Wage Adjustment in Local Labor Markets: Do the Wage Rates in all Industries Adjust?

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Abstract

Previous research finds that an increase in a local area's labor demand increases the area's total employment and average wage rate relative to U.S. total employment and the U.S. average wage rate. This paper extends previous research by exploring heterogeneity within an area's labor market. Using employment and average hourly earnings estimates for U.S metropolitan areas, disaggregated by industry, I test whether an increase in an area's overall labor demand increases the wage rate of an industry with constant labor demand located in the area. And, if so, does employment for the industry in the area decrease?

I find that an increase in an area's overall labor demand increases the average hourly earnings of an industry with constant labor demand located in the area, although the industry's employment in the area only slightly decreases or actually increases. Under the structure of a model in which all industries compete for the area's pool of workers, this suggests that an area's labor demand is quite inelastic.

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I. Introduction and Overview

Labor market models with costless factor and product mobility predict that wage rates will be the same in all metropolitan areas of the United States. If the wage rate were higher in a particular area, workers would move to the area to increase their utility and firms would move out of the area to increase their profits. The area's wage rate would fall to the level in other areas.[1] However, it is costly for both labor and firms to move. Short-run mobility costs are likely to prevent wages from adjusting immediately, allowing an area's wage rate to diverge from the U.S. wage rate in the short run.

Several empirical studies find that an increase in an area's labor demand increases the area's wage rate relative to the U.S. wage rate. Topel (1986), Bartik (1991), Eberts and Stone (1992), and Blanchard and Katz (1992) are all examples. Bartik and Eberts and Stone use data for U.S. metropolitan areas. Topel and Blanchard and Katz use U.S. state data. The labor demand/labor supply diagram in Figure 1 gives a grossly simplified summary of these studies. Let $n_{.j}$ equal log employment in area j differenced from U.S. log employment. Let $w_{.j}$ equal the log average wage rate in area j differenced from the U.S. log average wage rate.[2]

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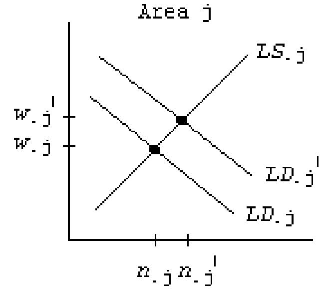
[1]See Rosen (1979) and Roback (1982) for an explanation of why wage rates may vary across areas in the long run.

[2]Section AI of the appendix summarizes this paper's notation.

Figure 1



The studies estimate the response of $n_{.j}$ and $w_{.j}$ to a shift in labor demand from $LD_{.j}$ to $LD_{.j}'$. In general, they find that an area's elasticity of labor supply is between 2.0 and 5.0. That is, an increase in the area's labor demand increases both an area's employment and its wage rate. The percent increase in employment tends to exceed the percent increase in the wage rate, which suggests that $LS_{.j}$ in Figure 1 is fairly elastic.

This paper extends the work in previous studies by exploring heterogeneity within an area's labor market. Previous studies typically use an area's total employment, an estimate of an area's average wage rate, and a single instrument for an area's labor demand to estimate the area's elasticity of labor supply. Consequently, their results imply that an increase in an area's labor demand increases the area's total employment and average wage rate.[3] However, does an increase in an area's average wage rate represent an increase in wage rates among all firms and individuals located in the area? When an area's overall labor demand increases, the labor demand curves of all

[3]This is a bit overstated. Eberts and Stone (1992) also use employment and average wage rates for areas divided into good-producing and service-producing sectors. Blanchard and Katz (1992) also use average wage rates in manufacturing for U.S. states. And Bartik (1991) uses several estimates for areas' wage rates, including estimates for quantiles of areas' wage rates.

industries in the area undoubtedly do not increase uniformly. Do the wage rates of all industries in the area increase uniformly or do the wage rates of some industries diverge from the wage rates of others? And how does an increase in an area's labor demand affect employment among industries in the area? As a concrete example, between 1980 and 1986, average hourly earnings increased by 18% in Akron, Ohio. In Denver, Colorado, average hourly earnings increased by 38%.[4] Both Akron and Denver had firms in the furniture manufacturing industry in 1980. Did the wage rate of workers from Akron furniture manufacturing firms increase by 18% from 1980 to 1986 while the wage rate of workers from Denver furniture manufacturing firms increased by 38%? If so, did employment in Denver furniture manufacturing firms grow at a slower rate than employment in Akron furniture manufacturing firms?

This paper considers two alternative answers to these questions. Both are extreme cases. I will refer to the first case as the area model. In the area model, the wage rates of all industries in an area increase uniformly with an increase in the area's overall labor demand. Figure 2 shows the effect of an increase in labor demand for industry i=I while labor demand for other industries in area j remains constant. $N_{.j}$ equals total employment in area j, N_{ij} equals employment for industry i in area j, and W_j equals the wage rate in area j.

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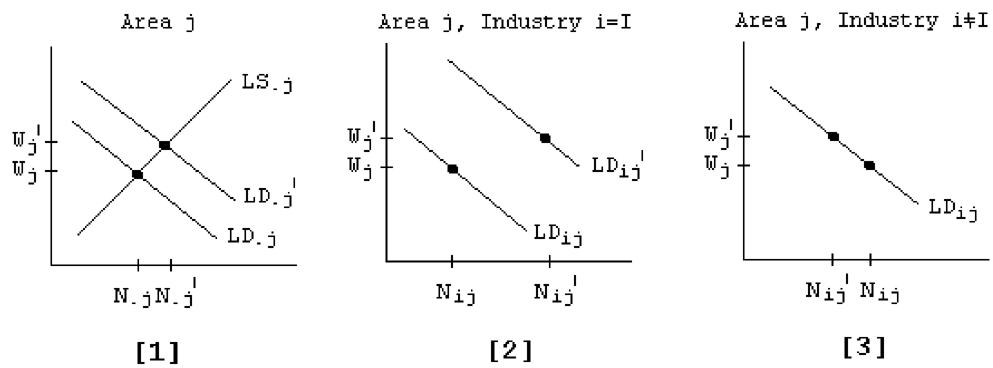
[4]Average hourly earnings growth in nominal terms; calculated using data described in Section III.

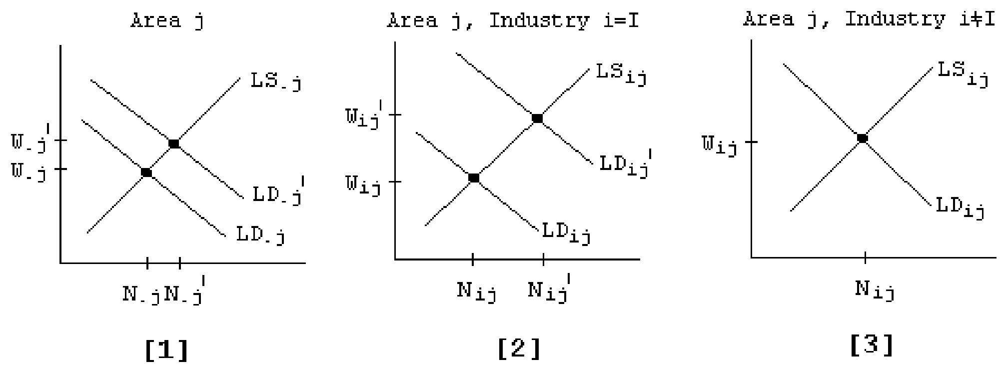
Figure 2: Area Model



As shown in panel [2], the labor demand curve for industry i=I shifts to the upper right from LD_{ij} to LD_{ij}'. The labor demand curve for area j is the sum of the labor demand curves across industries in area j, so an increase in labor demand for industry i increases area j's overall labor demand. As shown in panel [1], area j's labor demand curve shifts to the upper right from $LD_{.j}$ to $LD_{.j}'$, although the increase is proportionally smaller than the increase in labor demand for industry i=I in area j. The wage rate in area j increases from W_j to W_j' and total employment increases from $N_{.j}$ to $N_{.j}'$. For industry i=I, employment increases from N_{ij} to N_{ij}'. For the other industries in area j, as shown in panel [3], employment decreases from N_{ij} to N_{ij}'. An increase in labor demand for industry i=I acts as a negative labor supply shock for other industries located in area j.

