given caseload, c, and that it does so at the minimum cost[1]. Thus the hospital solves

$$\text{Min } (N\, W(N) + Xr): N, X \text{ such that } f(N,X) = c$$

where $f(N,X)$ is the production function connecting inputs N and X to the output c. At this point I depart from the method used by Sullivan (1989) Using the Lagrange Multiplier method of optimizing constrained functions, I obtain the first order condition.

Lagrangian Function : $L(N, X, \lambda) = N\, W(N) + Xr - \lambda\,(f(N, X))$

FOC: $\partial L / \partial N = N\, W_N(N) + W(N) - \lambda f_N(N, X) = 0$

Since N and $W_N(N)$ are positive,

$$W(N) - \lambda f_N(N, X) < 0$$

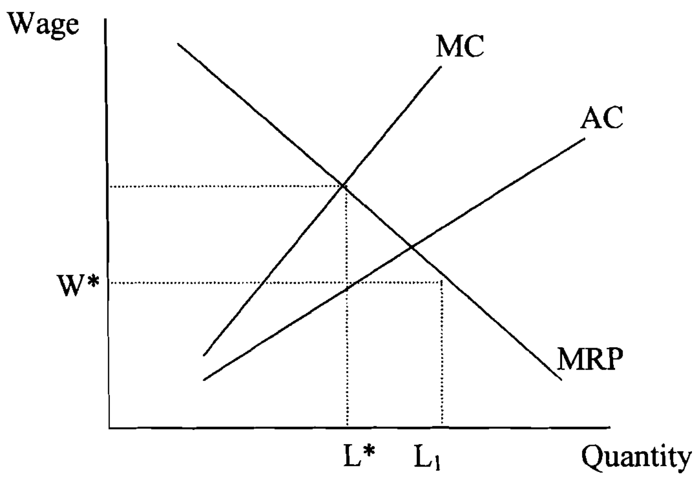
The economic interpretation of λ is that it is ∂ **L** / ∂ **c** which is the marginal cost of producing an additional unit of output. At the cost minimizing quantity, MR=MC=P. Thus λ is the price of the output.

$$W(N) < \lambda f_N(N,X) = MRP$$

Thus at the cost minimizing level of nursing employment, the wage rate paid to the nurses is less than the marginal revenue product of nursing labor. This result can be shown diagrammatically as well. In Figure A.1, which is reproduced from Lin (2002), AC and MC are respectively the Average and Marginal Cost Curves of a monopsonist. The market equilibrium will occur at the point where MC equals the Marginal Product. The firm will employ L* workers and pay wage w*.

If the monopsonist were explicitly asked how many nurses it would like to hire, it would indicate quantity L_1, where MRP = w*. The number represented by $L_1 - L^*$ are the firm's "equilibrium vacancies" according to Archibald (1954). And according to Hurd (1975) the nursing shortage is characterized by such "equilibrium vacancies."

Figure A.1: "Equilibrium Vacancies"



Appendix B

This Appendix explores the possibility that the short run supply curve exhibits some elasticity. To allow this, I add the current wage to the supply equation of the model described on page 10, and see if its co-efficient is significantly greater than zero.

The model now is:

1) $\mathbf{Q^S}_t = b_{21} + b_{22}\,\mathbf{WAGE}_t + b_{23}\,\mathbf{WAGE}_{t-4} + b_{24}\,\mathbf{AWAGE}_{t-4}$

$+ b_{25}\,\mathbf{FEMENGINEER}_{t-4} + \mathbf{b26\ FEMLABOR}_t$

2) $\mathbf{Q^D}_t = b_{11} + b_{12}\,\mathbf{WAGE}_t + b_{13}\,\mathbf{HEALTHEXP}_t$

3) $\mathbf{Q^S}_t = \mathbf{Q^D}_t = \mathbf{Q}_t$

Since $\mathbf{WAGE}_t$ and $\mathbf{Q}_t$ are simultaneously determined, I estimate the coefficients using the two stage least square method. The coefficients of the supply equations, along with the absolute T-statistics, are given in the following table.

Table B.1: Equation 1 Supply Equation
Dependent Variable: Number of Full time Employed Registered Nurses

Variable	**Coefficient**
WAGE_t	2.32
	(1.431)
WAGE_{t-4}	3.01
	(2.31)*
AWAGE_{t-4}	-7.60
	(1.769)
FEMENGINEER_{t-4}	-6.65
	(0.194)
FEMLABOR_t	34.23
	(4.716)**

* indicates significance at 5%, ** at 1%

We fail to find that the co-efficient of the WAGE_t is significantly different from zero. Hence it is reasonable to assume that in the short run, the supply of nursing labor is inelastic.