The Labor Supply of Nurses and Nursing Assistants in the United States

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Abstract

Employers of nurses and nursing aides often report shortages and seek public assistance to enable them to pay higher wages. Persistent shortages may in theory be due to monopsony power, rigidity of relative wages, or incomplete contracts. Consistent with rigidity of relative wages, time series for employment and earnings of registered nurses (RNs), licensed practical nurses (LPNs), and nursing aides, orderlies, and attendants (NAOAs), 1987–2002, suggest coexistence of excess demand for RNs and NAOAs with excess supply of LPNs since 1993. Labor supply functions for RNs and NAOAs are estimated by Bayesian limited information methods, yielding posterior distributions for short- and long-run wage elasticities of labor supply. The results suggest that increased public assistance to health care providers, designed to raise wages, probably would not reduce reported shortages arising from monopsony power but would nonetheless increase employment of RNs and NAOAs moderately in the short-run and strongly in the long-run.

JEL classification: C11, I10, J22, J40

1   Introduction

Health care administrators and public policy makers are currently much concerned with the labor supply of nurses and nursing assistants. Hospitals and nursing homes, complaining of labor shortages, request public assistance to enable them to pay higher wages. Before committing public funds, policy makers want up-to-date estimates of the wage elasticities of labor supply for nurses and nursing assistants. Constructing a framework within which these elasticities can be estimated requires consideration of the nature and possible origins of the reported shortages.

2   Review of the literature

2.1   Reported shortages

"Shortages," in various senses, have been reported for decades in U.S. markets for nurses and nursing assistants. Although this term is used loosely in the non-economic literature, at least some instances seem to involve persistent excess demand.[1] To explain such excess demand in labor markets, economists have often looked to deviations from perfect competition, most notably employers' monopsony power, inflexible relative wages, and incomplete contracts.

2.2   Monopsony power

A model of monopsonistic equilibrium in the nursing labor market was introduced by Yett (1970) and extended and applied by Currie et al. (2002), Grosskopf et al. (1990), Link and Landon (1975), Robinson (1988), and Sullivan (1989). In this model, a local monopsonist derives its marginal expenditure (ME) function from a given labor supply function, chooses a quantity of labor to equate its ME with its marginal revenue product (MRP), and pays just enough to attract this quantity of labor, given the labor supply curve. The gap between its chosen employment level and that which would equate its MRP to its chosen wage, as shown in Figure 1, may be one source of frequent reports of nurse shortages.

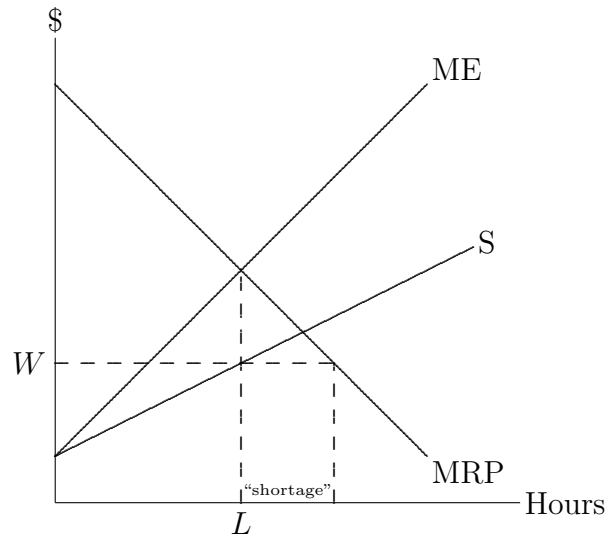[1]In the non-economic literature "shortage" sometimes means scarcity rather than excess demand.

Figure 1: A monopsonist facing a labor supply curve S and having marginal expenditure curve ME and marginal revenue product curve MRP chooses employment L and wage W.

This analysis, with minor modifications, can be extended to oligopsony and monopsonistic competition. Indeed, whenever employers face upward sloping labor supply curves, they have a degree of monopsony power. Evidence that monopsony power, in various forms, is widespread in labor markets is presented by Bhaskar et al. (2002) and Manning (2003).

Forms of public assistance often requested by health care providers—e.g., more generous reimbursement for treating Medicaid patients—could shift MRP schedules upward. This would typically increase wages and employment without reducing reported shortages. How much employment increased would, of course, depend on the wage elasticity of supply.

Monopsony power in labor markets is likely to be relatively weak in areas with a high density of suitable employers. When labor shortages are nonetheless reported in such areas, other market imperfections are likely responsible. Evidence that monopsony power is less than ubiquitous in nursing labor markets and less than adequate to explain observed outcomes is presented in Hirsch and Schumacher (1995), Hirsch and Schumacher (2004), and Staiger et al. (1999). Doubts about monopsony power as an explanation of reported shortages may motivate consideration of two other possibilities: rigidity of relative wages and incomplete contracts.

2.3   Rigidity of relative wages

The relative wages of employees who work together may be stabilized by considerations of fairness. Persistent wage structures have long been observed in several industries (Dunlop 1957; Kim 1999). In the health care sector, Krall notes, administrators have feared that changes in the customary wage differentials among registered nurses (RNs), licensed practical nurses (LPNs), and nursing aides, orderlies, and attendants (NAOAs) could create dissension and undermine cooperation (Krall 1995).

