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MONOPSONY POWER IN THE MARKET FOR NURSES

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ABSTRACT

Estimates are presented of the inverse elasticity of supply of nursing services to the individual hospital, a quantity which is a natural measure of employer market power. The estimates corresponding to employment changes taking place over one year are quite high (in the neighborhood of 0.79) and even for changes taking place over three years are substantial (in the neighborhood of 0.26). The estimates do not significantly differ for hospitals in major metropolitan areas and do not depend very sensitively on the assumed form of the oligopsony equilibrium.

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I. Introduction

The market for hospital nurses is literally *the* textbook example of monopsony in the labor market.[1] Yet, even for nurses, there is relatively little evidence on the quantitative significance of employer market power. This paper attempts to add to the understanding of monopsony power by presenting estimates of a natural measure of its importance, the inverse elasticity of supply of nursing services to an individual hospital. The dependence of the elasticity on the length of the relevant time period, on whether or not the hospital is located in a large metropolitan area and on the nature of the oligopsony equilibrium characterizing the interactions among hospitals is also investigated.

A number of policy issues make the market for nurses an important one to study. Indeed, the hypothesis that the market for nurses is characterized by substantial employer market power was first advanced by Donald Yett (1970) as an explanation for "the chronic shortage of nurses."[2] That is, Yett suggested that George Archibald's (1954) analysis of imperfectly competitive input markets provided the explanation for the apparent failure of market forces to eliminate the shortage of nurses. The argument is that owing to imperfect competition, an individual hospital faces an upward sloping supply curve for nurses, and thus at its optimal level of employment, pays wages 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 to attract more nurses since the benefits would be outweighed by the increase in wages paid to its existing work force.[3] Yett added that these "equilibrium" vacancies might represent a misallocation of resources that would not be corrected by normal market forces and thus constituted a significant public policy concern.[4]

More recently, the nursing profession has been at the center of the "comparable worth" controversy. Believers in "pay equity" reform proposals claim that occupations such as nursing which are held primarily by women have been paid less than occupations requiring similar levels of skill and responsibility which are held primarily by men. They apparently attribute this pay differential to a taste for discrimination on the part of employers. The existence of a significant level of monopsony power in the nursing market would provide an alternative explanation for the existence of such a differential.[5]

The theoretical case for the importance of hospital monopsony power is, however, far from clear. For instance, Sherwin Rosen (1970) has noted that the significance of monopsony is inversely proportional to the elasticity of supply and has offered several arguments for why this elasticity would be high in the nursing market. These include the existence of a nontrivial competitive fringe of non-hospital employers and a large pool of qualified nurses who move in and out of the labor market very freely. He also argued that anti-pirating agreements would be essential to effective collusion, but would be difficult to enforce, again because of the high turnover rates characteristic of nursing employment.

Yett responded to Rosen's arguments by pointing out that most metropolitan hospital associations had in place "wage standardization" programs which were tantamount to collusive agreements.[6] However, of at least equal importance to the monopsony hypothesis, is the observation that from the nurse's point of view, hospitals exhibit a significant degree of differentiation. That is, nurses do not necessarily regard the non-wage aspects of jobs with different employers as being equivalent. Such differentiation could obviously arise from the spatial separation of employers, but could also derive from differences in a multitude of other hospital characteristics such as the quality and safety of the work place, the composition of the caseload or the way nursing tasks are organized. If differentiation of this kind is substantial, then there could be significant monopsony power, in the sense of an upward sloping hospital level supply curve[7], even without highly collusive behavior on the part of hospitals.

The extent of differentiation and thus the strength of monopsony power are likely to depend heavily on the length of the relevant time period over which any changes would take place. Specifically, in the short run, the cost to workers of changing jobs is likely to be high enough that relatively few of them would immediately leave their employer if their wage was cut by a small amount. This would be especially true if it was difficult to distinguish a transitory from a permanent drop in the wage. In the long run, however, if the wage was kept low, more workers would leave and fewer replacements could be recruited. Thus the magnitude of employer market power is likely to be lower in the long run than in the short run. Market power may also be lower in large metropolitan areas where there are more likely to be hospitals which nurses will consider close substitutes. The estimates given below of the market power of an individual hospital are, accordingly, allowed to depend on these factors and also on assumptions about the nature of the oligopsonistic equilibrium.

A number of previous empirical studies of hospital monopsony power have examined the cross-sectional relationship between the wages of nurses and the level of employer concentration. Most of these studies have concluded that higher concentration is associated with lower wages. The earliest study, that of Richard Hurd (1973) found a strongly negative correlation of average nursing wages with employer concentration in a 1960 cross-section of Standard Metropolitan Statistical Areas and also in a cross-section of larger cities covered by the 1966 Bureau of Labor Statistics' Industry Wage Survey for the hospital industry. Similarly, Charles Link and John

Landon (1975), using data from a 1973 survey of their own construction, found a negative relationship between concentration and the wages of individual hospitals. Similar results were also found by Roger Feldman and Richard Scheffler (1982) in a national survey of hospitals conducted in 1977 and by Thomas Bruggink, Keith Finan, Eugene Gendel and Jefferey Todd (1985) for New Jersey Hospitals in the early 1980's. On the other hand, Killard Adamanche and Frank Sloan (1982) find no evidence of an association between starting wages and concentration in a 1979 survey of hospitals. This last study controls for the largest number covariates and uses what is arguably the best wage measure, so the results of the literature ought to be considered as, at best, mixed on the question of the relationship between concentration and wages.[8]

More recently, James Robinson (1988) has found that in a cross-section of hospitals, higher levels of concentration are associated with lower employment of nurses and a lower ratio of the number of the more highly trained Registered Nurses (RNs) to the number of less highly trained Licensed Practical Nurses (LPNs). These facts can also be considered consistent with the importance of monopsony power.

There are, however, fundamental difficulties with studies such as the ones described above. Except, perhaps, in the case where it is equal to zero, there is no structural interpretation for the key paramater which measures the partial association of the wage or level of employment with concentration. In particular, such studies do not directly address the question of how far monopsony actually depresses wages. The approach adopted here is more direct: Estimates are given of the elasticity of the supply curve facing an individual hospital. Monopsony power can then be measured by the inverse of this elasticity. As noted below, the inverse elasticity is directly related to the percentage difference between wages and marginal product and, if marginal product is constant, to the amount by which wages are lower than they would be under perfect competition.

The assessment of the extent of market power in output markets has, of course, long been one of the principal concerns of applied research in the field of industrial organization. Lately some attention has been focused on the development of formal econometric techniques which jointly estimate the gap between price and marginal cost and the "conjectural variations" or some other set of parameters describing the nature of interactions among firms. (See, for example, Iwata (1974), Gollup and Roberts (1979), Appelbaum (1982), Spiller and Favaro (1984) and Roberts and Samuelson (1988); Bresnahan (1988) surveys some of this literature.) Application of these methods would, however, require data on some variable which shifts the supply function of nurses to the individual hospital, data which the current study lacks.

An alternative line of research exemplified by Bresnahan (1981) and Baker and Bresnahan (1985, 1988) takes the nature of the equilibrium between the firms as given and uses this additional information to identify the gap between price and marginal cost. This is the approach adopted here.[5] More specifically, estimates of the hospital level inverse elasticity of supply are presented below under three alternative assumptions about the nature of the market equilibrium: An employment level setting equilibrium, a wage setting equilibrium and a consistent conjectural variations equilibrium. In each case, variation in individual hospitals' caseloads is used to identify the supply response. No formal tests of whether any of these three equilibrium concepts is the correct one are given. The development of such tests would, of course, be a valuable contribution. However, as a first step, it seems sensible to find out how much outcomes could differ under alternative models.

The results presented below suggest that hospitals have very substantial monopsony power in the short run and that even over a longer time horizon may exercise significant market power. Specifically, the inverse elasticity of supply over one year periods is estimated to be 0.79 (with a standard error of 0.13) and over three year periods to be 0.26 (with a standard error of 0.07). It is also found that monopsony power is not significantly lower in major metropolitan areas. Finally, the results do not indicate significant dependence of monopsony power on the assumed form of the oligopsony equilibrium.

Section II of this paper reviews the elementary theory of monopsony, describes the equilibrium concepts which are assumed in the estimation of the hospital level inverse elasticity of supply and then lays out the econometric strategy used to obtain estimable statistical models corresponding to the three equilibrium concepts. Section III describes the data and discusses possible sources of biases in the methods. The results are presented in section IV and conclusions are discussed in section V.

II. Theoretical Framework and Econometric Strategy

This section begins by reviewing the elementary theory of monopsony and discussing the relevant quantities to be estimated under three alternative assumptions about the oligopsonistic equilibrium characterising the market for nurses. It concludes with a discussion of the econometric strategy which yields statistical models which can be estimated with the available data.

Consider first a monopsonist hospital which faces inverse supply function $W(N)$. That is, in order to attract N nurses it needs to offer a wage of $W(N)$. For concreteness, suppose that the hospital is required to service the needs of a certain exogenously given level of caseload, c , and that it does so at minimum cost. It employs nurses and other inputs X which have prices r. Thus the hospital solves $\min \; NW(N) + Xr \quad \text{s.t.} \quad f(N, X) = c$ where $f(N, X)$ is the production function connecting inputs N and X to the output c. Suppressing the arguments of functions and denoting partial derivatives by subscripts, the first order condition for this problem can be written as

$$\frac{W - \lambda f_N}{W} = NW_N / W \equiv \theta , \tag{1}$$

where λ is a Lagrange multiplier. (If the caseload variable c and the production function $f(N, X)$ are vector valued, λf_N should be interpreted as the inner product of a vector of LaGrange multipliers with the vector of derivatives of $f(N, X)$ with respect to N.) Equation (1) states that the percentage gap between the marginal product and the wage is equal to θ, the inverse elasticity of supply.[10] Moreover, if λf_N is constant then θ will also measure the percentage gap between the equilibrium wage and the wage that would have prevailed had the hospital been a price taker. Thus θ is a natural measure of a hospital's monopsony power and it is this quantity that is estimated below.

Consider now the case of k + 1 hospitals which have to service caseloads $c_0, c_1, \ldots , c_K$ and which face interconnected inverse supply functions

$$\begin{aligned} w_0 &= W^0(N_0 , N_1 , \ldots , N_K) \\ &\;\;\vdots \\ w_K &= W^K(N_0 , N_1 , \ldots , N_K) . \end{aligned} \tag{2}$$

In order to talk meaningfully about the firm level supply function facing hospital 0, it is necessary to specify the nature of the equilibrium for all the hospitals. Three possible equilibria are discussed below[11].