However, suppose industries' wage rates in an area do not increase uniformly with an increase in the area's labor demand. At the other extreme, which I will refer to as the alternative model, suppose the wage rate of an industry in an area is not affected by the labor demand of other industries located in the same area. Figure 3 shows the effect of an increase in labor demand for industry i=I while labor demand for other industries in area j remains constant. W_{ij} equals the wage rate for industry i in area j, and $W_{.j}$ equals the average wage rate in area j.

Figure 3: Alternative Model



As shown in panel [2], the increase in labor demand increases employment and the wage rate of industry i in area j. In panel [3], however, employment and the wage rate of other industries in the area are not affected. Total employment and the average wage rate in area j increase, as shown in panel [1], which is substantively the same as panel [1] from Figure 2. However, unlike panel [1] from Figure 2, the change in area j's average wage rate does not represent the change in any industry's wage rate in area j. The change in an area's average wage rate is merely the aggregate of the change in each industry's wage rate.

The empirical work in previous studies is largely analogous to estimating the slope of the labor supply curve in panels [1] of Figures 2 and 3. In contrast, by using employment and average hourly earnings estimates for 166 U.S. metropolitan areas disaggregated by 37 2-digit (SIC) industries, this paper tests whether employment and wage rate movement among industries in a metropolitan area is consistent with the diagrams in panels [2] and [3] of Figure 2 or consistent with the diagrams in panels [2] and [3] of Figure 3.

I use an industry's U.S. employment and U.S. average hourly earnings to instrument for the industry's labor demand in a metropolitan area. Thus, the empirical test is the following. For an industry with constant U.S. employment and constant U.S. average hourly earnings, does the industry's average hourly earnings in a metropolitan area increase with an increase in the U.S. employment and U.S. average hourly earnings of other industries located in the same area? In other words, for an industry with constant labor demand, does the industry's average hourly earnings in an area increase with an increase in the area's overall labor demand? And, if so, does the industry's employment in the area decrease, following the prediction of panel [3] from Figure 2?

The empirical results are summarized as follows.

- The average hourly earnings of an industry with constant labor demand increases with an increase in labor demand among other industries located in the same area. However, the average hourly earnings of all industries in an area do not increase uniformly with an increase in the area's overall labor demand.

- The magnitude of the increase in an industry's average hourly earnings in an area, given an increase in labor demand among other industries located in the same area, depends on the similarity of the industries' distribution of occupations.

- Even though the average hourly earnings of an industry with constant labor demand increases with an increase in the area's overall labor demand, employment for the industry only slightly decreases or actually increases. Under the structure of the area model shown in Figure 2, this suggests that an area's labor demand is quite inelastic.

The remainder of the paper is organized as follows. Section II summarizes the specification used for the empirical work in Section IV. Section III briefly describes the data used for the empirical work. Section IV presents the empirical results. Section V summarizes.

II. Empirical Specification

The empirical work in Section IV consists of estimating the parameters for two sets of regression equations: equations (1) and (2) and equations (3) and (4).

(1) $(N_{.jt}-N_{.jt-1})/N_{.jt-1} = \tau_{1t} + \Theta_{11}Z_{Njt} + \Theta_{12}Z_{Wjt} + v_{1.jt}$

(2) $W_{.jt}-W_{.jt-1} = \tau_{2t} + \Theta_{21}Z_{Njt} + \Theta_{22}Z_{Wjt} + v_{2.jt}$

(3) $(N_{ijt}-N_{ijt-1})/N_{ijt-1} = \tau_{3t} + \Theta_{31}[(N_{i.t}-N_{i.t-1})/N_{i.t-1}] + \Theta_{32}(W_{i.t}-W_{i.t-1}) + \Theta_{33}Z_{Njt} + \Theta_{34}Z_{Wjt} + v_{1ijt}$

(4) $W_{ijt}-W_{ijt-1} = \tau_{4t} + \Theta_{41}[(N_{i.t}-N_{i.t-1})/N_{i.t-1}] + \Theta_{42}(W_{i.t}-W_{i.t-1}) + \Theta_{43}Z_{Njt} + \Theta_{44}Z_{Wjt} + v_{2ijt}$

where: N_{ijt} = employment for industry i in area j in year t.
W_{ijt} = average hourly earnings for industry i in area j in year t.
$N_{.jt}$ = total employment in area j in year t.
$W_{.jt}$ = average hourly earnings in area j in year t.
$N_{i.t}$ = U.S. employment for industry i in year t.
$W_{i.t}$ = U.S. average hourly earnings for industry i in year t.
$Z_{Njt} = \Sigma_i(N_{ijt-1}/N_{.jt-1})[(N_{i.t}-N_{i.t-1})/N_{i.t-1}]$
$Z_{Wjt} = \Sigma_i(N_{ijt-1}/N_{.jt-1})(W_{i.t}-W_{i.t-1})$

In equations (1) and (2), the percent change in an area's total employment and the change in an area's average hourly earnings are regressed on instruments for the change in the area's overall labor demand. In equations (3) and (4), the percent change in employment and the change in average hourly earnings for an industry in an area are regressed on instruments for the change in the industry's labor demand and instruments for the change in the area's overall labor demand. The Θ parameters are coefficients for the labor demand instruments. The τ parameters are year-varying intercept terms.

In equations (1) through (4), the percent change in an industry's U.S. employment and the change in an industry's U.S. average hourly earnings instrument for the change in the industry's labor demand in an area.[5] Analogously, the average percent change in industries' U.S. employment and the average change in industries' U.S. average hourly earnings instrument for the change in an area's overall labor demand, where the averages are weighted by the area's mix of industries in the previous year. That is, $[(N_{i.t}-N_{i.t-1})/N_{i.t-1}]$ and $(W_{i.t}-W_{i.t-1})$ instrument for the change in industry i's labor demand in area j, while Z_{Njt} and Z_{Wjt} instrument for the change in area j's overall labor demand.[6]

The specifications in equations (1) through (4) are based on the two models of an area's labor market. Figure 2 demonstrates the area model. Figure 3 demonstrates the alternative model. Section AII of the Appendix presents the two models in detail. In this section, however, I only summarize the models' predictions, as they merely formalize the intuition in Figures 2

[5]The specifications in equations (1) through (4) are based on the models of an area's labor market presented in Section AII of the Appendix. The models assume that the change in labor demand for an industry in an area has a component that is common to the industry across all areas, while the change in labor supply for an industry in an area has no component that is common to the industry across all areas. With these and the models' other assumptions, the percent change in an industry's U.S. employment and the change in an industry's U.S. average hourly earnings are valid instruments for the change in the industry's labor demand in an area.

[6]Bartik (1991) and Blanchard and Katz (1992) use a similar instrument. A potential problem with using the industry's proportion of the area's total employment in the previous year to calculate the instruments for the change in an area's overall labor demand is that, in equation (3), N_{ijt-1} is used to calculate the dependent variable and two of the independent variables: Z_{Njt} and Z_{Wjt}. This could lead to spurious correlation. However, I experimented with using the industry's proportion of the area's total employment in the current year, as well as the industry's proportion of the area's total employment over multiyear periods. The results were not sensitive.

and 3. In the area model, all industries compete for an area's pool of workers, thereby determining the area's wage rate. An increase in an area's overall labor demand increases the wage rates of industries in the area uniformly. Thus, the change in the wage rate for an industry in an area is determined by the change in labor demand among all industries in the area, not by the change in labor demand for any single industry. In contrast, in the alternative model, each area/industry combination is a separate labor market. Employment and the wage rate for an industry in an area is determined by labor demand for the industry alone. Labor demand among other industries located in the same area is not relevant.

The following lists the area and alternative models' predictions for the parameters in equations (1) through (4).