Rigidity of relative wages may help explain reported shortages for some categories of nurses. Starting from an initial equilibrium in which wages for all categories of nurses have been independently set at levels that clear each market, suppose that the MRP curve shifts outward for one group of nurses but inward for another. Employers may want to raise wages for the former and cut them for the latter but cannot do so for fear of upsetting the customary wage structure. Aversion to wage cuts is compounded by a belief, widespread among employers, that such cuts hurt morale and accelerate labor turnover (Bewley 1999). Under these circumstances, the shifting MRP curves are likely to result in excess demand for one group of nurses and excess supply of the other.

2.4   Incomplete contracts

The most recent suggestion for explaining persistent reports of shortage is offered by Heyes (2003), who notes that labor contracts covering nurses are incomplete in the sense that although a contract may require a nurse to give injections it cannot effectively require her to give them "with tender loving care" (p. 3). An employer wanting nurses to go beyond their contractual obligations needs to attract nurses motivated in part by a sense of vocation rather than simply by pay. Heyes shows that, under some conditions, raising wages increases the proportion of job applicants motivated solely by pay. An employer who is unable to observe applicants' motivations may prefer to keep wages low, hoping to attract mainly nurses with the desired sense of vocation.[2]

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[2]Professors as well as nurses work under incomplete contracts. Because Heyes's model could be used to justify holding down their salaries, professors stand to gain financially from it being discredited in the eyes of university administrators. However, any professor who refutes it risks appearing mercenary. This conflict between group and individual

While incomplete contracts may explain some persistent shortages, they fail to explain the cases in which employers not only report a shortage but also seek government assistance to enable them to raise wages. In those cases, monopsony and/or inflexible relative wages may be more relevant.

2.5 Wage elasticity of labor supply

The wage elasticity of labor supply is of central interest to employers and policy makers who wonder how much it would cost to increase employment. Economists have made many attempts to estimate the elasticity for RNs, LPNs, and NAOAs. A range of estimates based on U.S. data and published since 1975 are graphically displayed in Figure 2. Although the estimates published in the 1970s and 1980s were widely dispersed, those published in the 1990s are all between 0 and 2, suggesting a degree of convergence in the literature. Full convergence should not be expected because studies differ with regard to the type of nurses covered and the length of the adjustment period covered.

3 Estimation of labor supply equations

This paper contributes to the literature on the elasticity of labor supply by utilizing recent extensions of the relevant time series and by using Bayesian methods to integrate the data with prior information.

3.1 Data

Our data are annual time series for 1987–2002 covering full-time employment of RNs, LPNs, and NAOAs and variables influencing their labor supply. In particular, our data on employment and median weekly earnings of full-time wage and salary workers are annual averages as reported in January issues of the Bureau of Labor Statistics' *Employment & Earnings*.[3] Data on the civilian labor force come from the same source. Nominal earnings are deflated

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interests might be called a professor's dilemma were it not already named for prisoners.

    [3]Because the employment data are annual averages for full-time workers, a person working full-time for a fraction of a year counts as that fraction of a worker. For example, two individuals each working half a year would together count as one year-round worker in the annual average.
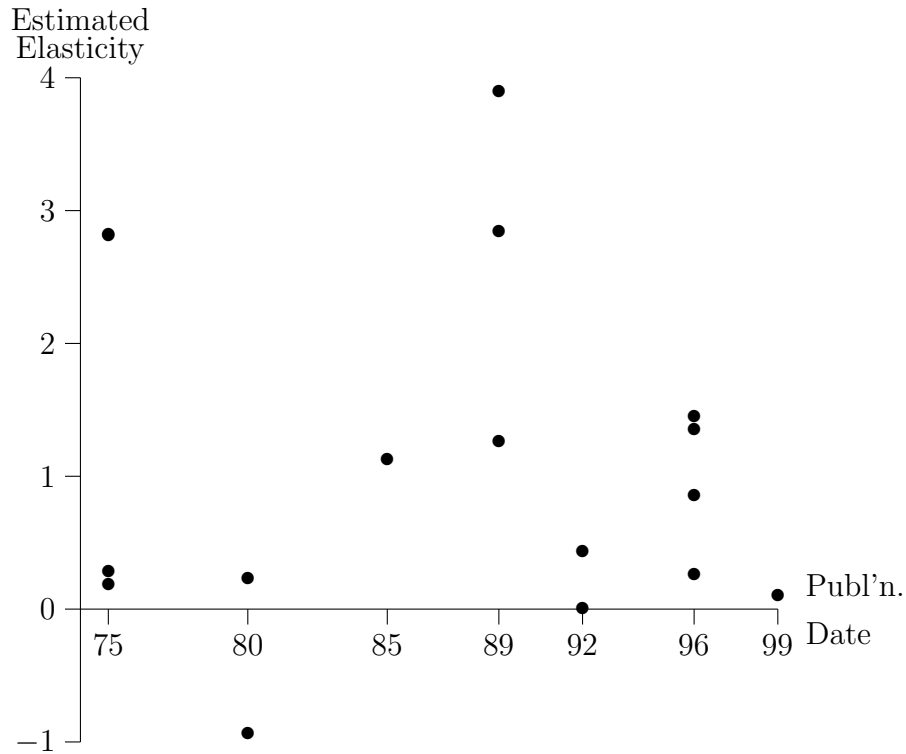
Figure 2: Estimates, based on U.S. data, of wage elasticities of labor supply for nurses, as published between 1975 and 1999

by the urban Consumer Price Index (base period 1982–84 = 100). Population data come from the Census Bureau, *Statistical Abstract of the United States*.