Suppose first that Nash equilibrium in employment levels is the correct notion of equilibrium in this market. Then it follows that for hospital 0,

$$\frac{w_0 - \lambda f_{N_0}}{w_0} = N_0 W^o{}_{N_0} / w_0 \equiv \theta . \tag{3}$$

In this case the natural notion of firm level supply takes the employment levels of other hospitals as fixed and the equation of interest for monopsony power is the first equation of (2).

On the other hand, if certain regularity conditions are satisfied, the supply system can be re-arranged to yield

$$w_0 = \tilde{W}^o (N_0 , w_1 , \ldots , w_K) , \tag{4}$$

which gives the wage hospital 0 would have to pay to attract N_0 nurses as a function of the wage rates of the other hospitals. Thus if Nash equilibrium in wage rates correctly describes the behavior of firms, then for firm 0

$$\frac{w_0 - \lambda f_{N_0}}{w_0} = N_0 \tilde{W}^o{}_{N_0} / w_0 \equiv \theta . \tag{5}$$

In this case firm level supply can be thought of as taking the other hospitals wage rates as fixed and the natural equation to estimate is (4), the equation relating the hospital's wage to its employment level and the wages of other hospitals.

Finally, the notion of consistent conjectural variations equilibrium implies that the relevant equation to be estimated is

$$w_0 = R^o (N_0 , c_1 , \ldots , c_K) . \tag{6}$$

That is, under this hypothesis, whose implications for the estimation firm level demand elasticities has been explored by Baker and Bresnahan (1988), the relevant notion of firm level supply takes the levels of the exogenous variables shifting other firms' demands as fixed. This is motivated by the assumption that the hospital is a Stackelberg leader with respect to the other employers. If hospital 0 chooses employment level N_0, the other hospitals are assumed to solve their cost minimization problems taking that level as given. The solutions to these minimization problems are a set of reaction functions

$\tilde{N}_i(N_0 , c_i)$ which express the employment levels of the other hospitals in terms of their caseloads and the employment level of hospital 0. Hospital 0 is then assumed to take these reactions into account in solving its own cost minimization problem. Thus the natural notion of firm level supply for the Stackelberg leader is obtained by substituting these reaction functions into the standard supply equation (2):

$$w_0 = W^0(N_0, \tilde{N}_1(N_0, c_1), \dots, \tilde{N}_K(N_0, c_K)) \tag{7}$$

$$\equiv R^0(N_0, c_1, \dots, c_K) .$$

In this case the gap between the wage and the marginal product is given by

$$\frac{W_0 - \lambda f_{N_0}}{W_0} = N_0 R^0_{N_0} / W_0 \equiv \theta \tag{8}$$

and (6) is the natural equation to estimate.

Baker and Bresnahan (1988) note that the consistent conjectures assumption in an output market is satisfied under several well known sets of assumptions. There are an analogous set of circumstances in the case of an input market. For instance, a dominant hospital with a competitive fringe of other employers will act as a Stackelberg leader. Similarly a constant employment share cartel would have the consistent conjectures property. Baker and Bresnahan also note that when product (or in this case, job) differentiation becomes extreme, questions of strategic interaction become unimportant as all notions of equilibrium converge.[12]

Baker and Bresnahan (1988) settle on extreme product differentiation as their justification for using the consistent conjectures approach to analyze the market power of firms in the beer industry, but do not consider other assumptions. If differentiation is, indeed, very extensive, then the three measures proposed above should be close. This provides a check on their assumption.

The three notions of oligopsonistic equilibrium each imply an econometric specification for the inverse supply function giving the hospital's wage rate as a function of its employment level. The specifications differ only in which additional variables they imply should be included. For the employment level setting equilibrium, the employment levels of other firms need to be held constant. For the wage rate setting equilibrium, the wage rates of other firms need to be held constant. Finally for the consistent conjectural variations equilibrium, it is the levels of the exogenous variables effecting other firms' demand for nurses which need to be held constant. In each case, the hospital's own caseload is the excluded exogenous variable that accounts for the endogeneity of the hospital's level of employment and identifies the firm level inverse elasticity of supply.[13]

The available data[14] consist of the levels of nursing wages and employment and measures of the caseload for a large class of hospitals over a small number of years. Thus in order to produce estimable versions of equations (2), (4) and (6), it is necessary to make some strong simplifying assumptions. The strategy employed here has two components. First it is assumed that the hospitals can be divided into a number of distinct regional markets and that interactions between hospitals in different regions can be ignored. Secondly, it is assumed that there is a high degree of symmetry in the relationship between hospitals in the same region.

Let w_{rit} , n_{rit} and c_{rit} , $i = 1, \dots k_r$, denote the natural logarithms of the nursing wage, the number of nurses employed and the caseload (possibly a vector of caseload variables) for the i^{th} hospital in region r in year t. Then a linear in logs approximation to equation (2) for hospitals in region r would take the form

$$\begin{bmatrix} w_{r1t} \\ \cdot \\ \cdot \\ \cdot \\ w_{rk_rt} \end{bmatrix} = \begin{bmatrix} \alpha_{r1} + \delta_r t \\ \cdot \\ \cdot \\ \cdot \\ \alpha_{rk_r} + \delta_r t \end{bmatrix} + \begin{bmatrix} \theta_{r11} & \gamma_{r12} & \cdot\cdot & \gamma_{r1k_r} \\ \gamma_{r21} & \cdot & & \cdot \\ \cdot & & \cdot & \cdot \\ \cdot & & \cdot & \\ \gamma_{rk_r1} & \cdot & \cdot\cdot & \theta_{rk_rk_r} \end{bmatrix} \begin{bmatrix} n_{r1t} \\ \cdot \\ \cdot \\ \cdot \\ n_{rk_rt} \end{bmatrix} + \begin{bmatrix} \varepsilon_{r1t} \\ \cdot \\ \cdot \\ \cdot \\ \varepsilon_{rk_rt} \end{bmatrix} , \tag{9}$$

where a region specific time trend, $\delta_r t$, has been included in the model as empirical investigation found to be appropriate. Obviously, with only six years of data and a large number of hospitals, it is not possible to estimate all the parameters in the above specification. In order to get an estimable equation, it is assumed that $\theta_{rii} = \theta$ for all r and i and that $\gamma_{rij} = \gamma$ for all r, i and j. With these symmetry assumptions the system of equations (9) becomes a single equation that can be estimated by pooling across hospitals[15]:

$$w_{rit} = \alpha_{ri} + \delta_r t + \theta n_{rit} + \gamma (on)_{rit} + \varepsilon_{rit} \tag{10}$$

where $(on)_{rit} = \Sigma_{j \neq i} n_{rjt}$. In this specification, the α_{ri} are a set of hospital specific fixed effects. These control for unobserved differences in hospitals which are constant through time. For instance, the location of the hospital relative to population centers and other hospitals, the safety and other characteristics of the neighborhood, the style of nursing practice, whether the hospital is associated with a medical school or nursing school, and a number of other factors affecting a nurse's perception of the desirability of a job at a given hospital can be assumed to be approximately constant over the six year period of this study.

The hospital effects can be removed by differencing:

$$\Delta_d w_{rit} = \delta_r + \theta \Delta_d n_{rit} + \gamma \Delta_d (on)_{rit} + \Delta_d \varepsilon_{rit} \tag{11}$$

where $\Delta_d w_{rit} = w_{rit} - w_{rit-d}$ and similarly for the other variables. In the empirical work described below, estimates of equation (11) are presented differences of $d = 1$, 2 and 3 years. By looking at the association of wage changes and employment changes over different lengths of time, the dynamic nature of hospital level supply can be investigated. The estimates show the length of the relevant time interval (one, two, or three years) to be an important determinate of the strength of monopsony power (the inverse elasticity of supply).

It is worth noting that equation (11) requires at least two years of differenced data for estimation.[16] The reason is that $n_{rit} + (on)_{rit} = \Sigma_j n_{rjt}$ does not vary within hospitals in the same region and so would be confounded with δ_r if only a single year was used in estimation. Similarly, a specification which adds region specific year effects to equation (11) is not identified, no matter how many years of data are employed.[17] This is the analogue in the cross-section dimension of the problem of estimating the effects of non-time-varying variables in panel data studied by Hausman and Taylor (1981). Fortunately, for the purposes of this paper, there does not seem to be any reason not to use the time series variation in the data to estimate the firm level inverse supply.

The region specific intercepts in the differenced equation (corresponding to region specific time trends in the levels specification) can be removed by subtracting region specific means of the variables:

$$\Delta_d w_{rit} - \overline{\Delta_d w_{r..}} = \theta(\Delta_d n_{rit} - \overline{\Delta_d n_{r..}}) + \gamma(\Delta_d (on)_{rit} - \overline{\Delta_d (on)_{r..}}) + \Delta_d \varepsilon_{rit} - \overline{\Delta_d \varepsilon_{r..}} \tag{12}$$

where $\overline{\Delta_d w_{r..}}$ is the mean over time and hospitals in region r of $\Delta_d w_{rit}$ and similarly for the other variables. Equation (12) is estimated by two stage least squares using $(\Delta_d c_{rit} - \overline{\Delta_d c_{r..}})$ and $(\Delta_d (oc)_{rit} - \overline{\Delta_d (oc)_{r..}})$ as instrumental variables, where $(oc)_{rit}$ is the sum over hospitals other than hospital i in region r in year t of c_{rit}.[18]

Similar assumptions are used to arrive at estimable versions of equations (4) and (6). Specifically, estimates under the hypothesis of a wage rate setting equilibrium were obtained by estimating

$$\Delta_d w_{rit} - \overline{\Delta_d w_{r..}} = \theta(\Delta_d n_{rit} - \overline{\Delta_d n_{r..}}) + \gamma(\Delta_d (ow)_{rit} - \overline{\Delta_d (ow)_{r..}}) + \Delta_d \varepsilon_{rit} - \overline{\Delta_d \varepsilon_{r..}} \tag{13}$$

using $(\Delta_d c_{rit} - \overline{\Delta_d c_{r..}})$ and $(\Delta_d (oc)_{rit} - \overline{\Delta_d (oc)_{r..}})$ as instrumental variables. In model (13), $(ow)_{rit}$ is the average wage of hospitals other than hospital i in region r in year t and the other variables are as above.

Similarly, estimates of monopsony power under the consistent conjectures hypothesis, were obtained by estimating

$$\Delta_d w_{rit} - \overline{\Delta_d w_{r..}} = \theta(\Delta_d n_{rit} - \overline{\Delta_d n_{r..}}) + \gamma(\Delta_d (oc)_{rit} - \overline{\Delta_d (oc)_{r..}}) + \Delta_d \varepsilon_{rit} - \overline{\Delta_d \varepsilon_{r..}} \tag{14}$$

again using $(\Delta_d c_{rit} - \overline{\Delta_d c_{r..}})$ and $(\Delta_d (oc)_{rit} - \overline{\Delta_d (oc)_{r..}})$ as instrumental variables.