			Area Model (Figure 2)		Alternative Model (Figure 3)	
Eq.	Labor Demand Instrument	Coef.	Predicted sign	Restricted coefficent	Predicted sign	Restricted coefficent
(1)	Z_{Njt}	Θ_{11}	+	$[\eta^s/(\eta^d+\eta^s)]$	+	$[\eta^s/(\eta^d+\eta^s)]$
	Z_{Wjt}	Θ_{12}	+	$[\eta^d\eta^s/(\eta^d+\eta^s)]$	+	$[\eta^d\eta^s/(\eta^d+\eta^s)]$
(2)	Z_{Njt}	Θ_{21}	+	$[1/(\eta^d+\eta^s)]$	+	$[1/(\eta^d+\eta^s)]$
	Z_{Wjt}	Θ_{22}	+	$[\eta^d/(\eta^d+\eta^s)]$	+	$[\eta^d/(\eta^d+\eta^s)]$
(3)	$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	Θ_{31}	+	1	+	$[\eta^s/(\eta^d+\eta^s)]$
	$W_{i.t}-W_{i.t-1}$	Θ_{32}	+	η^d	+	$[\eta^d\eta^s/(\eta^d+\eta^s)]$
	Z_{Njt}	Θ_{33}	-	$-[\eta^d/(\eta^d+\eta^s)]$	0	0
	Z_{Wjt}	Θ_{34}	-	$-\eta^d[\eta^d/(\eta^d+\eta^s)]$	0	0
(4)	$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	Θ_{41}	0	0	+	$[1/(\eta^d+\eta^s)]$
	$W_{i.t}-W_{i.t-1}$	Θ_{42}	0	0	+	$[\eta^d/(\eta^d+\eta^s)]$
	Z_{Njt}	Θ_{43}	+	$[1/(\eta^d+\eta^s)]$	0	0
	Z_{Wjt}	Θ_{44}	+	$[\eta^d/(\eta^d+\eta^s)]$	0	0

Note: When all the models' restrictions are imposed, the τ parameters from equations (1) through (4) are functions of η^d, η^s, and a year-specific shock to labor supply that is common to all areas, defined as π_t.

When all the models' restrictions are imposed, the Θ coefficients are functions of the slopes of the labor demand and labor supply curves shown in Figures 2 and 3. The labor demand slope is defined as $-\eta^{\mathbf{d}}$. (Thus, a positive value for $\eta^{\mathbf{d}}$ implies a downward-sloping labor demand curve.) The labor supply slope is defined as $\eta^{\mathbf{s}}$. The models assume that the labor demand and labor supply slopes apply to all industries and areas. Also note that $\eta^{\mathbf{d}}$ and $\eta^{\mathbf{s}}$ are semi-elasticities; that is, they equal the percent change in employment with respect to a unit change in the wage rate.[7]

Section AII of the Appendix derives the restricted coefficients. However, their form is readily apparent from Figures 2 and 3. As panels [1] of Figures 2 and 3 suggest, the area and alternative models imply the same restrictions for equations (1) and (2). Thus, the interpretation of the parameter estimates for equations (1) and (2) is the same following either model. I concentrate on the models' restriction that both Θ_{11}/Θ_{21} and Θ_{12}/Θ_{22} equal $\eta^{\mathbf{s}}$. That is, because both Z_{Njt} and Z_{Wjt} instrument for shifts in an area's overall labor demand curve, their coefficients from the total employment equation divided by their coefficients from the average wage rate equation equal the slope of an area's labor supply curve.

In contrast, as panels [2] and [3] from Figures 2 and 3 suggest, the area and alternative models imply different restrictions for equations (3) and (4). Following the area model's intuition in Figure 2, the change in the wage rate for an industry in an area is determined by the change in the area's overall labor demand. Thus, the area model implies that the coefficients for Z_{Njt} and Z_{Wjt} in equation (4) are positive. Moreover, once the effect of a

[7]I use the percent change in employment and the level change in average hourly earnings to be consistent with the labor market models in Section AII. The results are the same qualitatively when I use the log change for both employment and average hourly earnings.

change in an industry's labor demand is accounted for in the change in an area's overall labor demand, it has no further effect on the expected change in the industry's wage rate in the area. Thus, the area model implies that the coefficients for $[(N_{i.t}-N_{i.t-1})/N_{i.t-1}]$ and $(W_{i.t}-W_{i.t-1})$ in equation (4) are zero. That is, because an increase in an area's overall labor demand increases the wage rates of all industries in the area uniformly, the change in an area's average wage rate represents the change in each industry's wage rate in the area. Thus, under the area model's assumptions, equation (4) is identical to equation (2), although I add an extra residual to equation (4) to account for idiosyncratic movement in an individual industry's wage rate.

For equation (3), the area model implies that the expected change in employment for an industry in an area is a function of both the change in the industry's labor demand and the change in the area's overall labor demand. Therefore, under the area model's assumptions, the instruments for the change in an individual industry's labor demand combine with the instruments for the change in an area's overall labor demand to identify the labor demand parameter $\eta^{\mathbf{d}}$. That is, holding labor demand for an industry constant, an increase in an area's overall labor demand moves the industry's employment and wage rate in the area to the upper left along a downward-sloping labor demand curve, as panel [3] of Figure 2 demonstrates.

In contrast to the area model, the alternative model assumes that each industry in an area is a separate labor market. That is, the change in employment and the wage rate for an industry in an area is a function of the change in labor demand for the industry alone. Moreover, the change in an area's total employment and average wage rate is merely the aggregate of the change in employment and the wage rate for individual industries located in the area. Thus, the restricted coefficients in equation (3) and (4) equal the restricted coefficients in equation (1) and (2) under the alternative model's assumptions.

The empirical work in Section VI is based primarily on the area model, although the alternative model provides alternative hypotheses. I estimate equations (1) and (2) and equations (3) and (4) as seemingly-unrelated regression systems. I estimate the parameters in both their linear form and imposing all the area model's restrictions. I use the procedure suggested by White (1980) to calculate asymptotic standard errors for the estimated parameters. Consequently, for equations (1) and (2), the standard error estimates are consistent under general forms of heteroskedasticity for $v_{1.jt}$ and $v_{2.jt}$ and general forms of correlation between $v_{1.jt}$ and $v_{2.jt}$ for observations from the same area and year. Similarly, for equations (3) and (4), the standard error estimates are consistent under general forms of heteroskedasticity among the v_{1ijt}'s and the v_{2ijt}'s, general forms of correlation among the v_{1ijt}'s and the v_{2ijt}'s for observations from the same area and year but different industries, and general forms of correlation between v_{1ijt} and v_{2ijt} for observations from the same area and year but different industries.

III. Data

I combine payroll and employment data from County Business Patterns (CBP) with hours worked data from the March Current Population Survey (CPS) to estimate employment and average hourly earnings for 166 U.S. metropolitan areas (MSAs), broken down by 37 2-digit (SIC) industries. Likewise, I combine CBP data with CPS data to estimate U.S. employment and U.S. average hourly earnings by 2-digit industry. The data run annually from 1974 through 1990, although the effective sample runs from 1975 through 1990 because the variables are first differenced. I convert average hourly earnings from all years to first-quarter 1990 dollars using the national Consumer Price Index for urban workers, though I make no adjustment for price-level differences among metropolitan areas. Lettau (1993) describes the data set in detail.

IV. Regression results

A. MSA results

In the first set of regressions, I estimate the parameters for equations (1) and (2), so the dependent variables are the percent change in an MSA's total employment and the change in an MSA's average hourly earnings. MSA j's total employment for year t equals the sum of employment across industries in area j for year t.

$$(5)\quad N_{.jt} = \Sigma_i N_{ijt}$$

MSA j's average hourly earnings for year t equals the mean of average hourly earnings across industries in area j for year t, weighted by each industry's employment.

$$(6)\quad W_{.jt} = \Sigma_i (N_{ijt}/N_{.jt}) W_{ijt}$$

As mentioned in Section I, previous studies typically use an area's total employment and an area's average wage rate to estimate the response of an area's employment and wage rate to a shift in labor demand. Therefore, the first set of regression results are comparable to results from previous studies. They provide the natural starting point. Table 1 shows descriptive statistics for the variables used to estimate equations (1) and (2).