3.2 Trends in employment and earnings

Employment has trended upward for RNs and NAOAs while rising and then falling for LPNs, as shown in Figure 3. The fall in LPN employment in the 1990s is probably due largely to efforts by administrators of hospitals and health maintenance organizations to replace LPNs by NAOAs in less complex tasks and by RNs in more complex ones.

If the wages of the three types of nurses were determined independently, we would expect to see the wages of LPNs dropping relative to those of RNs and NAOAs. In fact, the earnings of the three groups moved in near parallel, as shown in Figure 4. The nearly parallel movement of the earnings of the three groups is consistent with the constraints on wage adjustment discussed
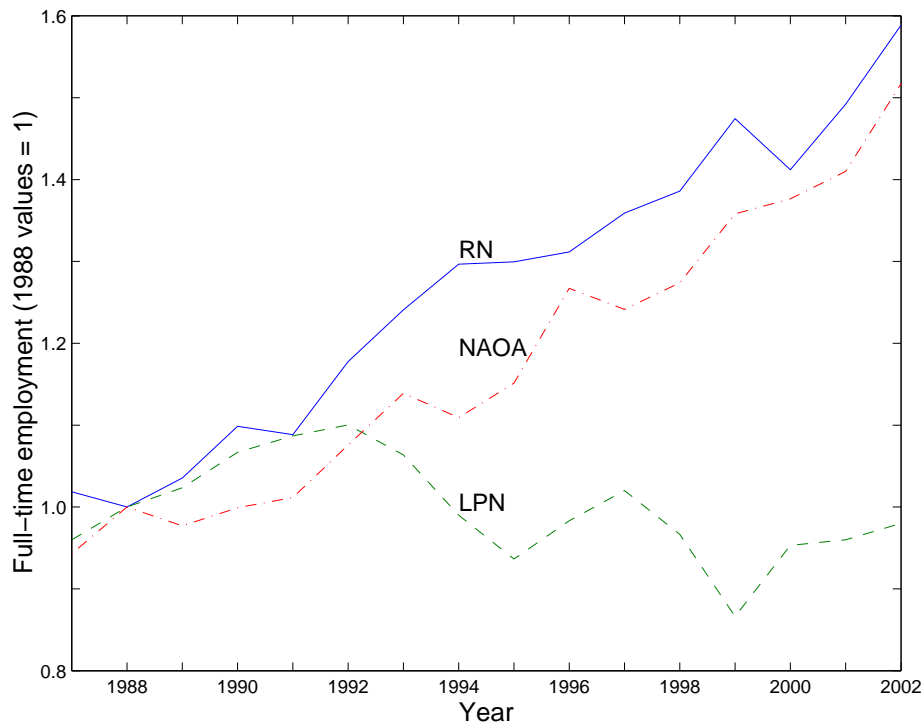
Figure 3: Employment of RNs, LPNs, and NAOAs, 1987–2002

above in our survey of the literature.

3.3   Specification of labor supply equations

Economic theory and previous studies suggest that the quantity of labor supplied in a particular occupational category, such as RNs, LPNs, or NAOAs, depends on the real wage in that occupation, real wages in alternative occupations, and the labor force.

Because changes in these variables take some time to fully affect the quantity of labor supplied, one or more lagged variables may be needed to capture dynamic adjustment. Our time series are too short to accommodate rich dynamic specifications; hence we use a simple partial adjustment model, in which the lagged dependent variable accounts for delayed responses and allows us to estimate long- and short-run elasticities.