Finally, note that, in general, two stage least squares estimates of structural equations such as (12), (13) and (14) depend on the normalization adopted (that is, on whether they are solved for the change in employment or the change in wages). However, when caseload, c, is a scalar, all of the above are just-identified and thus elasticity estimates do not depend on the normalization. In the empirical work presented below, estimates are given for the case where c is a scalar and also for a case where it has two components. Even in the case where c is a vector, equation (14) is just-identified and thus insensitive to the normalization. Moreover, it turns out that empirically the second component of c does not explain a great deal of the variation in the change in the wage and thus even the elasticity estimates based on (12) and (13) are basically insensitive to whether wage changes or employment changes are used as the right hand side variable. The normalization adopted above, that with the change in the wage on the left hand side, is the most convenient, since it makes the summary measure of monopsony power a parameter which is directly estimated.

III. Data

The econometric plan outlined above requires data on the wages, employment levels, and caseloads of hospitals. In the present study, all of these variables are derived from the American Hospital Association's (AHA) Annual Surveys of Hospitals (1979-1985). The Annual Survey is sent in October of each year to virtually all U.S. hospitals. The data elicited includes information on the number of full and part time workers in a number of job classifications including registered nurses (RNs) and licensed practical nurses (LPNs), data on payroll expenses by category of workers, and data on the size and breakdown of the hospital's caseload. For such an extensive survey, it has a relatively high response rate (50% or greater depending on the question). The AHA also estimates the values of a number of variables when a hospital fails to respond.

Unfortunately, however, the Annual Survey Data are not without problems. First, hospitals are only asked to report their total payroll expenses for full time RNs and LPNs combined. Thus the wage measure that can be constructed is actually for the combined RN and LPN category. Secondly, the hospitals report the cumulative total of their caseload and payroll expenses over the previous year, while the employment figures are for the date of the survey. In order to deal with the first problem, the variable, "full time nurses", was calculated as the number of full time RN's plus 0.765 times the number of full time LPN's.[19] In order to deal with with the second problem, the final employment level variable was taken to be the time average of the number "full time nurses" over the previous year under the assumption of exponential growth between the two survey dates.[20] The wage variable used below was then calculated as total payroll expenses for full time RN's and LPN's, plus a proportionate share of the hospital's expenses for benefits, all divided by the employment variable. The wage variable was then converted to constant 1985 dollars using the National Consumer Price Index.

Two caseload variables are employed in the analysis below: Total inpatient days (the total number of days spent in the hospital by inpatients during the previous year) and length of stay (total inpatient days divided by total admissions). In this data and with the number of inpatient days held constant, the latter is best thought of as a proxy variable for the ease of treating the hospital's particular mix of patients. That is, hospitals with longer average length of stay generally treat a less acute mix of patients.

Table 1 displays the variation in the aggregate levels of the four variables over the time period of the data used in this study. The top panel is for all hospitals in the 50 states and the District of Columbia. The middle panel is limited to general hospitals, which for the purposes of this study are defined to be those hospitals which responded that the majority of their admissions were for general medical and surgical services (either for patients of all ages or for children) and which for every year of available data had an average length of stay of less than 14 days. The bottom panel is for the collection of hospitals which are used in the estimation of the inverse elasticities described below. For a given year, these are the general hospitals for which all the relevant data was supplied by the hospital (rather than estimated by the AHA or imputed as described below). Also eliminated were a small number of hospitals which had very unlikely values for the wage measure or for the ratio of nurses to inpatient days.[21] The AHA estimates the values of each of the four variables whenever a hospital does not supply them itself. These estimated values are included in the totals shown in the top two panels of Table 1. Also included are some values which were imputed for the purposes of this study. The imputations are described in the appendix.

Table 1 shows that over the initial years of the period under study, nursing employment at hospitals was growing fairly rapidly. but began to decline in 1984 and 1985. Nursing wages, however, exhibited substantial real growth over the whole period, with especially impressive gains in 1982. Total inpatient days at hospitals were, on the other hand, falling over the whole period with especially sharp drops after the prospective payment system went into effect for Medicare patients in 1983. A little less than half of the drop in inpatient days is attributable to the drop in length of stay which was also continuous over the period. The difference between the employment and total inpatient days measures in the last two panels of Table 1 reflects the drop in response rate to the AHA survey which occurred in the second half of the time period under study. The average wage earnings and average length of stay variables for the estimation sample continued to closely track the levels for all general hospitals, however.

Table 2 displays some univariate statistics on the estimation sample for 1983. The distributions for number of nurses and total inpatient days are skewed heavily to the right.

(This motivates using the logs of the variables since the distributions of these variables are relatively symmetric.) Note that somewhat over 80% of the total "full time nurses" figure is actually accounted for by full time RN's. Thus the problem due to mixing of RN's and LPN's may not be overly severe. Table 2 also shows univariate statistics on the changes in the four variables for hospitals which were in both the 1980 and 1985 estimation samples. As was the case for the aggregate figures, inpatient days and length of stay tended to decline substantially while nursing employment tended to rise a moderate amount and real nursing wages tended to rise substantially. However, the distributions of the changes exhibit a considerable amount of variablility, with many hospitals moving in directions opposite from the general trends.

Table 3 displays some additional univariate statistics on the hospitals which were in the 1983 estimation sample and which also responded to the AHA's 1983 Hospital Nursing Personnel Survey. The latter was sent in April of 1983 to a random sample of roughly 20% of U.S. Hospitals.[22] The data on employment levels match reasonably closely those from the AHA Annual Survey. The Nursing Personnel Survey also contains data on starting salaries and average expense per man-hour exclusively for RN's. Adjusting for inflation, and making standard assumptions about the number of hours worked per year and the ratio of benefits to wages, the expense per man-hour figures from the nursing personnel survey are perhaps 5% too low relative to those from the Annual Survey. It is interesting to note the very small premiums paid for degrees requiring more years of schooling.[23] The table also shows that per RN recruitment and orientation costs are substantial.

Though 1983 was not considered a year in which the nursing shortage was particularly severe, more than 28% of the hospitals responding reported that they were experiencing a shortage of RN's.[24] 21% of the hospitals indicated that they were making use of RN's from temporary agencies. Unionization, a factor which is not considered in this study, amounts to just under 15% of hospitals responding to the question. A negligible fraction of hospitals reported some form of organized job action. Table 3 also shows the breakdown of RN educational training. Diploma nurses remain the largest category, followed by associate nurses. Baccalaureate nurses still make up only a fifth of hospital nurses. Substantial numbers of nurses have only a few years of experience on their current job with only 40% having greater than five years of tenure. Even in a year in which the nursing shortage was not considered severe, the table indicates that over 9% of budgeted positions for RN's were unfilled. The table also shows that over the previous quarter, 5.5% of nurses were newly hired and 4.3% were separated from the average hospital. Finally, those hospitals which used nurses from temporary agencies, used substantial numbers of them, with the mean ratio of temporaries to full time nurses being slightly over 0.25.

Before proceeding to examine the actual estimates of monopsony power, it is worth noting a few things about the direction of certain possible biases. First, as in the estimation of any inverse supply elasticity, the presence of a demand relation (in this case a first order condition for the firm, rather, than a standard demand function) gives rise to a negative bias in least squares estimates: When ε_{rit}, the error term on the inverse supply function is higher than average, hospitals will tend to substitute away from the use of nurses and hence there will be a negative correlation of ε_{rit} with n_{rit}. To the extent that the caseload variables may not be completely exogenous, this bias may also persist in the instrumental variables estimates given below.

Since the wage variable is calculated by dividing total wage payments by the measure of the employment level used on the right hand side of the inverse supply equations, any measurement error in the employment level will induce another negative bias to the estimates of the inverse elasticity, θ. The instrumental variables procedure should remove this bias if the measurement error in $\Delta_d n_{rit}$ (and $\Delta_d w_{rit}$) is uncorrelated with changes in the caseload.

Finally, there is a potentially important bias introduced by the use of average wage levels. That is, when a hospital gets a shock to its caseload that forces it to hire more nurses, the new workers will probably have less experience than the average member of the nursing staff. Thus as employment levels rise in response to increased caseload, the average level of experience will tend to go down. Thus when an upward sloping supply function forces the hospital to raise the scale of wages for every level of experience, the average wage may not rise by as much as the increase in the scale of wages.

The data from the Nursing Personnel Survey allow some of these possible biases to be investigated. In particular Table 4 indicates that issues of measurement error may be of substantial importance. The table displays the correlation matrix for the employment and wage measures used in the study (which as previously noted were derived from the Annual Survey data) and the employment level and starting baccalaureate salary measures from the special Nursing Personnel Survey.[25] For the two measures of the employment level, the correlation, 0.983, is quite high. However, the correlation between the two measures of wages is only 0.288, which indicates substantial measurement error.[26] Also of note in Table 4 is the fact that while the wage and employment levels from the nursing survey are quite highly positively correlated (the correlation coefficient is 0.416), the correlation between the wage and employment measures from the Annual Survey data is very weak and not statistically significant. The lower correlation in the Annual Survey data is apparentlt due to a combination of a higher noise levelin the wage measure and the "division bias" which, as was noted above, is a consequence of having a wage measure which is calculated by dividing wage payments by the employment measure.

Table 5 examines the correlation of the discrepancy between the two employment measures and changes in the two caseload variables.[27] The dependent variable in the regression models is the log of the Annual Survey employment level minus the log of the Nursing Personnel Survey employment level. The results indicate that when total inpatient days increases, the Annual Survey employment level tends to rise a small amount relative to the Nursing Personnel Survey figure. None of the estimated coefficients shown in the table are, however, statistically different than zero. Moreover, since the Nursing Personnel Survey was administered in the middle of the period covered by the 1983 Annual Survey data used to calculate the changes in caseload and the employment level, a small positive effect is probably to be expected even if measurement error in the employment level is completely unrelated to caseload.

Table 6 displays the equivalent statistics for the correlation of the discrepancy in the wage figures and changes in caseload. The results are more disturbing than those for employment levels. The point estimates of the regression coefficients are negative and relatively large in absolute value. Though the standard errors are also large enough that the estimates are not for the most part statistically significant, the results in Table 6 are certainly suggestive of the importance of a negative bias imparted to the monopsony power estimates by the use of average wages.