The top half of Table 2 shows parameter estimates for equations (1) and (2) when none of the models' restrictions are imposed. The dependent variable in column 1 is $(N_{.jt}-N_{.jt-1})/N_{.jt-1}$. The dependent variable in column 2 is $W_{.jt}-W_{.jt-1}$. Year dummy variables, Z_{Njt}, and Z_{Wjt} are the explanatory variables. Column 3 shows the implied estimate for an area's labor supply elasticity, which equals the coefficient estimate from the employment equation divided by the coefficient estimate from the wage rate equation, multiplied by 10, the approximate sample mean of $W_{.jt}$. According to both the area and the alternative models, the two labor demand instruments should give similar estimates for the elasticity of an area's labor supply. The elasticity estimates differ greatly however. The employment instrument gives a positive estimate of 3.172. The wage rate instrument gives a negative estimate of -0.096. The null hypothesis that Θ_{11}/Θ_{21} equals Θ_{12}/Θ_{22} is rejected with 99% confidence. Previous studies generally use an area's employment to instrument for shifts in the area's labor demand, so the labor supply elasticity estimate based on the coefficient estimates for Z_{Njt} is more comparable to estimates reported previously. An elasticity estimate slightly above 3.0 is in line with previous estimates, which are between 2.0 and 5.0.[8]

The bottom of Table 2 shows parameter estimates when I impose the models' restrictions. I estimate $\eta^{\mathbf{d}}$, $\eta^{\mathbf{s}}$, and π_t using nonlinear least-

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[8]With Z_{Wjt} excluded as an explanatory variable, the coefficient estimates for Z_{Njt} give a labor supply elasticity estimate of 2.908.

squares.[9] The estimate of η^{s} implies an estimate for an area's labor supply elasticity of 1.380, about halfway between the separate estimates given by Z_{Njt} and Z_{Wjt}. If preference is given to Z_{Njt} for measuring an area's labor demand, the labor supply elasticity estimate of 3.172 corroborates results from previous studies. However, if both labor demand instruments are assumed equally valid in identifying an area's labor supply elasticity, the results in Table 2 provide conflicting evidence. The coefficient estimates for Z_{Wjt} suggest that an area's labor supply elasticity is near zero.

The estimate of η^{d} implies a low elasticity of labor demand for an area, about 0.192. However, in equations (1) and (2), η^{d} is identified through functional form assumptions only. No variable instruments for shifts in an area's labor supply. Consequently, I make no inference from the estimate for η^{d} in Table 2.

B. Individual Industry Results

In the second set of regressions, I estimate the parameters for equations (3) and (4). The dependent variables are the percent change in an industry's employment in an MSA and the change in an industry's average hourly earnings in an MSA. Table 3 shows descriptive statistics. For 387 observations (0.5% of total observations), the average hourly earnings change is less than -5.0 or greater than 5.0. I omit these observations as outliers. The parameter estimates do not appear sensitive to the threshold for outliers.

Columns 1 and 2 of Table 4 show parameter estimates for equations (3) and (4) when Θ_{41} and Θ_{42} from equation (4) are restricted to equal zero. None of the area model's other restrictions are imposed however. The dependent

[9] The null hypothesis that the τ and Θ parameters from equations (1) and (2) are the functions of η^{d}, η^{s}, and π_t implied by the area and alternative models is rejected with 99% confidence.

variable in column 1 is the percent change in an industry's employment in an MSA. The dependent variable in column 2 is the change in an industry's average hourly earnings in an MSA. For the equation (3), the area model implies that the coefficient for $(N_{i.t}-N_{i.t-1})/N_{i.t-1}$ equals 1.0, the coefficient for $W_{i.t}-W_{i.t-1}$ is positive, and the coefficients for Z_{Njt} and Z_{Wjt} are negative. The coefficient estimate for $(N_{i.t}-N_{i.t-1})/N_{i.t-1}$ in column 1 is fairly close to 1.0 at 0.838, and the coefficient estimate for $W_{i.t}-W_{i.t-1}$ is positive though small in magnitude at 0.011. However, contrary to the area model's prediction, the coefficient estimate for Z_{Njt} in column 1 is positive and statistically significant at 1.428. The area model implies that, holding labor demand for an industry constant, an increase in an area's overall labor demand decreases employment for the industry in the area, as panel [3] of Figure 2 demonstrates. The size of the decrease depends on the slope of the industry's labor demand curve. However, the positive coefficient estimate for Z_{Njt} suggests that, for an industry with constant labor demand, employment increases with an increase in the area's overall labor demand rather than decreases. Under the structure of the area model, this suggests that an industry's labor demand curve slopes upward rather than downward. The alternative model implies that, holding labor demand for an industry constant, an increase in an area's overall labor demand does not affect employment for the industry in the area, so the positive coefficient estimate for Z_{Njt} also contradicts the alternative model. Consistent with the area model, the coefficient estimate for Z_{Wjt} in column 1 is negative at -0.032, though not statistically significant.

For equation (4), the area model implies that the coefficients for Z_{Njt} and Z_{Wjt} are positive. Consistent with the area model's prediction, the coefficient estimates for Z_{Njt} and Z_{Wjt} in column 2 of Table 4 are positive and statistically significant. However, they are only about a third the magnitude of the coefficient estimates when the dependent variable is the change in an area's average hourly earnings, shown in column 2 of Table 2. According to the area model, the only difference between the change in an industry's wage rate in an area and the change in an area's average wage rate is the extra residual added to equation (4). The τ and Θ parameters in equations (2) and (4) are the same. In other words, because an increase in an area's labor demand increases the wage rates of all industries in the area uniformly, the expected increase in the wage rate for an industry in an area equals the expected increase in the area's average wage rate. Accordingly, the coefficient estimates in column 2 of Table 4 should be similar to the coefficient estimates in column 2 of Table 2. However, the parameter estimates in Tables 2 and 4 imply that, with an increase in an area's labor demand, the expected increase in the area's average hourly earnings is about three times greater than the expected increase in the average hourly earnings of an industry in the area. This suggests that the wage rates of all industries in an area do not increase uniformly with an increase in the area's labor demand.

Columns 3 and 4 of Table 4 show parameter estimates for equations (3) and (4) under no restrictions. This specification incorporates the predictions of both the area and the alternative models. The coefficient estimates in column 3 differ slightly from the coefficient estimates in column 1 because I estimate equations (3) and (4) as a regression system. The coefficient estimates for Z_{Njt} and Z_{Wjt} in column 4 are similar to the coefficient estimates in column 2; that is, the coefficient estimates for Z_{Njt}

and Z_{Wjt} do not change much when $(N_{i.t}-N_{i.t-1})/N_{i.t-1}$ and $W_{i.t}-W_{i.t-1}$ are included as explanatory variables. Consistent with the area model and contrary to the alternative model, the positive coefficient estimates for Z_{Njt} and Z_{Wjt} in column 4 suggest that, for an industry with constant labor demand, an increase in an area's labor demand increases the industry's average hourly earnings in the area. However, contrary to the area model and consistent with the alternative model, the coefficient estimate for $W_{i.t}-W_{i.t-1}$ in column 4 is positive and significant, which implies that $W_{i.t}-W_{i.t-1}$ contributes to the expected change in industry i's average hourly earnings in area j beyond its contribution to Z_{Wjt}. This suggests that, if an industry's labor demand increases while labor demand for other industries in an area remains constant, the industry's wage rate in the area will diverge from the wage rates of other industries in the area. The joint hypothesis that Θ_{41} and Θ_{42} equal zero is rejected against the alternative that they do not zero with 99% confidence. Surprisingly, however, the coefficient estimate for $(N_{i.t}-N_{i.t-1})/N_{i.t-1}$ in column 4 is negative. The area model implies a zero coefficient while the alternative model implies a positive coefficient, so the negative coefficient estimate of -0.594 for $(N_{i.t}-N_{i.t-1})/N_{i.t-1}$ contradicts both models.

The unrestricted parameter estimates in Table 4 provide some support for the area model and some support for the alternative model, while the negative coefficient estimate for $(N_{i.t}-N_{i.t-1})/N_{i.t-1}$ in column (4) contradicts both models. Nonetheless, the top half of Table 5 shows parameter estimates for equations (3) and (4) with the area model's restrictions imposed on the τ and Θ parameter estimates.[10] The alternative model implies different

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[10]The null hypothesis that the τ and Θ parameters from equations (3) and (4) are the functions of $\eta^{\mathbf{d}}$, $\eta^{\mathbf{s}}$, and π_t implied by the area model is rejected with 99% confidence.

restrictions, so the estimates for η^d, η^s, and π_t in Table 5 are not valid under the alternative model's assumptions. The estimates for η^d and η^s imply the values for the linear coefficients in equations (3) and (4) shown in the bottom half of the table.