All variables are used in logarithmic form, allowing us to interpret regression coefficients as elasticities. In particular, the coefficient of an occupation's
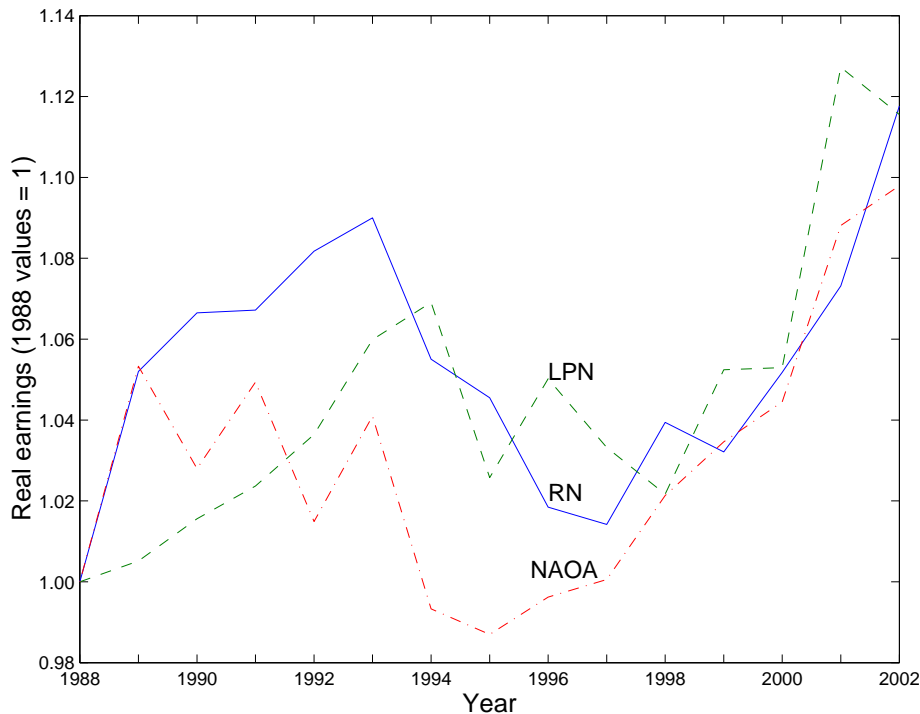
Figure 4: Median real earnings of full-time RNs, LPNs, and NAOAs, 1987–2002

own real wage can be interpreted as the wage elasticity of supply.

Our labor supply equation can be written as follows:

$$\ln L_t = \beta_1 + \beta_2 \ln ow_t + \beta_3 \ln aw_t + \beta_4 \ln f_t + \beta_5 \ln L_{t-1} + \epsilon_t,$$

where L is full-time employment in an occupation, ow is median real earnings of full-time workers in the occupation,[4] aw is median real earnings of full-time workers in alternative occupations,[5] f is the civilian labor force (with female and male components weighted to match the sex-composition of the

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[4]The wage rate, were it observed, would be preferable to earnings as a regressor. However, *median* earnings of *full-time* workers probably are strongly correlated with the wage rate because use of the median diminishes the impact of fluctuations in overtime hours and the restriction to full-time workers eliminates the effects of fluctuations in part-time hours.

[5]Although *ow* and *aw* are measured as median earnings of full-time employees, we will for brevity sometimes call them wages.

occupation), ϵ is a random disturbance,[6] and the subscript denotes time.

3.4 Econometric analysis

Our primary interest is in the effect of wage changes on the quantity of labor supplied; however, to obtain an unbiased estimate of this effect we must also consider how shifts in the labor supply curve affect wages. To this end, we can supplement the labor supply function with either a MRP function or a reduced form wage equation, the latter including as explanatory variables both factors shifting the labor supply curve and those shifting the MRP curve. Due to uncertainty about the form of the MRP function, we prefer to use a reduced form equation. In other words, we opt for limited rather than full information estimation methods. This choice makes our estimates of the labor supply equation relatively robust in the face of uncertainty about the MRP equation. Our wage equation is specified as follows:

$$\ln ow_t = \beta_6 + \beta_7 \ln p_t + \beta_8 \ln aw_t + \beta_9 \ln f_t + \beta_{10}t + \beta_{11}t^2 + \beta_{12} \ln L_{t-1} + \epsilon_t,$$

where p is population with age groups weighted by health care expenditure, t measures years elapsed since 1987, and the other variables are as defined earlier in connection with the labor supply curve. The quadratic time trend proxies technological change in health care and other omitted variables.[7] Comparing the labor supply and the wage equation, we see that the former is identified by exclusion of $\ln p_t$, t, and t^2.

Preliminary efforts to estimate labor supply equations yielded much better fits for RNs and NAOAs than for LPNs. The reason for this difference, we suspect, is that employment of the first two groups has been constrained by labor supply while LPNs have more often in recent years been in excess

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[6]The disturbance includes the effect of variables such as unearned income that are excluded from the list of regressors for want of suitable time series. As a proxy for trending unobserved variables, a time trend was tried as an additional regressor. The estimated coefficient of the time trend in two-stage least squares estimation was not significantly different from 0 at the .10 level. The time trend was omitted from the final specification to conserve degrees of freedom.

[7]Capital might be either a complement or a substitute for nurses. As a proxy for the price of capital, the real interest rate was tried as an additional regressor. Its estimated coefficient was not significantly different from zero, suggesting that capital is on the border line between a complement and a substitute. Health insurance coverage was also considered as a possible regressor; however, data for insurance in 2002 were unavailable.

supply. In other words, employment provides a good measure of the quantity of labor supplied for RNs and NAOAs but not for LPNs. To estimate a labor supply curve for an occupation such as LPNs in which excess supply is common would require far more data than we currently have. Thus in what follows we focus on RNs and NAOAs.

Initial estimates of our labor supply function were obtained using a two-stage least squares (2SLS) estimator. In the first stage, the reduced form wage equation was estimated by ordinary least squares (OLS) and the fitted values of the wage were saved. In the second stage, the labor supply equation was estimated with the fitted wage values substituting for the corresponding observed values.