Table 7 looks directly at how a number of characteristics of the work force of nurses, including tenure on the job and the distribution of type of degree, change as the level of caseload changes. Specifically, the table shows the coefficients of the change in caseload from 1983 to 1985 in a number of regression models in which the dependent variable is the corresponding change in some measure of a characteristic of the work force of nurses taken from the Nursing Personnel Surveys. The percentage of nurses in the two lowest tenure categories evidently increases and the percentage of nurses in the two highest tenure categories decreases when total inpatient days increases. The coefficient on the change in log inpatient days in the model for the overall tenure index is roughly equal to the standard deviation of the tenure index, so a rough tripling in the caseload would lead to a one standard deviation drop in the tenure index. The average years of education also drop as the number of inpatient days increases. A rough tripling of the caseload would decrease the average years of education by roughly two thirds of a standard deviation. The effects of changes in caseload on both tenure[28] and education work in the direction which suggests that using average wages instead of a measure of the scale of wages imparts a negative bias in the inverse supply elasticity estimates. Finally, the table shows that the vacancy ratio tends to increase as the caseload increases while there are only small effects on the part time ratio and the ratios of new hires and separations to full time RN's.

IV. Results

Before considering the estimates of the structural hospital level inverse supply functions (12), (13) and (14), it is illuminating to first examine the reduced form relationship between nursing employment and wages and the caseload of hospitals. Table 8 shows the nature of this relationship for the levels of the these variables in the 1983 cross-section. As can be seen, when the only caseload variable used in the regression is the total number of inpatient days, a basically constant returns to scale relationship is found, with the coefficient on log caseload in the model for log employment having a coefficient just slightly larger than one. On the other hand, in the cross-section, wages are only very weakly related to hospital size, as the coefficient of the log of inpatient days in the model for the log wage is just slightly greater than zero. When the log of length of stay is added to the regression model for log employment, its coefficient is -0.62 (with a standard error of 0.03) which supports the interpretation of length of stay as an inverse proxy for the relative severity of the hospital's caseload. Including this variable also causes the coefficient on total inpatient days to rise to 1.12, so that with this specification there is a "long-run decreasing returns to scale" relationship between output and nursing inputs. Adding the log of the length of stay to the wage equation has, on the other hand, no effect.

Table 9 shows the reduced form estimates for the change in the log of employment using one, two, and three year differences. Estimates are given for the full estimation sample,[29] and also for subsamples consisting of those hospitals which are and are not located in metropolitan areas with a half million or more population. The independent variables are the change in the logs of the hospital's inpatient days and average length of stay and the change in the logs of the those variables for other hospitals in the same Hill Burton Service Area (HSA).[30] The estimates of the standard errors are consistent for the case of arbitrary forms of heteroscedasticity and/or serial correlation.[31]

The results show the same "short-run increasing returns to scale" phenomenon that Hall (1988) has interpreted as evidence of a departure of price from marginal cost in U.S. Industry.

The coefficient on the change in the log of inpatient days, increases from 0.236 (standard error 0.015) in the equation estimated using one year differences and all the hospitals as longer time periods are used to difference the data, but even for three year differences, the coefficient is still only 0.422 (with a standard error of (0.023). The coefficient on the change in the log of other hospitals' patient days, which theory would predict should be zero or negative is actually positive for one year differences. It is essentially zero, however, in the equations estimated using two and three year differences.

The change in the log of length of stay is estimated to have a negative coefficient in all specifications. Including this variable also raises somewhat the coefficient on the log of inpatient days. The major difference between the estimates obtained from the major metropolitan areas and the rest of the country is that the coefficient on the change in the log of inpatient days is somewhat larger for the former. That is, the increasing returns phenomenon is not as strong in major metropolitan areas.

Table 10 shows the reduced form equations for the change in the log of the hospital's wage. The most important result is that, even controlling for movements in the caseloads of surrounding hospitals, an increase in the caseload of a hospital causes it to raise its wage. For one year differences, only inpatient days included and all hospitals, the elasticity is 0.187 (with a standard error of (0.024). This declines to 0.124 (with a standard error of 0.025) for three year differences. Including the length of stay variables, causes only minor changes. Perhaps somewhat surprising is that the elasticity of the wage with respect to a hospital's own caseload is higher in major metropolitan areas than outside those areas. However, Table 9 showed that these hospitals increased their nursing staffs more rapidly in response to changes in caseload and thus may have to raise the wage more even if they face a lower firm level inverse elasticity of supply.

Tables 11, 12, and 13, display the estimates of the hospital level inverse supply functions for, respectively, the employment level setting equilibrium, the wage setting equilibrium and the consistent conjectural variations equilibrium. Columns one, three and five of the tables give the estimates using only the change in the log of inpatient days and the change in the log of other hospitals' inpatient days as instruments. Columns two, four and six add the change in the log of length of stay and the change in the log of other hospitals' length of stay to the list of instruments.[32]

The estimates of the hospital level inverse elasticity are approximately the same for all three oligopsony equilibrium hypotheses. That is, for one year differences, only inpatient days variables in the instrument list and all hospitals included, the inverse elasticity is estimated to be 0.79 (with standard errors ranging from 0.13 to 0.14). Thus in the short run, the estimates suggest that hospitals have a great deal of monopsony power. The estimates of monopsony power decline as the period of time over which the changes take place increases. For three year changes, only inpatient days variables in the instrument list and all hospitals included, the inverse elasticity is estimated to be 0.26 to 0.27 (with standard errors of approximately 0.07). Thus even for three year changes, the level of monopsony power is estimated to be quite significant.

It is also interesting to note that in the shortest run, the hypothesis that the variables summarizing the behavior of other hospitals have coefficients of zero in the hospital level inverse supply function cannot be rejected at conventional significance levels. However, as the length of the time period over which the changes occur increases, these variables make their effects felt. For instance, in the wage level setting estimates, using only inpatient days variables and all hospitals, the coefficient on the average of other hospitals' wages goes from 0.11 (with a standard error of 0.24) for one year differences, to 0.77 (with a standard error of 0.16) for two year differences to 0.94 (with a standard error of 0.19) for three year differences.

Including the length of stay variables as instruments decreases the estimated inverse elasticities by a few percent, with the effect most noticeable in the wage setting estimates. The estimated monopsony power is lower by only a small amount in metropolitan areas with population over a half million when one and two year differences are considered. With three year differences, the two sets of hospitals are estimated to have about the same amount of monopsony power.

V. Conclusion

The estimates presented above of the inverse elasticity of supply to the individual hospital are strikingly high. This is obviously especially true of the estimate of 0.79 for one year changes, but even the estimate of 0.26 for changes taking place over three years, is quite substantial. Since, the dynamics of the response are evidently so important, it is not appropriate to interpret any of the estimated inverse elasticities as percentage markdowns as implied by the static theory in equations (3), (5) and (8). However, even if the inverse elasticity over longer periods of time was somewhat lower than that found above for three year changes, a reasonable conjecture would be that a cost minimizing hospital would find it in its interest to pay wages considerably below its nurses' marginal product.

An equally striking result is that the hospital level inverse elasticity is not much lower in major metropolitan areas. Indeed, given the way that judgements of relative market power are usually formed, this may be the least intuitively plausible result of the study. One possible explanation for this result is offered below, but it may simply be that the factors usually thought of as determining employer market power are not the relevant ones or even that monopsony power is pervasive in this kind of labor market.

As noted in section III, there are a number of biases which can be expected to cause the monopsony power estimates to be too low. Thus it is somewhat remarkable that they come out so high. On the other hand, it is not hard to point to a potential source of upward bias in the estimates. That is, though a considerable amount of effort went into making them at least reasonable proxies, the variables used to control for the behavior of other hospitals would have to be characterized as relatively crude. The inverse relationship between the significance of these variables and the size of the inverse elasticity, suggests that improvements in controlling for the behavior of other hospitals may reduce the estimates of monopsony power.

The relation of the current results to the "short-run increasing returns" phenomenon is also worth noting. If a constant returns relationship had been estimated and the findings for the reduced form for the wage equation been unchanged, the monopsony power estimates for one year differences would have been about one fourth as large and for three year differences about one half as large. One explanation for the low coefficients seen in Table 9 is error in the measures of caseload. The measurement error could come from actual recording errors, or, as Zvi Grilliches and Jerry Hausman (1986) note, could come from using the actual change in output when, in fact, the correct variable would be the change in output expected at some earlier time when decisions on employment levels were actually made. Measurement error may, indeed, explain a substantial portion of the increasing returns puzzle, but it would not necessarily effect the conclusions about the extent of monopsony power since, presumably, the estimate of the coefficient of caseload in the reduced form equation for the change in the wage would be effected by the measurement error in the same way the as in the equation for the change in employment.

It should also be noted that the theoretical framework of this study ignores a number of possibly important real world phenomena. Perhaps the most important omission is that of the labor union. Though the results of the Survey of Nursing Personnel indicate that unionization is still fairly uncommon, its extent is by no means trivial. Exactly what value of the estimated inverse supply should be expected when hospitals are unionized is not entirely clear since, under the usual assumptions, a well defined supply curve does not exist for effectively unionized workers.[33] However, if a monopoly union considers the wage rate to be a normal good, then an increase in caseload is likely to translate into an increase in the wage even if the hospital treats the wage as exogenous. Thus the market power estimates given above may be exaggerated because of the presence of unions. Unfortunately, except for those responding to the personnel survey, it is not known exactly which hospitals are unionized. However, since it is known that unionization is concentrated in the major metropolitan areas, this may at least partially explain why the differences between these areas and the rest of the country appear to be so hard to detect.

Another real world complication that is ignored in this paper is the fact that many hospitals are parts of multi-hospital systems which presumably set wages in consultation with each other. The cooperative behavior of some hospitals may invalidate the assumption of statistical independence, but should not have a first order effect on the estimates of the hospital level elasticity of supply which depends on the behavior of nurses rather than hospitals (except to the extent that hospitals may be choosing a point on a supply function with non-constant elasticity). However, none of the three oligopsony equilibria described in section II of this paper will be strictly correct. Thus it would be innapropriate to interpret any of the firm level elasticities as a markdown of the wage under the marginal product for the hospitals which cooperate.

A final complication is that, as was seen above, many hospitals make substantial use of nurses from temporary agencies. The existence of temporary agencies may explain part of the "increasing returns to scale" phenomenon captured in Table 9. Specifically, hospitals can partially respond to increased caseload by hiring temporary rather than permanent nurses. Such a strategy will be particularly advantageous when, as seems to be the case, the short run supply curve of permanent nurses rises substantially more quickly in the short run than in the long run. However, as long as the elasticity estimates presented above are interpreted as estimates of the elasticity of regular permanent-employee nurses, the existence of temporary nurses causes no problem with the estimates. The temporary nurses are simply another input used by hospitals.