Under the area model's assumptions, variation in labor demand shifts among industries in an area identifies the slope of the area's labor demand curve. Thus, observable variables identify η^d, rather than solely functional form assumptions. The estimate of η^d implies that an area's elasticity of labor demand equals 0.126. To see why the elasticity estimate is so low, again consider the coefficient estimates in columns 1 and 2 of Table 4, where Θ_{41} and Θ_{42} are restricted to equal zero but the area model's other restriction are not imposed. The coefficient estimates for Z_{Njt} and Z_{Wjt} in the wage rate equation are positive, so an increase in an area's labor demand increases the average hourly earnings of an industry in the area. In the employment equation, the coefficient estimate for Z_{Wjt} is negative but small in magnitude while the coefficient estimate for Z_{Njt} is positive. Thus, for an industry with constant labor demand, an increase in an area's overall labor demand increases the industry's average hourly earnings in the area and only slightly decreases or actually increases the industry's employment in the area. Under the area model's structure, this translates into a very steep slope for an industry's labor demand curve. All industries in an area are assumed to have the same labor demand parameter η^d, so an industry's labor demand elasticity in an area equals the area's labor demand elasticity. Therefore, under the area model's assumptions, the results in Table 5 suggest that an area's labor demand is very inelastic at 0.126.

The estimate for an area's elasticity of labor supply in Table 5 is 3.180, about twice the magnitude of the estimate from the MSA regressions in Table 2. However, with employment and average hourly earnings broken down by industry and metropolitan area, η^s is identified largely through functional form assumptions. Consequently, I emphasize the labor supply elasticity estimate in Table 2, which is valid under either the area or the alternative model's assumptions.

C. Extensions

Equations (1) through (4) are based on the area and alternative models, which are static and extremely simple. Therefore, in this subsection, I modify the empirical specification of equations (3) and (4) to account for some of the models' limitations.

1. Local Demand Spillovers

In both the area and alternative models, I assume that there is no cost to trading a good in an area in which it is not produced. However, if a good is costly to trade where it is not produced, the price of the good is likely to differ among areas. Moreover, local demand for the good may be tied to the area's employment or average wage rate, resulting in the industry's labor demand in an area being correlated with the area's overall labor demand. For example, output from the Eating and Drinking industry may be supplied exclusively to the area in which it is produced. As a consequence, the change in U.S. employment and U.S. average hourly earnings for other industries in the area may better predict the change in Eating and Drinking's labor demand in the area than does the change in Eating and Drinking's U.S. employment or U.S. average hourly earnings. In terms of equation (3), v_{1ijt} may be correlated with Z_{Njt} and Z_{Wjt} for industries that supply their output primarily to area j. This may explain why the coefficient estimates for Z_{Njt} in columns 1 and 3 of Table 4 are positive, contrary to either model's prediction.

To mitigate the bias, Tables 6 and 7 show parameter estimates for equations (3) and (4) when only observations from mining and manufacturing industries are used, on the assumption that mining and manufacturing industries primarily supply their output to a national market, so demand for goods produced by these industries is not tied to a single area's employment or average wage rate. I continue to use employment and average hourly earnings from all industries to calculate Z_{Njt} and Z_{Wjt}.

The parameter estimates in Table 6 are fairly similar to the parameter estimates in Table 4 however. In fact, the coefficient estimates for Z_{Njt} in columns 1 and 3 of Table 6 remain positive and are larger in magnitude than the estimates in columns 1 and 3 of Table 4. Table 7 shows parameter estimates when I impose all the area model's restrictions. The labor demand elasticity estimate of 0.040 is even closer to zero than the labor demand elasticity estimate in Table 5, when observations from all industries are used.

2. Occupation Similarity of Industries

In the area model, an increase in labor demand for any industry in an area increases the wage rate of all industries in the area equally. In the alternative model, a change in labor demand for an industry in an area does not affect the wage rates of other industries in the area. Reality is probably between the two extremes. The degree to which an industry's labor demand affects the wage rates of other industries in the area likely depends on the degree to which the industries demand workers with similar skills.

Thus, I next introduce measures of the similarity of occupations between industries into equations (3) and (4).

Rewrite equations (3) and (4) as follows. The instruments for an area's overall labor demand are redefined to include measures of the similarity of the occupation distribution between industries. (For clarity, I use a subscript k rather than an italic i when summing across industries.)

$$(7)\quad (N_{ijt}-N_{ijt-1})/N_{ijt-1} = \tau_{3t} + \Theta_{31}[(N_{i.t}-N_{i.t-1})/N_{i.t-1}] + \Theta_{32}(W_{i.t}-W_{i.t-1}) + \Theta_{33}Z_{Nijt} + \Theta_{34}Z_{Wijt} + u_{3ijt}$$

$$(8)\quad W_{ijt}-W_{ijt-1} = \tau_{4t} + \Theta_{41}[(N_{i.t}-N_{i.t-1})/N_{i.t-1}] + \Theta_{42}(W_{i.t}-W_{i.t-1}) + \Theta_{43}Z_{Nijt} + \Theta_{44}Z_{Wijt} + u_{4ijt}$$

where: $Z_{Nijt} = \Sigma_k \omega_{ikjt}[(N_{k.t}-N_{k.t-1})/N_{k.t-1}]$

$Z_{Wijt} = \Sigma_k \omega_{ikjt}(W_{k.t}-W_{k.t-1})$

$\omega_{ikjt} = [(N_{kjt-1}/N_{.jt-1})(S_{ikt})^{\alpha}]/\{\Sigma_k[(N_{kjt-1}/N_{.jt-1})(S_{ikt})^{\alpha}]\}$, so $\Sigma_k \omega_{ikjt} = 1$ for all i,j,t

S_{ikt} = Similarity of occupation distribution between industry i and industry k for year t

Equations (7) and (8) differ from equations (3) and (4) in that two weights are used to calculate the change in an area's overall labor demand. In previous regressions, the change in an area's overall labor demand equaled the weighted average of the change in each industry's labor demand, weighted by the industry's proportion of the area's total employment in the previous year, shown as Z_{Njt} and Z_{Wjt} in equations (1) through (4). In equations (7) and (8), however, I add a second weight: $(S_{ikt})^{\alpha}$. S_{ikt} measures the similarity of the distribution of occupations between industry i and industry k for year t. S_{ikt} ranges from zero to one. S_{ikt} equals zero if the two industries employ no workers from the same occupation; S_{ikt} equals one if the two industries have the same distribution of occupations, such as when i equals k. I use March CPS data on workers' industry and occupation to calculate S_{ikt} for each year and industry combination. The parameter α is estimated with the τ and θ parameters. Section AIII of the appendix describes of how S_{ikt} is calculated.

When α equals zero, equations (7) and (8) reduce to equations (3) and (4). When α is greater than zero, however, Z_{Nijt} and Z_{Wijt} are labeled more properly as instruments for labor demand in area j that is relevant to industry i. In equations (7) and (8), the expected change in an industry's employment and average hourly earnings given an increase in labor demand for another industry located in the same area depends on two factors: the other industry's proportion of the area's total employment **and** whether the other industry tends to employ workers from similar occupations. Because industries differ in the similarity of their distribution of occupations, Z_{Nijt} and Z_{Wijt} differ among industries in an area.

Table 8 shows parameter estimates for equations (7) and (8). The dependent variable in column 1 is the percent change in employment for an industry in an area. The dependent variable in column 2 is the change in the average hourly earnings for an industry in an area. The estimate for the occupation similarity parameter α is allowed to differ between the two equations. For equations (7), including the occupation similarity measure has almost no effect on the parameter estimates. The estimate for α is small in magnitude at 0.038 and not statistically significant. The coefficient estimates for the Θ parameters are similar to the estimates in column 3 of Table 4. However, the estimate of α for equation (8) in column 2 is large in magnitude at 1.081 and statistically significant, which suggests that the expected change in an industry's average hourly earnings in an area given an increase in labor demand for other industries in the area depends on the similarity of the industries' distribution of occupations.