The 2SLS estimates of the labor supply equations for RNs and NAOAs are shown in Table 1. The numbers to the right of variable names are the corresponding estimated (short-run) elasticities. For example, the estimated wage elasticity of labor demand for RNs is 0.588 while that for NAOAs is 2.294. The numbers in parentheses are t-ratios.[8]

The 2SLS estimates have several attractive features. The summary statistics at the bottom of the table are indicative of a good fit without significant serial correlation. The signs of the estimated coefficients of the current variables are all as expected. The magnitude of the estimated own wage elasticities are consistent with results from previous studies. The difference between the own wage elasticities for RNs and NAOAs is consistent with the fact that RNs are more specialized and firmly attached to their occupation than are NAOAs.

Nonetheless, the 2SLS estimates are not fully satisfactory. The labor force elasticities are implausibly high. The negative sign of the estimated coefficient of the lagged dependent variable for NAOAs is contrary to theoretical expectations. The low precision of the estimated coefficients of the lagged dependent variables in both equations precludes any reliable inferences about long-run elasticities. Contributing to the implausible and imprecise estimates

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[8]For readers concerned about the interpretation of the t-ratios in a time series context, two points should be noted. First, the employment series are more likely to be trend stationary than difference stationary, as shown in an appendix that is available from the author. Second, in either case, the t-ratios and the standard tables of the t distribution are valid indicators of the shape of the likelihood function, which is arguably of greater substantive interest than the sampling-theory distribution of estimators (Sims 1988; Sims and Uhlig 1991). Similarly, in either case, the Bayesian estimates reported below are valid summaries of the posterior distribution of the parameters.

Table 1: 2SLS estimates of labor supply equations, 1988–2002

	Registered Nurses	Nursing Aides, etc.
Intercept	-6.901	-9.818
	(-3.007)	(-1.417)
Own real wage	0.588	2.294
	(2.217)	(2.548)
Average real wage	-0.441	-1.411
	(-1.315)	(-1.157)
Labor force	1.665	2.669
	(2.754)	(1.522)
Lagged dep. var.	0.271	-0.245
	(1.010)	(-0.292)
R^2	0.974	0.839
Breusch-Godfrey F	0.266	0.049
Tail area for F	0.620	0.830

is severe collinearity among the regressors, which is not surprising when we consider that all the regressors trend upward.[9]

To narrow the range of the uncertainty about the short- and long-run elasticities, we can supplement the sample evidence with prior information derived from economic theory and previous empirical studies. Techniques for combining sample and prior information are provided by Bayesian statistics, a field that has developed rapidly over the last fifteen years as the cost of computer simulation has dropped (Gelman et al. 2004; Koop 2003; Lancaster 2004).

Researchers and various members of their audience often have different background information. Prior information that is widely if not universally shared is employed in the remainder of this section. Readers with different beliefs or more detailed information are offered simulation files that can be easily reanalyzed from various points of view.

Based on economic theory and previous studies, we may reasonably sup-

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[9]Collinearity in our labor supply equations was diagnosed using scaled condition indices and variance decomposition proportions as proposed by Belsley (1991) and summarized by Hill and Adkins (2001). Supplemental regressions show that $\ln ow_t$ and $\ln aw_t$ are closely related, as are $\ln f_t$ and $\ln L_{t-1}$.

pose that an increase in RN or NAOA own wages increases the quantity of labor supplied to the occupation ($\beta_2 > 0$), an increase in wages in alternative occupations decreases the labor supply to nursing ($\beta_3 < 0$), an increase in the labor force increases the supply of nurses roughly proportionately ($0 < \beta_4 < 2$), and the adjustment of labor supply to changes in its determinants is only partially completed within a year ($0 < \beta_5 < 1$). With regard to the reduced form wage equation, we believe that an increase in the population (with age groups weighted by health care expenditure) increases demand for nurses and hence their wages ($\beta_7 > 0$), but an increase in the labor force increases the supply of nurses and thus depresses their wages ($\beta_9 < 0$).

The prior information indicated in the previous paragraph is combined with the sample evidence in two steps. First, Bayesian estimates are calculated using the sample and a diffuse (uninformative) prior distribution for the parameters.[10] Computer simulation methods are used to draw a large sample from the posterior (post-data) distribution of the parameters.[11] From this simulated sample, summary statistics such as means and standard errors are easily calculated. These preliminary Bayesian estimates are much like the 2SLS estimates shown in Table 1. Second, the inequality constraints specified in the previous paragraph are imposed by discarding elements of the simulated sample that violate them. From the accepted elements, summary statistics can again be calculated. Posterior means and t-statistics based on the informative prior distribution are shown in Table 2. The posterior means for the short-run own wage elasticities (β_2) are 0.654 for RNs and 1.572 for NAOAs.

Posterior distributions, particularly those involving inequality constraints, may be asymmetric, making means and t-statistics less useful than quantiles and graphical summaries. Quantiles of the posterior distributions of the parameters are shown in Table 3 for RNs and Table 4 for NAOAs. The interpretation of these tables can be illustrated by focusing on the line in Table 3 for the own real wage. This line indicates, inter alia, that the median of the posterior distribution for the coefficient of the own real wage (β_2) is .6436 for RNs, there is a 90% posterior probability that β_2 exceeds .2607, and the

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[10]While diffuse, the prior distribution is proper (integrates to one). The prior used here is centered at zero and has a standard deviation of 100 for each parameter.