If the estimates presented above are reliable, then hospitals have, at least in the short run, a substantial degree of monopsony power. Since the extent of this power is not much less in major metropolitan areas. one policy implication of this study would be that the antitrust enforcement authorities might want to reconsider their rather tolerant attitude towards attempted collusion by hospital administrators. With regard to the "comparable worth" controversy, the estimates do suggest that wages of nurses may be depressed because of monopsony power, but given that the estimates do not differ in the expected way between metropolitan and non-metropolitan areas and that no comparable estimates of the monopsony power possessed by other classes of employers are available, it would be premature to claim that monopsony explains any of the results obtained by "pay equity" researchers.

Finally, there are also some implications for the methodology of evaluating market power. First, at least in this example, the type of equilibrium assumed to characterize the interactions of the firms makes very little difference to the estimated levels of market power. On the other hand, this study should also make it clear that alternative forms of the Baker and Bresnahan (1985, 1988) methodology can be easily implemented. Secondly, this study has shown that the dynamics of market power may be very important and specifically that short run and long run market power may differ substantially. Thus a natural topic for future research would be the development of truly dynamic specifications of firm level inverse supply and demand.[34]

Appendix. Imputation.

Each year a small number (approximately 20) hospitals are added to the AHA data set with a designation indicating that they are not actually new or newly merged hospitals or are dropped from the data set with a designation indicating that they have not actually closed or merged with another hospital. In the former cases, it has been assumed that the hospital actually existed in every year prior to its showing up on the data set and in the latter cases it has been assumed that the hospital actually existed in every year after it was removed from the data set. No data (estimated or not) is available from the AHA on such hospitals for years in which they presumably existed but were not part of the data set. Similarly when a hospital appears on the data set for the first time (whether or not it was actually a new hospital) the wage and employment measures used in this study cannot be computed until the next year since a time average is used to compute the employment figure. (For the same reason no 1979 data is used in this study for any hospital (except to calculate the 1980 employment figure)). Finally, wild values for the wage and the ratio of nurses to inpatient days have caused some values to be set to missing.

In order to impute a value when none is otherwise available, hospital specific means of the logs of each of the four variables were computed. The deviation of all the hospital's values from their means was then computed and, for each year and region, a mean of these deviations was computed. For hospitals with missing data, values were imputed by adding the mean deviation for the year and region in question to the hospital's own mean computed using all the data available on it. For a few hospitals, there was no data available for any year on the wage or the level of employment. In the former case, the mean level of the log of the wage in that region and year was the value imputed. In the latter case a mean for the hospital's log employment was imputed by adding a constant to the mean of the log of its number of inpatient days. (The constant was the mean of the log of the ratio of nurses to inpatient days for all hospitals and years.) The imputed mean log employment level was then used to impute the employment levels for each year as described above.

The total value of all imputations was a small fraction of the values in Table 1. In fact, no value in Table 1 would change in the first two digits if no imputations were made. In a number of cases, however, the mean or total value for a particular region was significantly effected. Some sensitivity analysis indicates that the imputation process described above probably reduced the estimates of the hospital level inverse elasticity of supply by roughly 5%.

Notes.

1 See e.g. John Addison and William Siebert (1979) pp. 167-169 or Ronald Ehrenberg and Robert Smith (1982) pp. 65-66. The only other example cited with any regularity in intermediate microeconomics or labor economics textbooks is the market for professional athletes.

2 Donald Yett (1975) notes that from the late 1930's to the time of his study reports of a widespread shortage of registered nurses were almost continuous. Little has changed has changed in this regard in the years since his study.

3 The American Hospital Association puts the argument from the point of view of the hospital administrator: In its handbook, Surviving the Nursing Shortage: Strategies for Recruitment and Retention of Hospital Nurses (1986), the association cautions, "[t]he third source of nurse employees -- other hospitals and health care settings -- is tempting but may be fraught with problems. Trying to lure nurses away from their current employers with tempting salaries, bonuses, desirable hours, and so forth, often sets up a climate for 'nurse wars' in which the stakes just keep getting higher and the competition more cutthroat. Apart from creating ill will within the health care community, such competition can put the control of the situation almost entirely in the hands of the employees and destroy the conditions that contribute to a mutually satisfying marketing exchange."

4 Under the urging of the hospital industry, the federal government has responded to the nursing shortage by instituting a number of programs which have heavily subsidized the cost of nursing education. Stephen Mennenmeyer and Gary Gaumer noted in 1983 that $1.2 billion had been spent in the previous 17 years on subsidizing the education of registered nurses. See Donald Yett (1975) and Richard McKibbin (1982) for description and analysis of some of these programs. On the other hand, James Robinson (1988) notes that the reduction in these subsidies which occurred in 1978 was largely due to the acceptance by policy makers of the monopsony hypothesis. The perceived shortage of nurses has also led to a very liberal policy with respect to the immigration of nurses from around the world. See, for example, Washington Times (July 11, 1988).

5 Of course, a finding of no monopsony power would not constitute proof that the low earnings of nurses (relative to occupations judged comparable by researchers) *is* attributable to a taste for discrimination. See Mark Killingsworth (1985) for a discussion of the relevance of monopsony power to the comparable worth controversy.

6 Fourteen of the fifteen associations which responded to Yett's survey indicated that they had such a program. The fifteenth requested information on how they might start one. Eugene Devine (1969) offers some evidence for hospital collusion in the setting of wages. See also Committee on Post Office and Civil Service (1983) for allegations of area wide wage fixing arising out of Lemons vs. City and County of Denver, the well known comparable worth case involving nurses.

7 Throughout this paper, the phrase monopsony power will be used in this sense rather than as a description of a market in which there is literally one employer or one perfectly collusive cartel of employers.

8 Adamanche and Sloan note that population density per square mile, a variable included in their wage equation, but not in those of other studies, is highly negatively correlated with hospital concentration. While the argument for the inclusion of this variable in a model which already controls for measures of the cost of living and alternative wage rates is not particularly obvious, it points up a problem with all cross-section studies of wages and concentration. That is, concentration is closely associated with the size of a city and thus with many other variables which may be related to wages. Other related studies include those of Frank Sloan and Richard Elnicki (1979) who find that starting salaries for nurses and other workers are only weakly related to hospital market share in a 1973 cross-section of hospitals, Myron Fottler (1977) who finds that higher concentration is associated with lower wages for non-professional hospital employees in a cross-section of SMSA's in the 1960s and early 1970's, Brian Becker (1979) who finds that hospital market share is not related to wages for non-professional hospital workers in a sample of Illinois, Minnesota and Wisconsin hospitals in 1975 and Karen Davis (1973) who finds, at the state level, a positive association of hospitals per square mile with average wages for all hospital workers only when variables measuring the presence of specialized facilities are excluded from the model.

9 The current approach is also closely related to that of David Scheffman and Pablo Spiller (1987) who operationalize the geographic market definition exercise proposed in the Justice Department's Merger Guidelines (1982) by estimating the demand elasticity facing the collection of firms in progressively larger geographic areas.

10 The assumption of cost minimization is not essential to any of the following analysis. As long as the hospital solves some kind of optimization problem subject to an upward sloping supply function, there will be a gap between the wage and some notion of a marginal product. For instance suppose that the hospital acts so as to maximize some function,

$U(N, B, z)$ where N is again the level of employment, B is the wage bill, $NW(N)$, and z is some vector of exogenous variables. The first order condition for the firm's maximization problem is, in this case,

$$\frac{(U_N / - U_B) - W}{W} = W_N \, N / W = \theta .$$

Here $(U_N / - U_B)$ takes the place of a marginal product, but the form of the relationship is the same and ø is still the parameter which describes market power.

11 All three notions of equilibrium considered are completely static and assume perfect certainty. Incorporating dynamics and uncertainty intc the theoretical framework would be a valuable extension.

12 See Jonathon Baker and Timothy Bresnahan (1988) for a more detailed discussion of the consistent conjectures assumption.

13 The assumption that caseload is exogenous is standard in the large literature on the estimation of hospital cost functions. See, for example, Thomas Grannemann, Randall Brown and Mark Pauly (1986) or Daniel Sherman (1988). Robert Conrad and Robert Strauss (1983) are the most explicit in giving the argument that the demand for hospital services is "exogenous to the principal decisions of the hospital administrator." Physicians, in their view, "operate as independent, demand creating entities."

14 The data is discussed more fully below.

15 In the empirical work reported below, separate estimates are given for hospitals in major metropolitan areas and those outside of such areas. In preliminary work, no detectable dependence of the inverse elasticity on the census region or per-capita income was found.

16 Thus to estimate model (11) it is necessary to have d + 2 years of data.

17 It is also worth noting that if $(on)_{rit}$ was replaced with a set of region specific year effects when, in fact, model (11) was correct, the resulting estimates of the inverse elasticity would be inconsistent since (11) can be rewritten as

$$\Delta_d w_{rit} = \delta_r + (\theta - \gamma) \Delta_d n_{rit} + \gamma \, \Delta_d (sn)_{rt} + \Delta_d \, \varepsilon_{rit}$$

where $(sn)_{rt} = \Sigma_j n_{rjt}$. Thus the region specific year effects effects would tend to $\gamma \, \Delta_d (sn)_{rt}$ and the coefficient on $\Delta_d \, n_{rit}$ would tend to $\theta - \gamma$.

18 In the actual estimation to be described below, it was found that $(on')_{rit} = \log \Sigma_{j \neq i} n_{rjt}$ replaced $(on)_{rit}$ in (12). The advantage of the log of the sum over the sum of the logs is that the former deals straightforwardly with changes in the number of hospitals in the region due to openings, closings, mergers and demergers. The variable $(on)_{rit}$ may also give too much weight to smaller hospitals which frequently experience large percentage changes in employment and caseload. Similar substitutions were made for variables summarizing other hospitals' wages and caseloads.

19 The figure 0.765 is the ratio of average LPN wages to average RN wages in the state of Maryland in 1984. See Daniel Sullivan (1987).

20 That is, if the number of RN equivalents was en_t at the date of the survey in year t and en_{t-1} at the date of the survey the previous year, then the employment measure used in the subsequent analysis was

$$n_t = (en_t - en_{t-1}) / (\log en_t - \log en_{t-1}) \quad (\text{or } n_t = en_t \text{ if } en_t = en_{t-1}.)$$

21 Specifically any hospital which, for a given year, had values more than two times the inter-quartile range from the median of the log of the wage measure or the log of the ratio of nurses to inpatient days was eliminated from the sample for that year. Its value for the wild variable was also set to missing and then a value for it imputed as described below. Note that this was done for all hospitals -- not just those which would otherwise have been included in the estimation sample.