Table 9 shows descriptive statistics for $(S_{ikt})^{\alpha}$ evaluated at the two estimates of α. The estimate of α from the employment equation is close to zero, so $(S_{ikt})^{\alpha}$ is estimated to be close to one regardless of the value of S_{ikt}. However, $(S_{ikt})^{\alpha}$ evaluated at the estimate of α from the wage rate equation takes on a much wider range of values. Consider the following example. The maximum value of S_{ikt} across all years and industry combinations (when k does not equal i) is 0.965 for Electrical Machinery/Industrial Machinery in 1990. The value of S_{ikt} for Electrical Machinery/Education in 1990 is 0.501, which is near the median across all years and industries. Under the specification in equation (8), the estimate of 1.081 for α implies that an increase in labor demand for Electrical Machinery in area j has about twice the effect on the average hourly earnings of Industrial Machinery workers in area j as on Education workers in area j; that is, $(0.965/0.501)^{1.081} = 2.031$. Conversely, the estimate of 0.038 for α from the employment equation suggests that an increase in labor demand for Electrical Machinery in area j has about the same effect on employment for Industrial Machinery workers in area j as on employment of Education workers in area j; that is, $(0.965/0.501)^{0.038} = 1.025$.

Considering the results from previous regressions, the discrepancy between the two estimates for α is not surprising. Previous results suggest that there is little or no tendency for employment of an industry with constant labor demand to decrease with an increase with an area's overall labor demand, even though the industry's average hourly earnings tends to increase. Therefore, it is not surprising that the effect of an increase in an industry's labor demand on another industry's employment in an area is not related to the similarity of the two industries' distribution of occupations, whereas the effect on the other industry's average hourly earnings is related to the similarity of the two industries' distributions of occupations.[11]

3. Lagged Adjustment

Eberts and Stone (1992) and Blanchard and Katz (1992) find that, although both an area's total employment and average wage rate increase with an increase in the area's labor demand, the increase is not simultaneous. The increase in an area's total employment tends to peak a few years before the increase in an area's average wage rate peaks. The regression results so far consider only contemporaneous relations between the dependent variables and the labor demand instruments.

In Tables 10 and 11, I add two lagged values of the labor demand instruments to the MSA and the Individual Industry regressions. The sample runs from 1977 to 1990. For comparison, columns 1 and 2 of the tables show regression results for the same period but with the lagged labor demand instruments excluded. A full interpretation of the coefficient estimates for the lagged instruments requires a dynamic model of areas' labor markets, which is beyond this paper. Rather, I include these results to examine whether significant comovement between the dependent variables and the labor demand instruments is missed by looking only at contemporaneous relations.

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[11]The residual standard deviations (the standard deviation of the residuals from regressions on year dummy variables) of Z_{Nijt} and Z_{Wijt} from equation (8) are 58% and 36% higher than the residual standard deviations of Z_{Njt} and Z_{Wjt} from equation (4). Consequently, the magnitude of the coefficient estimates for Z_{Nijt} and Z_{Wijt} in column 2 of Table 8 are not directly comparable to the magnitude of the coefficient estimates for Z_{Njt} and Z_{Wjt} in column 4 of Table 4.

In general, in both Tables 10 and 11, the coefficient estimates for the lagged labor demand instruments are either not statistically significant or statistically significant but small in magnitude compared to the coefficient estimates for the contemporaneous labor demand instruments. That is, contemporaneous labor demand instruments appear to pick up most of the comovement between the dependent variables and the labor demand instruments. However, notable exceptions are the coefficient estimates for lagged values of Z_{Wjt} (the area labor demand instrument based on U.S. industries' average hourly earnings), particularly when the dependent variable is either the percent change in an MSA's total employment or the percent change in an industry's employment in an MSA. In column 1 of both Tables 10 and 11, the coefficient estimate for Z_{Wjt} is not statistically significant. In column 3 of Tables 10 and 11, however, the coefficient estimates for Z_{Wjt}, Z_{Wjt-1}, and Z_{Wjt-2} are negative, statistically significant, and larger in magnitude than the coefficient estimate for Z_{Wjt} in column 1.

The similarity between the coefficient estimates in column 3 of Tables 10 and 11 contradicts the prediction of the area model. The negative coefficient estimates for Z_{Wjt}, Z_{Wjt-1}, and Z_{Wjt-2} in column 3 of Table 11 are consistent with the area model's prediction that the coefficient for Z_{Wjt} is negative. Moreover, they contradict the conclusion, based on the results in Tables 4 and 5, that competition for labor among industries in an area does not decrease employment for an industry with constant labor demand. However, the coefficient estimate for Z_{Njt} in column 3 of Table 11 remains positive, as are the coefficient estimates Z_{Njt-1} and Z_{Njt-2}. Also, the area model predicts a positive coefficient for Z_{Wjt} in equation (2). Therefore, the negative coefficient estimates for Z_{Wjt}, Z_{Wjt-1}, and Z_{Wjt-2} in column 3 of Table 10 are not consistent with Z_{Wjt}, Z_{Wjt-1}, and Z_{Wjt-2} instrumenting for an area's labor demand.

V. Summary

This paper extends the empirical literature on the response of an area's labor market to a shift in labor demand by exploring heterogeneity within an area's labor market. Two contrary models, which Figures 2 and 3 demonstrate, provide the framework for the paper's empirical results. In the area model, labor demand conditions from all industries in an area jointly determine the area's wage rate and each industry's employment. Conversely, in the alternative model, an industry's employment and wage rate in an area are not affected by labor demand for other industries located in the same area. I estimate the models' parameters using employment and average hourly earnings for 166 U.S. metropolitan areas, disaggregated by 37 industries.

I present two sets of regression results. In the first set, the unit of observation is an MSA. In the second set, the unit of observation is an industry in an MSA. From the first set of regressions, the labor demand instrument based on industries' U.S. employment implies that an area's elasticity of labor supply is slightly above 3.0, which corroborates estimates from previous research. However, the labor demand instrument based on industries' U.S. average hourly earnings implies that an area's elasticity of labor supply is near zero.

Results from the second set of regressions follow neither the area model nor the alternative model completely. Consistent with the area model, the parameter estimates suggest that an increase in an area's overall labor demand increases the average hourly earnings of an industry with constant labor demand located in the area. Consistent with the alternative model, however, the results also suggest that all industries' average hourly earnings in an area do not increase uniformly with an increase in the area's overall labor demand. Moreover, extending the regressions to include measures of the similarity of occupations between industries suggests that the magnitude of the increase in an industry's average hourly earnings, given an increase in labor demand for other industries located in the same area, is larger the more similar the industries' distributions of occupations.

The results also suggest that, for an industry with constant labor demand, an increase in an area's overall labor demand only slightly decreases or actually increases the industry's employment in the area, even though the increase in the area's overall labor demand increases the industry's average hourly earnings. Under the area model's structure, this translates into a very inelastic estimate of 0.124 for an area's labor demand elasticity. In other words, there is little evidence that competition for labor among industries in an area causes a stagnant industry in the area to reduce its employment,[12] even though the stagnant industry tends to increase its wage rate. A caveat to this conclusion, however, is that the evidence is more conflicting when the regressions are extended to include lagged values of the labor demand instruments. Contemporaneous and lagged instruments for an area's overall labor demand based on industries' U.S. average hourly earnings suggest that employment for an industry with constant labor demand does decrease with an increase in the area's overall labor demand, although

[12]Gleaser et al. (1992) find that growth in a U.S. city's four largest industries between 1956 and 1987 had a positive effect on growth in the city's employment between 1956 and 1987 outside the city's four largest industries. They interpet this result as support for urbanization externalities and aggregate demand spillovers among industries in an city and against the crowding out of industries from a city.

contemporaneous and lagged instruments for an area's overall labor demand based on industries' U.S. employment continue to suggest that employment for an industry with constant labor demand increases with an increase in the area's overall labor demand.