[11]The simulation is done using Bayesian Analysis, Computation, and Communication (BACC) software. BACC is described in Geweke et al. (2003) and freely available at http://www2.cirano.qc.ca/~bacc/.

Table 2: Bayesian posterior means and t-statistics for labor supply equations, 1988–2002

	Registered Nurses	Nursing Aides, etc.
Intercept	-6.002	-4.768
	(-3.828)	(-2.158)
Own real wage	0.654	1.572
	(2.065)	(1.550)
Average real wage	-0.488	-1.073
	(-1.790)	(-1.095)
Labor force	1.415	1.328
	(3.512)	(2.719)
Lagged dep. var.	0.386	0.388
	(2.081)	(1.595)

90% central credible interval is (.1691, 1.2383). The fact that the gap between the .05 quantile and the median is smaller than the gap between the median and the .95 quantile is indicative of a rightward skew in the distribution. Comparing the entries for own real wage in Tables 3 and 4, we see that each quantile for NAOAs is greater than the corresponding quantile for RNs, consistent with NAOAs' weaker occupational attachment. The posterior medians for the long-run elasticities are 1.058 for RNs and 1.901 for NAOAs.[12] The central 90% credible intervals for the long-run elasticities are (0.2535, 3.3378) for RNs and (0.5528, 10.703) for NAOAs.

Posterior probability density functions (PDFs) for RNs short-run own wage elasticity, based on diffuse and informative prior distributions, are shown in Figure 5. In both cases, the mode of the function is near .5. As expected, the PDF is more tightly concentrated around the mode in the case of the informative prior distribution.

Posterior PDFs for NAOAs' short-run own wage elasticity are shown in

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[12]The long-run elasticity is $\beta_2/(1 - \beta_5)$. The posterior distribution of this function of the parameters was explored by numerical simulation. The posterior sample consists of all draws that satisfy all the prior inequalities. Each draw includes an estimate of β_2 and β_5, say b_1 and b_2. For each draw in the posterior sample, $b_2/(1 - b_5)$ was calculated. The posterior median for the long-run elasticity is estimated by the median of these values of $b_2/(1 - b_5)$.

Table 3: Quantiles of the posterior distribution of parameters of the labor supply equation for RNs, 1988–2002

	.05	.10	.50	.90	.95
Intercept	-8.2439	-7.8885	-6.1808	-3.6837	-2.9060
Own real wage	0.1691	0.2607	0.6436	1.0809	1.2383
Average real wage	-1.0189	-0.8783	-0.4682	-0.1356	-0.0719
Labor force	0.5991	0.8067	1.4644	1.8893	1.9459
Lagged dep. var.	0.1269	0.1680	0.3713	0.6666	0.7568

Table 4: Quantiles of the posterior distribution of parameters of the labor supply equation for NAOAs, 1988–2002

	.05	.10	.50	.90	.95
Intercept	-7.6426	-7.3027	-5.1345	-1.6878	-0.7122
Own real wage	0.3425	0.4854	1.1349	2.2342	2.6712
Average real wage	-2.3491	-1.9145	-0.6751	-0.1198	-0.0580
Labor force	0.3469	0.5911	1.4086	1.8824	1.9436
Lagged dep. var.	0.0703	0.1134	0.3655	0.7575	0.8454

Figure 6. The mode for the function based on a diffuse prior distribution is slightly less than one while the mode based on the informative distribution is slightly greater than one. The major difference, however, is that the former distribution has a long left tail while the latter does not.

Posterior PDFs for RNs' long-run own wage elasticity, based on diffuse and informative priors, are shown in Figure 7. Both modes are slightly less than one. The PDF based on the informative prior, compared to that based on the diffuse prior, is shifted slightly to the right and has a truncated left tail.

Posterior PDFs for NAOAs' long-run own wage elasticity are shown in Figure 8. The mode based on the diffuse prior is slightly less than one while that based on the informative prior is slightly less than two. The PDF based on the informative prior, compared to that based on the diffuse prior, is shifted substantially to the right and is truncated on the left.