22 The Nursing Personnel Survey for 1983 was thus administered midway between the times of the 1982 and 1983 Annual Surveys. Given the manner in which the employment and wage variables of this study are calculated from the Annual Survey, we should expect a reasonable match between the data of the two surveys. Two more Nursing Personnel Surveys were administered to the same sample of hospitals in July of 1984 and October of 1985.

23 Associate, Diploma and Baccalaureate programs generally require two, three and four years of training respectively. Stephen Mennenmeyer and Gary Gaumer (1983) using micro data on nursing wages similarly find very small premia for baccalaureate degrees after controlling for a number of human capital variables and for some characteristics of the employer and the job. Lavonne Booton and Julia Lane (1985) argue that the lack of a wage premium for holders of a baccalaureate degree is explained by what they argue is the

oligopsonistic nature of the nursing market.

24 In a similar survey conducted in 1987, 76.2% of hospitals reported experiencing a shortage. See U.S. Department of Health and Human Services (1988).

25 As was done with the annual survey data, hospitals for which the log wage or the log ratio of nurses to inpatient days as reported on the nursing survey were more than two times the inter-quartile rage from the median were eliminated from the sample used to compute the correlations.

26 Detailed examination of some of the larger discrepancies between the two wage measures revealed that one likely source of measurement error in the Annual Survey data was misunderstanding on the part of hospitals about whose wages were to be included in the category for RN's and LPN's. The instructions on the facing page of the survey state that only full time employees' wages should be included. However, this is not printed next to the blank on the survey. A number of the larger discrepancies between the two measures seem likely to be due to the hospital also including part time employees wages in the figure reported to the AHA. Indeed, the author initially made the same mistake in calculating the wage measures used to produce the estimates in the first draft of this paper. On the other hand, many other discrepancies could not so easily be explained.

27 Regressions of employment level and wage level discrepancies between the two surveys o the levels of the caseload variables revealed no significant relationship.

28 It would have been interesting to see how average levels of total experience in nursing (as opposed to tenure on the current job) change with changes in caseload, but the Nursing Personnel Survey did not ask that question.

29 In order to be used in the estimation, the hospital has to be in the estimation sample for both years.

30 For the length of stay variable, the average over all other hospitals was computed as total inpatient days at all other hospitals divided by admissions at all other hospitals). Some of the smaller HSA's were combined into larger regional groupings. Specifically the following were combined: 14020 and 14030; 16010 and 16020; 16040 and 16050; 21020 and 21040; 22020 and 22030; 31010 and 32050; 32020 and 32030; 41030 and 41040; 41080 and 41090; 41070 and 41100; 43010 and 62030; 43040 and 43090; 44050 and 44060; 45040 and 45060; 53020 and 53020; 86030 and 86050; 86030 and 86040; 88010 and 88020; 93040 and 93070; 94010, 94020 and 94030. With these modifications, hospitals in the 50 states and the District of Columbia are

divided under this classification scheme into 186 mutually exclusive and exhaustive groups.

31 Specifically, denote the column vector of dependent variables (for the different years) for the i^{th} hospital as y_i, the matrix of explanatory variables for the various years as X_i, and the vector of residuals as e_i. (Different hospitals will supply different numbers of observations because they will have different patterns of missing data. Thus the matrices above will not have the same number of rows.) The standard errors are the analogues for longitudinal data of those proposed by White (1980), namely the square roots of the diagonal elements of the matrix $[\Sigma_i X_i' X_i][\Sigma_i X_i' e_i' e_i X_i]^{-1} [\Sigma_i X_i' X_i]$. See, for example, Gary Chamberlain (1984).

32 The standard errors for the instrumental variables estimation are also heteroscedasticity and autocorrelation consistent. The expression for the standard errors is the same as in note [31] except that the matrix X_i now contains the fitted values from the first stage of two stage least squares.

33 Janet Currie (1989) has recently presented estimates of equations similar to those of this paper for a sample of entirely unionized school districts. She finds that the estimated inverse elasticity is positive and statistically significant.

34 David Scheffman and Pablo Spiller (1987) actually estimate a dynamic model for the demand function facing a group of firms in a given area, although they do not emphasize the short run results. Their estimates imply somewhat surprisingly that market power is greater in the long run.

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Table 1
Aggregate Nursing Employment, Average Annual Earnings, Hospital Inpatient Days and Average Length of Stay: AHA Hospitals, General Hospitals, Estimation Sample

Year	Total Employment[1]	L%Δ[2]	Average Earnings[3]	L%Δ	Inpatient Days[4]	L%Δ	Length of Stay[5]	L%Δ
ALL AHA HOSPITALS								
1980	812.8		29.99		394.0		10.041	
1981	840.8	3.39	31.30	4.28	395.0	0.25	9.993	-0.48
1982	857.9	2.01	33.42	6.55	393.0	-0.50	9.944	-0.49
1983	883.9	2.99	35.30	5.47	384.1	-2.29	9.802	-1.44
1984	883.0	-0.10	36.26	2.68	364.6	-5.21	9.546	-2.65
1985	868.7	-1.63	37.48	3.31	340.5	-6.84	9.319	-2.41
GENERAL HOSPITALS								
1980	633.9		29.41		267.3		7.353	
1981	659.0	3.88	30.60	3.97	269.3	0.75	7.352	-0.01
1982	673.8	2.22	32.91	7.28	267.7	-0.60	7.325	-0.37
1983	696.2	3.27	34.60	5.01	262.5	-1.96	7.237	-1.21
1984	695.2	-0.14	35.38	2.23	245.9	-6.53	6.961	-3.89
1985	681.4	-2.01	36.48	3.06	226.3	-8.31	6.715	-3.60
ESTIMATION SAMPLE								
1980	383.2		29.58		163.5		7.501	
1981	411.1	7.03	30.99	4.66	168.9	3.25	7.529	0.37
1982	417.3	1.50	33.48	7.73	167.9	-0.59	7.463	-0.88
1983	396.6	-5.09	35.34	5.41	151.2	-10.47	7.409	-0.73
1984	341.9	-14.84	36.06	2.02	121.9	-21.54	7.063	-0.48
1985	339.4	-0.73	37.25	3.25	113.4	-7.23	6.809	-3.66

Notes:

[1] In 1000's. Sum over all AHA hospitals of full time RN's + 0.765 times full time LPN's. Includes AHA estimates and imputations as described in the text.

[2] 100 times change in natural logarithms.

[3] In 1000's of 1985 dollars. Total payroll expense for full time RN's and LPN's plus proportionate share of hospital benefits payments all divided by total employment.

[4] In 1,000,000's. Includes A.H.A estimates and imputations as described in the text.

[5] Total inpatient days divided by total admissions. Includes imputations as described in the text.

Table 2
Descriptive Statistics:
A.H.A. Annual Survey[1]

Variable	Mean	Standard Deviation	Median	Interquartile Range	Sample Size
1983 Level of:					
Inpatient Days[2]	52.37	55.68	33.77	64.18	2834
Length of Stay[3]	6.85	1.81	6.56	2.30	2834
Full Time Nurses[4]	149.84	179.26	91.18	156.45	2834
Full Time RN's	121.14	155.12	68.00	128.00	2834
Full Time LPN's	37.51	43.14	24.00	39.00	2834
Part Time RN's	51.30	68.38	24.00	63.00	2834
Part Time LPN's	14.59	20.63	7.00	17.00	2834
Average Annual RN Earnings[5]	36.13	11.82	34.37	14.65	2834
L%Δ[6](1980-1985) in:					
Inpatient Days	-24.92	26.31	-22.63	30.25	1647
Length of Stay	-11.15	14.37	-11.60	15.48	1647
Full Time Nurses	5.05	29.27	4.34	33.70	1647
Average Annual RN Earnings	21.74	32.85	21.49	38.29	1647

Notes:
1. See text for sample selection criteria.
2. In 1000's.
3. Inpatient days divided by admissions.
4. Full time RN's + 0.765 times full time LPN's.
5. In 1000's of 1985 dollars. Total payroll expense for full-time RN's and LPN's plus proportionate share of hospital benefits payments all divided by full time nurses.
6. 100 times change in natural logarithms.

Table 3
Descriptive Statistics:
Hospital Nursing Survey 1983[1]

Variable	Mean	Standard Deviation	Median	Interquartile Range	Sample Size
Full Time Nurses[2]	153.47	180.28	88.24	165.85	393
Full Time RN's	120.92	156.02	64.00	131.50	393
Full Time LPN's	42.55	47.52	27.00	46.50	393
Part Time RN's	41.23	56.66	20.00	50.00	393
Part Time LPN's	15.44	22.57	7.00	17.00	393
Starting Wage[3]:					
Associate Degree	8.33	0.99	8.30	1.24	407
Diploma Degree	8.35	0.99	8.30	1.26	404
Bachelors Degree	8.39	1.00	8.34	1.30	403
Expense per Manhour[4]	11.27	2.68	10.87	2.51	320
Recruitment Cost	666.06	1334.57	300.00	698.00	327
Orientation Cost	2004.52	1785.58	1500.00	1500.00	356
Shortage[5] (yes = 1)	0.286				409
Temp Agency[6] (yes = 1)	0.212				410
Union[7] (yes = 1)	0.147				409
Strike[8] (yes = 1)	0.025				405
Percentage[9] with					
Associate Degree	33.1	21.8	30.0	34.0	393
Diploma Degree	46.6	23.1	45.0	30.0	393
Bachelor Degree	19.0	15.4	16.0	18.0	393
Masters Degree	1.2	2.2	0	2.0	393
Average Years Educ[10]	14.90	0.32	14.94	0.41	393
Percentage[11] with					
0-1 Years Tenure	16.4	12.1	14.0	15.0	398
1-2 Years Tenure	16.0	11.0	15.0	10.0	398
2-5 Years Tenure	27.1	13.6	25.5	15.0	398
> 5 Years Tenure	40.5	19.1	40.0	23.0	398
Tenure Index[12]	2.73	0.77	2.71	0.97	398
Vacancy Ratio[13]	0.092	0.170	0.028	0.102	368
New Hire Ratio[14]	0.055	0.062	0.036	0.077	381
Separation Ratio[15]	0.043	0.056	0.027	0.056	374
Temporary Ratio[16]	0.255	0.552	0.067	0.211	78

Notes:

[1] See text for sample selection criteria. Figures are for the week of April 1, 1983 unless otherwise indicated.

[2] Full time RN's + 0.765 times full time LPN's.

[3] Hourly salary offered to newly licensed applicants with education shown. Not adjusted for inflation.

[4] Total payroll expense for registered nurses divided by manhours worked.

[5] Question is whether hospital is experiencing an overall shortage of registered nurses.

[6] Question is whether hospital uses registered nurses from temporary agencies.

[7] Question is whether nurses are organized for the purposes of collective bargaining.