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Table 1

Descriptive Statistics for Variables used in MSA Regressions, Data from County Business Patterns and the CPS, 1974-90

	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
$N_{.jt}$	2,656	355,524	462,204	31,258	3,745,160
$W_{.jt}$	2,656	10.075	1.324	6.303	16.911
$(N_{.jt}-N_{.jt-1})/N_{.jt-1}$	2,656	0.029	0.050	-0.256	0.251
$W_{.jt}-W_{.jt-1}$	2,656	-0.066	0.343	-3.820	2.064
Z_{Njt}	2,656	0.026	0.032	-0.086	0.096
Z_{Wjt}	2,656	-0.026	0.153	-0.438	0.470
Deviation from year mean					
$(N_{.jt}-N_{.jt-1})/N_{.jt-1}$	2,656	0.000	0.038	-0.300	0.269
$W_{.jt}-W_{.jt-1}$	2,656	0.000	0.325	-3.726	2.270
Z_{Njt}	2,656	0.000	0.006	-0.048	0.030
Z_{Wjt}	2,656	0.000	0.041	-0.438	0.258

Notes: The subscript j indexes for MSAs, and t indexes for years. The unit of observation is an MSA. Variables under the heading "deviation from year mean" are residuals from a regression on year dummy variables.

Table 2

Parameter Estimates from MSA Regressions,
Data from County Business Patterns and the CPS, 1974-90

	[1]	[2]	[3]
Linear coefficient estimates			
	$(N_{.jt}-N_{.jt-1})/N_{.jt-1}$	$W_{.jt}-W_{.jt-1}$	Labor Supply Elasticity
Z_{Njt}	1.982 **	6.249 **	3.172 **
	(0.134)	(1.105)	(0.580)
Z_{Wjt}	-0.018	1.911 **	-0.096
	(0.022)	(0.191)	(0.116)
Year dummies included	yes	yes	
R^2	0.48	0.17	
Observations	2,656	2,656	

Parameter estimates under restrictions of the area or alternative model

Labor demand elasticity:	$\eta^d \times 10$	0.192 **
		(0.091)
Labor supply elasticity:	$\eta^s \times 10$	1.380 **
		(0.300)
π_t estimated		yes
Observations		2,656

Notes: Asymptotic standard errors are in parentheses; ** indicates significance at 5%. The subscript j indexes for MSAs, and t indexes for years. The unit of observation is an MSA.

Table 3

Descriptive Statistics for Variables used in Individual Industry Regressions, Data from County Business Patterns and the CPS, 1974-90

	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
N_{ijt}	77,036	11,006	25,416	3	578,409
W_{ijt}	77,036	10.064	3.307	1.953	37.630
$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	77,036	0.036	0.186	-0.912	8.236
$W_{ijt}-W_{ijt-1}$	77,036	-0.045	0.911	-4.983	4.996
$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	77,036	0.019	0.054	-0.288	0.274
$W_{i.t}-W_{i.t-1}$	77,036	-0.030	0.397	-1.899	2.002
Z_{Njt}	77,036	0.026	0.032	-0.086	0.096
Z_{Wjt}	77,036	-0.026	0.153	-0.438	0.470
Deviation from year mean					
$(N_{.jt}-N_{.jt-1})/N_{.jt-1}$	77,036	0.000	0.183	-0.949	8.206
$W_{.jt}-W_{.jt-1}$	77,036	0.000	0.901	-5.196	5.224
$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	77,036	0.000	0.043	-0.333	0.323
$W_{i.t}-W_{i.t-1}$	77,036	0.000	0.363	-1.710	2.035
Z_{Njt}	77,036	0.000	0.006	-0.048	0.030
Z_{Wjt}	77,036	0.000	0.040	-0.438	0.259

Notes: The subscript j indexes for MSAs, i indexes for industries, and t indexes for years. The unit of observation is an industry in an MSA. Variables under the heading "deviation from year mean" are residuals from a regression on year dummy variables.

Table 4

Parameter Estimates from Individual Industry Regressions, Data from County Business Patterns and the CPS, 1974-90

	[1]	[2]	[3]	[4]
	Linear coefficient estimates			
	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$
$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	0.838 **	--	0.850 **	-0.594 **
	(0.018)		(0.018)	(0.091)
$W_{i.t}-W_{i.t-1}$	0.011 **	--	-0.001	0.566 **
	(0.002)		(0.002)	(0.011)
Z_{Njt}	1.428 **	2.252 **	1.430 **	2.199 **
	(0.142)	(0.588)	(0.142)	(0.586)
Z_{Wjt}	-0.032	0.636 **	-0.032	0.617 **
	(0.026)	(0.092)	(0.026)	(0.091)
Year dummies included	yes	yes	yes	yes
R^2	--	--	0.08	0.07
Observations	77,036	77,036	77,036	77,036

Notes: Asymptotic standard errors in parentheses; ** indicates significance at 5%. The subscript j indexes for MSAs, i indexes for industries, and t indexes for years. The unit of observation is an industry in an MSA.

Table 5

Parameter Estimates from Individual Industry Regressions, Data from County Business Patterns and the CPS, 1974-90

Parameter estimates under restrictions of the area model

Labor demand elasticity:	$\eta^d \times 10$	0.126 ** (0.020)
Labor supply elasticity:	$\eta^s \times 10$	3.180 ** (0.674)
π_t estimated		yes
Observations		77,036

Linear coefficients implied by parameter estimates

	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$
$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	1.000	0.000
$W_{i.t}-W_{i.t-1}$	0.013	0.000
Z_{Njt}	-0.038	3.025
Z_{Wjt}	-0.000	0.038

Notes: Asymptotic standard errors are in parentheses; ** indicates significance at 5%. The subscript j indexes for MSAs, i indexes for industries, and t indexes for years. The unit of observation is an industry in an MSA.

Table 6

Parameter Estimates from Individual Industry Regressions, Data from County Business Patterns and the CPS, 1974-90, Mining and Manufacturing Industries Only

	[1]	[2]	[3]	[4]
	Linear coefficient estimates			
	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$
$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	0.862 **	--	0.879 **	-0.862 **
	(0.035)		(0.035)	(0.173)
$W_{i.t}-W_{i.t-1}$	0.004	--	-0.004	0.468 **
	(0.004)		(0.004)	(0.021)
Z_{Njt}	2.081 **	1.498	2.081 **	1.488
	(0.239)	(1.107)	(0.239)	(1.104)
Z_{Wjt}	-0.057	1.033 **	-0.056	0.968 **
	(0.042)	(0.173)	(0.042)	(0.171)
Year dummies included	yes	yes	yes	yes
R^2	--	--	0.07	0.04
Observations	34,855	34,855	34,855	34,855

Notes: Asymptotic standard errors in parentheses; ** indicates significance at 5%. The subscript j indexes for MSAs, i indexes for industries, and t indexes for years. The unit of observation is an industry in an MSA.

Table 7

Parameter Estimates from Individual Industry Regressions,
Data from County Business Patterns and the CPS, 1974-90,
Mining and Manufacturing Industries Only

Parameter estimates under restrictions of the area model

Labor demand elasticity:	$\eta^d \times 10$	0.040
		(0.035)
Labor supply elasticity:	$\eta^s \times 10$	3.722 **
		(1.647)
π_t estimated		yes
Observations		34,855

Linear coefficients implied by parameter estimates

	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$
$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	1.000	0.000
$W_{i.t}-W_{i.t-1}$	0.004	0.000
Z_{Njt}	-0.011	2.658
Z_{Wjt}	-0.000	0.011

Notes: Asymptotic standard errors are in parentheses; ** indicates significance at 5%. The subscript j indexes for MSAs, i indexes for industries, and t indexes for years. The unit of observation is an industry in an MSA.

Table 8

Parameter Estimates from Individual Industry Regressions,
Data from County Business Patterns and the CPS, 1974-90,
Measure of Occupation Similarity Included

	[1]	[2]
	Linear coefficient estimates	
	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$
$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	0.846 **	-0.768 **
	(0.024)	(0.113)
$W_{i.t}-W_{i.t-1}$	-0.001	0.540 **
	(0.002)	(0.014)
Z_{Nijt}	1.424 **	1.723 **
	(0.142)	(0.458)
Z_{Wijt}	-0.032	0.583 **
	(0.026)	(0.085)
Occupation Similarity Parameter: α	0.038	1.081 **
	(0.094)	(0.209)
Year dummies included	yes	yes
R^2	0.08	0.07
Observations	77,036	77,036

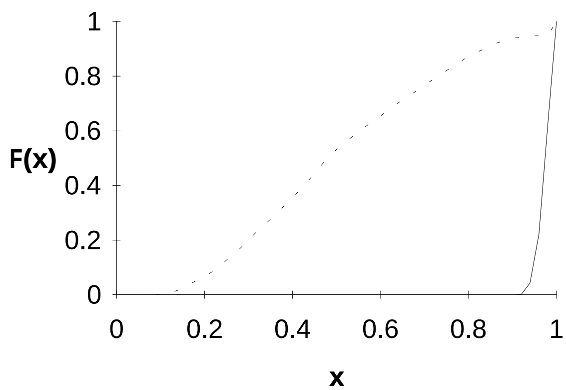
Notes: Asymptotic standard errors in parentheses; ** indicates significance at 5%. The subscript j indexes for MSAs, i indexes for industries, and t indexes for years. The unit of observation is an industry in an MSA.