Readers interested in combining the data evidence with their own prior information or in deriving the posterior distribution of functions (of parameters) not discussed here may download simulation files that can be easily reanalyzed. These contain draws from the posterior distribution of
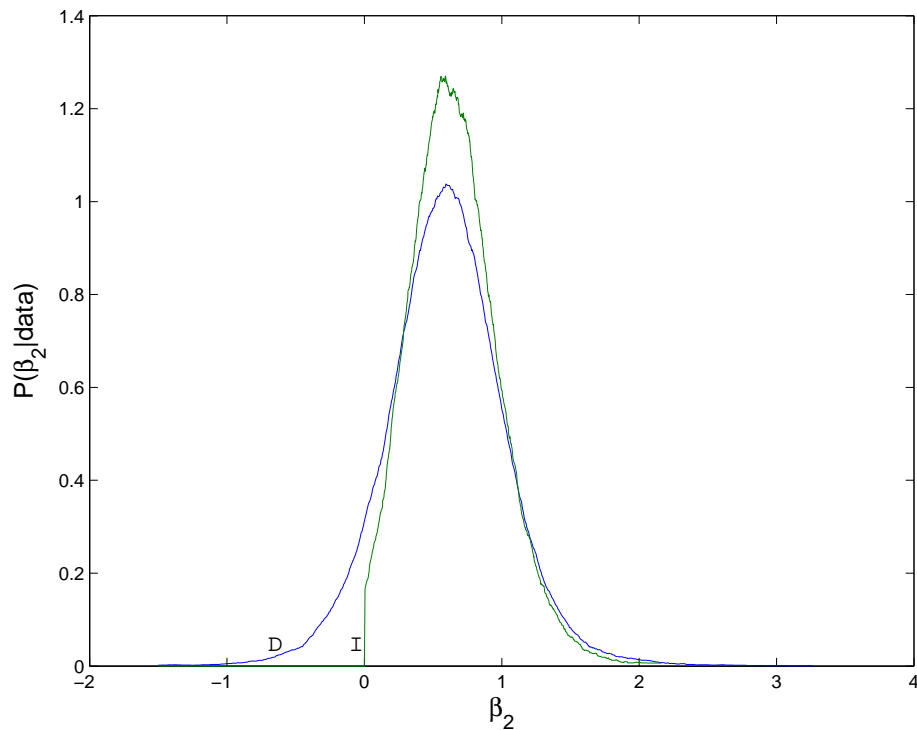
Figure 5: Posterior probability density functions for the short-run wage elasticity of labor supply for RNs based on diffuse (D) and informative (I) priors.

model parameters based on a diffuse prior distribution. The file for RNs, RNmi1.bin, contains 5,000 draws while that for NAOAs, NAOAmi1.bin, contains 50,000.[13] An example of Matlab code to reanalyze these simulation files is given in client.m.[14] These files are available at http://www.uri.edu/artsci-ecn/burkett/nurses.htm.

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[13]A larger number of draws were make for NAOAs because more are rejected by our inequality constraints.

[14]This code calls on routines contained in BACC, which can be obtained from http://www2.cirano.qc.ca/∼bacc/.
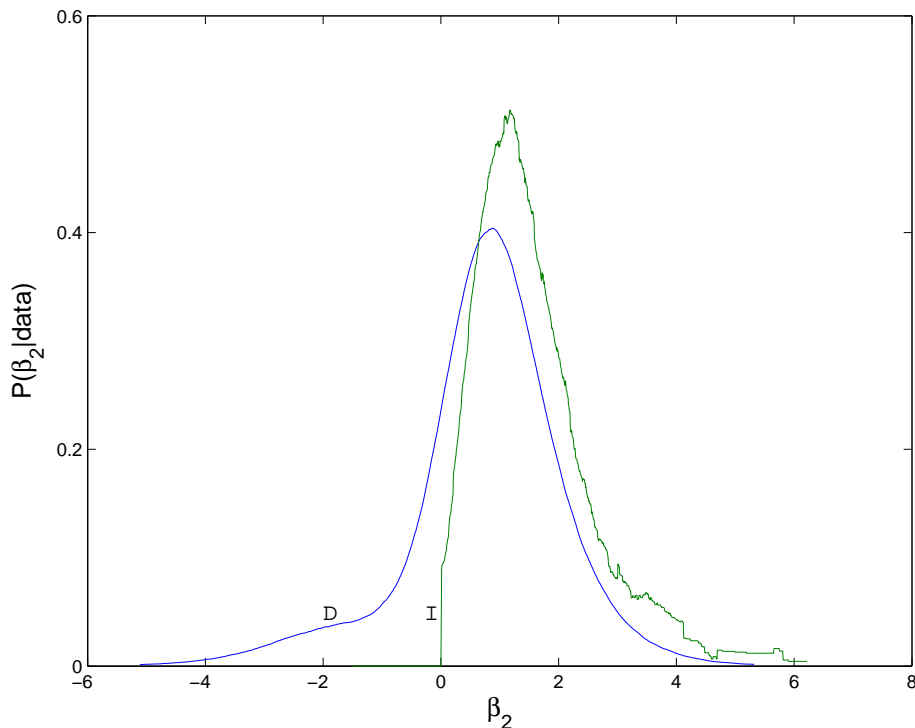
Figure 6: Posterior probability density functions for the short-run wage elasticity of labor supply for NAOAs based on diffuse (D) and informative (I) priors.

4   Conclusions

In U.S. markets for nurses and nursing assistants, there have been frequent reports of "shortages," some of which involve excess demand attributable to monopsony power, inflexible relative wages, or incomplete contracts. Recent trends in employment and wages data suggest that excess demand for RNs and NAOAs may coexist with excess supply of LPNs.