[8] Question is whether there has been a work stoppage, slowdown, or other organized interuption of regular work by full time RN's between April 1, 1982 and March 31, 1983.

[9] Percentage of full time RN's with the educational preparation shown.

[10] Average calculated assuming Associate Degree = 14 years, Diploma Degree = 15 years, Bachelors Degree = 16 years, Masters Degree = 18 years, and Doctoral Degree = 20 years.

[11] Percentage of full time RN's with tenure on the current job as shown.

[12] Weighted average of scores form bracketed responses: 0 for less than one year, 1 for one to two years, 2 for two to five years and 5 for five or more years.

[13] Budgeted vacancies for full time RN's divided by full time RN's.

[14] Newly hired full time RN's in the quarter Jan 1, 1983 to March 31, 1983 divided by full time RN's.

[15] Full time RN's terminated and/or voluntarily separated in the quarter Jan 1, 1983 to March 31, 1983 divided by full time RN's.

[16] Number of shifts filled by RN's from temporary agencies divided by full time RN's. Sample limited to hospitals reporting that they use temporary agencies.

Table 4
Correlations of Employment and Wage Data From
1983 A.H.A. Annual Survey and Nursing Personnel Survey[1]

	log employment aha survey[2]	log wage aha survey[3]	log employment nursing survey[4]	log wage nursing survey[5]
log employment aha survey	1.000			
log wage aha survey	0.014 (0.797)	1.000		
log employment nursing survey	0.983 (0.0001)	0.060 (0.261)	1.000	
log wage nursing survey	0.397 (0.0001)	0.288 (0.0001)	0.416 (0.0001)	1.000

Notes:
[1] The sample size is 351. Numbers in parentheses are significance levels. See text for sample selection criteria.
[2] log full time nurses from 1983 A.H.A. Annual Survey of Hospitals.
[3] log average annual nurse earnings from 1983 A.H.A. Annual Survey of Hospitals.
[4] log full time nurses from 1983 Nursing Personnel Survey.
[5] log hourly starting salary for newly licensed Baccelaureate RN's from 1983 Nursing Personnel Survey.

Table 5
Regression Models for Reporting Differences Between 1983
A.H.A. Annual Survey and 1983 Nursing Personnel Survey:
Log Full Time Nurses[1]

Independent Variable						
Δlog ipd[2](83-82)	0.057 (0.110)	0.048 (0.129)				
Δlog los[3](83-82)		0.029 (0.218)				
Δlog ipd (83-81)			0.014 (0.091)	0.030 (0.132)		
Δlog los(83-81)				-0.056 (0.149)		
Δlog ipd (83-80)					-0.010 (0.078)	0.01 (0.08
Δlog los(83-80)						-0.09 (0.14
Δloc ipd (83-82)	0.232 (0.150)	0.019 (0.181)	0.206 (0.151)	0.001 (0.182)		
Δlog los (83-82)		0.521 (0.285)		0.550 (0.283)		
Δlog ipd (82-81)	0.048 (0.160)	0.011 (0.174)				
Δlog los (82-81)		0.085 (0.237)				
Δlog ipd (82-80)			-0.061 (0.119)	-0.049 (0.132)		
Δlog los (82-80)				-0.106 (0.215)		

Notes:

[1] Dependent variable is log full time nurses (from 1983 A.H.A. Annual Survey) minus log full time nurses (from 1983 Nursing Personnel Survey). Numbers in parentheses are standard errors. See text for sample selection criteria.

[2] Change in natural logarithms of inpatient days.

[3] Change in natural logarithms of average length of stay.

Table 6
Regression Models for Reporting Differences Between 1983
A.H.A. Annual Survey and 1983 Nursing Personnel Survey:
Log Average Annual Earnings and Log Starting Wage

Independent Variable						
Δlog ipd[2](83-82)	-0.265 (0.146)	-0.179 (0.171)				
Δlog los[3](83-82)		-0.274 (0.289)				
Δlog ipd (83-81)			-0.231 (0.120)	-0.141 (0.132)		
Δlog los (83-81)				-0.311 (0.196)		
Δlog ipd (83-80)					-0.138 (0.104)	-0.088 (0.116)
Δlog los (83-80)						-0.181 (0.192)
Δlog ipd (83-82)	-0.302 (0.143)	-0.121 (0.173)	-0.307 (0.145)	-0.130 (0.175)		
Δlog los (83-82)		-0.521 (0.272)		-0.493 (0.273)		
Δlog ipd (82-81)	-0.137 (0.137)	-0.038 (0.166)				
Δlos los (82-81)		-0.299 (0.227)				
Δlog ipd (82-80)			-0.086 (0.115)	-0.045 (0.127)		
Δlog los (82-80)				-0.107 (0.207)		

Notes:

[1] Dependent variable is log average annual earnings (from 1983 A.H.A. Annual Survey) minus log RN starting wage for newly licensed baccalaureates (from 1983 Nursing Personnel Survey). Numbers in parentheses are standard errors. See text for sample selection criteria.

[2] Change in natural logarithms of inpatient days.

[3] Change in natural logarithms of average length of stay.

Table 7
Regression Models for 1983 to 1985 Change in Selected Variables on Change in Log Caseload and Change in Log Length of Stay

Dependent Variable[6]	Δlog ipd[2]	(s.e.)[3]	Δlog los[4]	(s.e.)[5]
Δ percent Tenure	4.027	(4.829)		
< 1 Year	3.196	(6.067)	1.974	(8.700)
Δ percent Tenure	18.645	(4.422)		
1 - 2 Years	22.326	(5.543)	-8.748	(7.848)
Δ percent Tenure	-6.163	(5.988)		
2 - 5 Years	0.733	(7.488)	-16.389	(10.738)
Δ percent Tenure	-16.562	(7.049)		
> 5 Years	-26.313	(8.797)	23.172	(12.615)
Δ Tenure Index	-0.765	(0.283)		
	-1.078	(0.354)	0.743	(0.507)
Δ percent Associate	-3.950	(6.434)		
Degree	1.080	(7.946)	-12.710	(11.780)
Δ percent Diploma	6.190	(6.926)		
Degree	5.042	(8.570)	2.900	(12.705)
Δ percent Bachelor	-1.268	(4.443)		
Degree	-5.221	(5.481)	9.986	(8.125)
Δ Average Years	-0.206	(0.121)		
Education	-0.333	(0.149)	0.320	(0.220)
Δ Part Time Ratio	-0.080	(0.215)		
	-0.136	(0.268)	0.140	(0.399)
Δ Vacancy Ratio	0.156	(0.153)		
	0.351	(0.193)	-0.467	(0.285)
Δ New Hire Ratio	0.014	(0.056)		
	-0.011	(0.071)	0.060	(0.108)
Δ Separation Ratio	-0.006	(0.044)		
	0.054	(0.054)	-0.153	(0.083)

Notes:
[1] See text for sample selection criteria.
[2] Coefficient of change in log inpatient days (1983 to 1985).
[3] Estimated standard error of coefficient of change in log inpatient days.
[4] Coefficient of change in log of average length of stay (1983 to 1985).
[5] Estimated standard error of coeffifient of change in log average length of stay.
[6] See notes to Table 3 for variable definitions.

Table 8
Cross-Sectional Regression Models for Log Wage and Log Employment on Log Caseload and Log Length of Stay (1983)[1]

Independent Variable	Log Employment[2]		Log Wage[3]	
log ipd 83[4]	1.0390	1.1209	0.0158	0.0149
	(0.0054)	(0.0061)	(0.0053)	(0.0065)
log los 83[5]		-0.6218		0.0063
		(0.0271)		(0.0286)
RMSE[6]	0.327	0.301	0.317	0.317
Observations[7]	2834	2834	2834	2834

Notes:
[1] See text for sample selection criteria. Numbers in parentheses are standard errors.
[2] Dependent variable is log of nurse employment in 1983.
[3] Dependent variable is log of average annual earnings of nurses in 1983.
[4] log of inpatient days in 1983.
[5] log of average length of stay in 1983.
[6] Root mean square error.
[7] Number of observations.

Table 9
Reduced Form Models for Change in Log Employment[1]

Independent Variable	1 Year Differences[2]		2 Year Differences[2]		3 Year Differences[2]	
FULL SAMPLE						
Δlog ipd[3]	0.236 (0.015)	0.278 (0.018)	0.382 (0.021)	0.428 (0.024)	0.422 (0.023)	0.469 (0.025)
Δlog los[4]		-0.108 (0.022)		-0.145 (0.031)		-0.162 (0.034)
Δlog oipd[5]	0.164 (0.029)	0.183 (0.040)	0.007 (0.038)	0.067 (0.062)	-0.044 (0.041)	-0.015 (0.073)
Δlog olos[6]		-0.028 (0.064)		-0.076 (0.105)		0.004 (0.131)
RMSE[7]	0.112	0.112	0.169	0.169	0.195	0.194
Obs[8]	11,445	11,445	8250	8250	5669	5669
METROPOLITAN AREAS						
Δlog ipd	0.302 (0.029)	0.341 (0.036)	0.446 (0.043)	0.478 (0.047)	0.484 (0.036)	0.517 (0.035)
Δlog los		-0.126 (0.039)		-0.136 (0.055)		-0.152 (0.053)
Δlog oipd	0.154 (0.054)	0.173 (0.076)	0.001 (0.068)	0.143 (0.107)	0.006 (0.069)	0.222 (0.124)
Δlog olos		0.011 (0.115)		-0.180 (0.169)		-0.298 (0.198)
RMSE	0.100	0.100	0.152	0.151	0.168	0.168
Obs	3994	3994	2868	2868	1962	1962
NON-METROPOLITAN AREAS						
Δlog ipd	0.214 (0.017)	0.254 (0.021)	0.364 (0.023)	0.417 (0.028)	0.4068 (0.028)	0.463 (0.021)
Δlog los		-0.098 (0.026)		-0.151 (0.037)		-0.175 (0.033)
Δlog oipd	0.167 (0.034)	0.190 (0.047)	0.005 (0.045)	0.049 (0.075)	-0.068 (0.050)	-0.052 (0.090)
Δlog olos		-0.051 (0.079)		-0.059 (0.135)		0.014 (0.185)
RMSE	0.117	0.117	0.176	0.176	0.204	0.203
Obs	7451	7451	5382	5382	3707	3707

Notes:

[1] See text for sample selection criteria. Models also include HSA specific dummy variables. Standard errors in parentheses are consistent in the presence of arbitrary forms of heteroscedasticity and serial correlation.

[2] Dependent variable is change in the natural log of employment over the number of years indicated.

[3] Change in log inpatient days over the number of years indicated by the column.

[4] Change in log length of stay over the number of years indicated by the column.

[5] Change in log of the sum of inpatient days for other hospitals in the HSA over the number of years indicated by the column.

[6] Change in log of the average length of stay for other hospitals in the HSA over the number of years indicated by the column.

[7] Root mean square error.

[8] Number of observations.

Table 10
Reduced Form Models for Change in Log Wage[1]

Independent Variable	1 Year Differences[2]		2 Year Differences[2]		3 Year Differences[2]	
FULL SAMPLE						
Δlog ipd[3]	0.187 (0.024)	0.188 (0.030)	0.143 (0.025)	0.139 (0.030)	0.113 (0.025)	0.124 (0.028)
Δlog los[4]		-0.004 (0.040)		0.009 (0.049)		-0.035 (0.045)
Δlog oipd[5]	0.164 (0.050)	0.152 (0.080)	0.300 (0.054)	0.173 (0.098)	0.300 (0.057)	0.292 (0.108)
Δlog olos[6]		0.029 (0.143)		0.275 (0.176)		0.034 (0.198)
RMSE[7]	0.237	0.237	0.279	0.279	0.291	0.291
Obs[8]	11,445	11,445	8250	8250	5669	5669
METROPOLITAN AREAS						
Δlog ipd	0.233 (0.050)	0.250 (0.061)	0.145 (0.051)	0.151 (0.060)	0.126 (0.045)	0.139 (0.051)
Δlog los		-0.053 (0.076)		-0.037 (0.088)		-0.086 (0.082)
Δlog oipd	0.223 (0.099)	0.273 (0.165)	0.343 (0.099)	0.164 (0.186)	0.351 (0.091)	0.078 (0.191)
Δlog olos		-0.079 (0.257)		0.354 (0.295)		0.555 (0.298)
RMSE	0.226	0.226	0.261	0.261	0.274	0.274
Obs	3994	3994	2868	2868	1962	1962
NON-METROPOLITAN AREAS						
Δlog ipd	0.173 (0.028)	0.167 (0.034)	0.140 (0.028)	0.128 (0.034)	0.103 (0.030)	0.106 (0.034)
Δlog los		0.015 (0.047)		0.032 (0.057)		-0.009 (0.053)
Δlog oipd	0.143 (0.059)	0.136 (0.093)	0.289 (0.063)	0.197 (0.117)	0.291 (0.068)	0.412 (0.132)
Δlog olos		0.018 (0.178)		0.205 (0.227)		-0.283 (0.264)
RMSE	0.241	0.241	0.286	0.286	0.296	0.296
Obs	7451	7451	5382	5382	3707	3707

Notes:

[1] See text for sample selection criteria. Models also include HSA specific dummy variables. Standard errors in parentheses are consistent in the presence of arbitrary forms of heteroscedasticity and serial correlation.

[2] Dependent variable is change in the natural log of the wage over the number of years indicated.

[3] Change in log inpatient days over the number of years indicated by the column.

[4] Change in log length of stay over the number of years indicated by the column.

[5] Change in log of the sum of inpatient days for other hospitals in the HSA over the number of years indicated by the column.

[6] Change in log of the average length of stay for other hospitals in the HSA over the number of years indicated by the column.

[7] Root mean square error.

[8] Number of observations.

Table 11
Inverse Supply: Employment Setting Equilibrium[1]

Independent Variable	1 Year Differences[2]		2 Year Differences[2]		3 Year Differences[2]	
FULL SAMPLE						
Δlog n[3]	0.789	0.740	0.369	0.351	0.265	0.264
	(0.131)	(0.128)	(0.078)	(0.077)	(0.066)	(0.064)
Δlog on[4]	0.068	0.092	0.555	0.545	0.561	0.556
	(0.151)	(0.146)	(0.117)	(0.116)	(0.111)	(0.110)
RMSE[5]	0.281	0.277	0.312	0.310	0.317	0.317
Obs[6]	11,445	11,445	8250	8250	5669	5669
METROPLOLITAN AREAS						
Δlog n	0.767	0.746	0.316	0.331	0.255	0.270
	(0.208)	(0.208)	(0.139)	(0.142)	(0.108)	(0.091)
Δlog on	0.195	0.211	0.602	0.478	0.578	0.443
	(0.261)	(0.254)	(0.111)	(0.190)	(0.184)	(0.202)
RMSE	0.262	0.261	0.285	0.286	0.294	0.296
Obs	3994	3994	2868	2868	1962	1962
NON-METROPOLITAN AREAS						
Δlog n	0.808	0.744	0.380	0.346	0.251	0.241
	(0.169)	(0.163)	(0.093)	(0.089)	(0.082)	(0.078)
Δlog on	0.016	0.053	0.550	0.571	0.569	0.578
	(0.188)	(0.181)	(0.143)	(0.141)	(0.133)	(0.132)
RMSE	0.290	0.285	0.322	0.318	0.322	0.321
Obs	7451	7451	5382	5382	3707	3707

Notes:

[1] See text for sample selection criteria. Models also include HSA specific dummy variables. Estimation is by instrumental variables. Columns 1, 3 and 5 use Δ log ipd and Δ log oipd as instruments. Columns 2, 4 and 6 use these variables and Δ log los and Δ log olos. Standard errors in parentheses are consistent in the presence of arbitrary forms of heteroscedasticity and serial correlation.

[2] Dependent variable is change in the log of the wage over the number of years indicated.

[3] Change in log of employment over the number of years indicated by the column.

[4] Change in log of total employment by other hospitals in the HSA over the number of years indicated by the column.

[5] Root mean square error.

[6] Number of observations.

Table 12
Inverse Supply: Wage Setting Equilibrium[1]

Independent Variable	1 Year Differences[2]		2 Year Differences[2]		3 Year Differences[2]	
FULL SAMPLE						
Δlog n[3]	0.785	0.711	0.352	0.328	0.257	0.261
	(0.138)	(0.129)	(0.078)	(0.076)	(0.067)	(0.064)
Δlog ow[4]	0.110	0.236	0.771	0.816	0.944	0.927
	(0.243)	(0.225)	(0.161)	(0.157)	(0.188)	(0.183)
RMSE[5]	0.280	0.275	0.313	0.312	0.323	0.323
Obs[6]	11,445	11,445	8250	8250	5669	5669
METROPLOLITAN AREAS						
Δlog n	0.749	0.742	0.317	0.307	0.254	0.265
	(0.224)	(0.226)	(0.139)	(0.129)	(0.101)	(0.098)
Δlog ow	0.357	0.336	0.891	0.928	1.150	1.128
	(0.473)	(0.455)	(0.197)	(0.283)	(0.424)	(0.382)
RMSE	0.261	0.260	0.288	0.287	0.301	0.302
Obs	3994	3994	2868	2868	1962	1962
NON-METROPOLITAN AREAS						
Δlog n	0.808	0.709	0.354	0.320	0.237	0.229
	(0.175)	(0.159)	(0.096)	(0.091)	(0.084)	(0.081)
Δlog ow	0.025	0.187	0.743	0.795	0.910	0.914
	(0.289)	(0.261)	(0.190)	(0.185)	(0.213)	(0.211)
RMSE	0.290	0.282	0.323	0.320	0.326	0.326
Obs	7451	7451	5382	5382	3707	3707

Notes:
[1] See text for sample selection criteria. Models also include HSA specific dummy variables. Estimation is by instrumental variables. Columns 1, 3 and 5 use Δ log ipd and Δ log oipd as instruments. Columns 2, 4 and 6 use these variables and Δ log los and Δ log olos. Standard errors in parentheses are consistent in the presence of arbitrary forms of heteroscedasticity and serial correlation.
[2] Dependent variable is change in the log of the wage over the number of years indicated.
[3] Change in log of employment over the number of years indicated by the column.
[4] Change in log of total employment by other hospitals in the HSA over the number of years indicated by the column.
[5] Root mean square error.
[6] Number of observations.

Table 13
Inverse Supply: Consistent Conjectural Variations Equilibrium[1]

Independent Variable	1 Year Differences[2]		2 Year Differences[2]		3 Year Differences[2]	
FULL SAMPLE						
$\Delta \log n$[3]	0.791	0.737	0.374	0.352	0.261	0.266
	(0.129)	(0.126)	(0.077)	(0.076)	(0.065)	(0.063)
$\Delta \log oipd$[4]	0.034	0.020	0.297	0.159	0.350	0.298
	(0.077)	(0.105)	(0.062)	(0.111)	(0.061)	(0.118)
$\Delta \log olos$[5]		0.082		0.320		0.034
		(0.166)		(0.195)		(0.216)
RMSE[6]	0.281	0.277	0.312	0.310	0.318	0.317
Obs[7]	11,445	11,445	8250	8250	5669	5669
METROPLOLITAN AREAS						
$\Delta \log n$	0.772	0.751	0.325	0.317	0.261	0.258
	(0.204)	(0.210)	(0.134)	(0.136)	(0.106)	(0.097)
$\Delta \log oipd$	0.105	0.145	0.343	0.120	0.350	0.016
	(0.140)	(0.204)	(0.111)	(0.209)	(0.110)	(0.281)
$\Delta \log olos$		-0.063		0.415		0.604
		(0.293)		(0.316)		(0.405)
RMSE	0.262	0.261	0.285	0.284	0.295	0.294
Obs	3994	3994	2868	2868	1962	1962
NON-METROPOLITAN AREAS						
$\Delta \log n$	0.809	0.743	0.384	0.351	0.253	0.244
	(0.165)	(0.159)	(0.092)	(0.088)	(0.082)	(0.078)
$\Delta \log oipd$	0.008	-0.003	0.287	0.197	0.309	0.433
	(0.093)	(0.126)	(0.074)	(0.132)	(0.072)	(0.142)
$\Delta \log olos$		0.088		0.237		-0.287
		(0.208)		(0.252)		(0.286)
RMSE	0.290	0.285	0.322	0.318	0.322	0.321
Obs	7451	7451	5382	5382	3707	3707

Notes:
[1] See text for sample selection criteria. Models also include HSA specific dummy variables. Estimation is by instrumental variables. Columns 1, 3 and 5 use Δ log ipd and Δ log oipd as instruments. Columns 2, 4 and 6 use these variables and Δ log los and Δ log olos. Standard errors in parentheses are consistent in the presence of arbitrary forms of heteroscedasticity and serial correlation.

[2] Dependent variable is change in the log of the wage over the number of years indicated.

[3] Change in log of employment over the number of years indicated by the column.

[4] Change in log of the sum of inpatient days for other hospitals in the HSA over the number of years indicated by the column.

[5] Change in log of the average length of stay of other hospitals in the HSA over the number of years indicated by the column.

[6] Root mean square error.

[7] Number of observations.