Based on annual time-series data for the United States, 1988–2002, we have derived posterior distributions for short- and long-run own wage elasticities of labor supply by RNs and NAOAs. The median of the distribution for the short-run elasticity is .644 for RNs and 1.135 for NAOAs. The central 90% posterior credible interval for the short-run elasticity is (.169, 1.238) for RNs and (.343, 2.671) for NAOAs. The median of the distribution for the long-run elasticity is 1.058 for RNs and 1.901 for NAOAs. The central
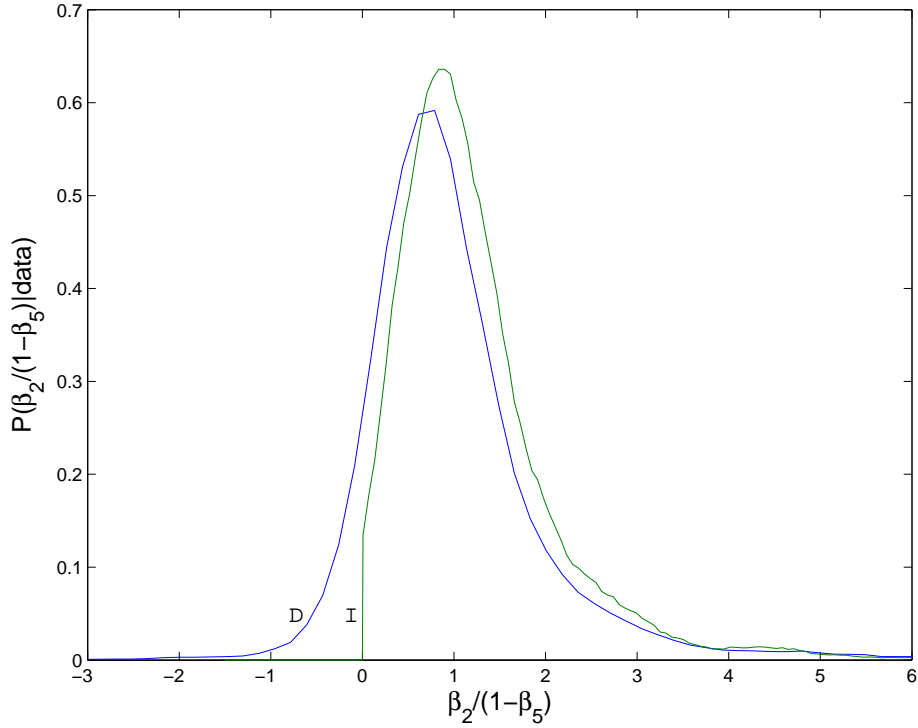
Figure 7: Posterior probability density functions for the long-run wage elasticity of labor supply for RNs based on diffuse (D) and informative (I) priors.

90% credible interval for the long-run elasticity is (0.254, 3.338) for RNs and (0.553, 10.703) for NAOAs.

This analysis suggests that increased public assistance to health care providers, designed to raise wages, probably would not reduce reported shortages arising from monopsony power but would nonetheless appreciably increase employment of RNs and NAOAs.

Policy makers considering possible initiatives to increase employment of nurses and nursing aides should of course consider spatial and individual heterogeneity, which is lost from view in the aggregate data analyzed here. A data set on individual workers, including information on their employers and communities, would certainly afford opportunities for a richer analysis.
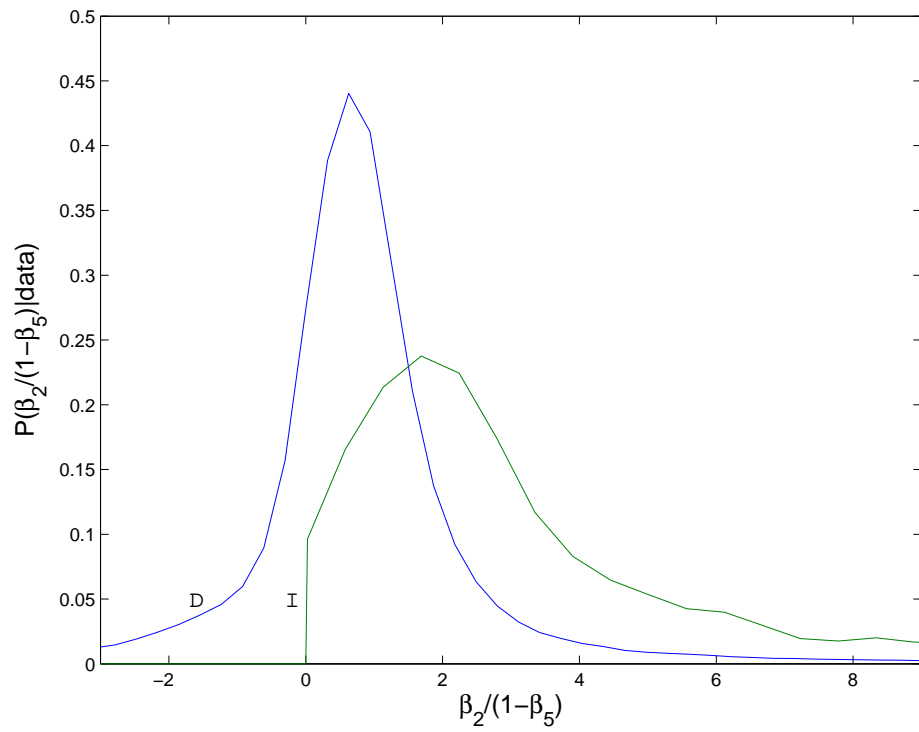
Figure 8: Posterior probability density functions for the long-run wage elasticity of labor supply for NAOAs based on diffuse (D) and informative (I) priors.

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