Table 9

Descriptive Statistics for Occupation Similarity Measure,
using Results from Individual Industry Regressions,
Data from County Business Patterns and the CPS, 1974-90

	$(\hat{S}_{ikt})^{\hat{\alpha}}$ from employment equation, ($\hat{\alpha}$ = 0.038)	**$(\hat{S}_{ikt})^{\hat{\alpha}}$ from avg. hourly earnings equation, ($\hat{\alpha}$ = 1.081)**	
No. of Obs.	11,248	11,248	
Mean	0.973	0.514	
Std	0.017	0.229	
Quartiles			
Min	0.902	0.054	Eating & Drinking/Social Services, 1975
25th	0.916	0.332	Hotels/Tobacco, 1985
Median	0.974	0.480	Construction/Elec. Machinery, 1989
75th	0.987	0.685	Elec. Machinery/Primary Metals, 1979
Max (<1)	0.999	0.962	Elec. Machinery/Ind. Machinery, 1990
CDF	——	---	

Cumulative Distribution Functions



Notes: S_{ikt} calculated using CPS data from 1975 through 1990. Statistics are for all years pooled together.

Table 10

Parameter Estimates from MSA regressions,
Data from County Business Patterns and the CPS, 1974-90

	[1]	[2]	[3]	[4]
	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$
Z_{Njt}	2.098 ** (0.140)	6.969 ** (1.314)	1.824 ** (0.174)	8.185 ** (1.751)
Z_{Njt-1}	--	--	0.177 (0.159)	-3.547 * (1.814)
Z_{Njt-2}	--	--	0.313 ** (0.133)	1.456 (1.445)
Z_{Wjt}	-0.030 (0.023)	1.840 ** (0.205)	-0.037 * (0.022)	1.861 ** (0.205)
Z_{Wjt-1}	--	--	-0.052 ** (0.026)	0.450 ** (0.187)
Z_{Wjt-2}	--	--	-0.050 ** (0.019)	-0.428 * (0.223)
Year dummies included	yes	yes	yes	yes
R^2	0.45	0.18	0.46	0.19
Observations	2,324	2,324	2,324	2,324

Notes: Asymptotic standard errors in parentheses; * indicates significance at 10%, ** indicates significance at 5%. The subscript j indexes for MSAs and t indexes for years. The unit of observation is an MSA.

Table 11

Parameter Estimates from Individual Industry Regressions,
Data from County Business Patterns and the CPS, 1974-90

	[1]	[2]	[3]	[4]
	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$	$(N_{ijt}-N_{ijt-1})/N_{ijt-1}$	$W_{ijt}-W_{ijt-1}$
$(N_{i.t}-N_{i.t-1})/N_{i.t-1}$	0.839 ** (0.019)	-0.417 ** (0.106)	0.868 ** (0.023)	-0.508 ** (0.121)
$(N_{i.t-1}-N_{i.t-2})/N_{i.t-2}$	--	--	0.002 (0.024)	0.137 (0.119)
$(N_{i.t-2}-N_{i.t-3})/N_{i.t-3}$	--	--	-0.077 ** (0.020)	0.131 (0.098)
$W_{i.t}-W_{i.t-1}$	-0.002 (0.002)	0.540 ** (0.012)	-0.001 (0.002)	0.539 ** (0.012)
$W_{i.t-1}-W_{i.t-2}$	--	--	0.001 (0.002)	0.013 (0.011)
$W_{i.t-2}-W_{i.t-3}$	--	--	0.003 * (0.002)	0.004 (0.011)
Z_{Njt}	1.471 ** (0.157)	2.622 ** (0.647)	1.189 ** (0.178)	3.106 ** (0.743)
Z_{Njt-1}	--	--	0.401 ** (0.148)	-0.678 (0.671)
Z_{Njt-2}	--	--	0.110 (0.111)	0.040 (0.513)
Z_{Wjt}	-0.035 (0.026)	0.596 ** (0.097)	-0.046 * (0.025)	0.623 ** (0.098)
Z_{Wjt-1}	--	--	-0.039 * (0.021)	0.247 ** (0.087)
Z_{Wjt-2}	--	--	-0.063 ** (0.017)	0.168 ** (0.085)
Year dummies included	yes	yes	yes	yes
R^2	0.07	0.07	0.07	0.07
Observations	66,190	66,190	66,190	66,190

Notes: Asymptotic standard errors in parentheses; * indicates significance at 10%, ** indicates significance at 5%. The subscript j indexes for MSAs, i indexes for industries, and t indexes for years. The unit of observation is an industry in an MSA.

Appendix

AI. Notation

In this paper, employment and wage rates are disaggregated by industry and area. The subscript i indexes for industries and j indexes for areas. For example, N_{ij} equals employment for industry i in area j. When employment or wage rates are aggregated across industries or areas, the corresponding subscript is replaced by an italic subscript in the summation and a . subscript in the sum. For example, the sum of employment across industries in area j is expressed as $N_{.j} = \Sigma_{i} N_{ij}$. I drop the . subscript, however, when I assume explicitly that the aggregate quantity is the same in all industries or areas. For example, when all industries in area j are assumed to pay the same wage rate, W_j equals the wage rate in area j. When all industries in area j are not assumed to pay the same wage rate, W_{ij} equals the wage rate for industry i in area j and $W_{.j}$ equals the average wage rate in area j.

AII. Models of an Area's Labor Market

A. Area Model

1. Labor Demand

Let metropolitan areas contain a positive number of firms from industries i = 1 ... I. Metropolitan areas are indexed by j = 1 ... J. The number of industries is finite while the number of areas approaches infinity. Within an industry, firms are homogeneous, so technology is the same for firms from the same industry regardless of where they are located. Each industry produces one good, so i indexes for goods as well as for industries. Goods are traded without cost, so the price of each good is the same in all areas.

Assume that firms are fixed in their location and that factors of production other than labor are fixed in the short run. The short-run production function for a firm from industry i in area j has a quadratic form.

(A1) $x_{ij} = \phi_i n_{ij} - (2\eta^{\mathbf{d}})^{-1} n_{ij}^2, \quad \eta^{\mathbf{d}} > 0.$

where: x_{ij} = output for a firm from industry i in area j

n_{ij} = employment for a firm from industry i in area j

I treat ϕ_i as a random variable with a mean equal to ϕ_0, $\phi_0 > 0$; ϕ_i accounts for labor demand conditions specific to firms from industry i. The labor demand parameter $\eta^{\mathbf{d}}$ applies to firms from all industries and areas.

Assume that workers are homogeneous and can move among firms and industries without cost, so firms from all industries in an area pay the same wage rate. Setting the marginal product of labor equal to a firm's product wage rate gives the labor demand curve for a firm from industry i in area j.

$$(A2) \quad n_{ij} = \eta^{\mathbf{d}}\phi_i - \eta^{\mathbf{d}}(W_j/P_i)$$

where: W_j = wage rate in area j
P_i = price of good i.

Labor demand for industry i in area j equals the number of firms from industry i in area j multiplied by labor demand for a firm from industry i in area j.

$$(A3) \quad N_{ij} = q_{ij}n_{ij}$$
$$= \eta^{\mathbf{d}}q_{ij}\phi_i - \eta^{\mathbf{d}}q_{ij}(W_j/P_i)$$

where: N_{ij} = employment for industry i in area j
q_{ij} = number of firms from industry i in area j

The number of firms from industry i in area j is assumed to be uncorrelated with the random variable ϕ_i.

Labor demand in area j equals the sum of N_{ij} across industries.

$$(A4) \quad N_{.j} = \Sigma_i N_{ij}$$
$$= \eta^{\mathbf{d}}\Sigma_i q_{ij}\phi_i - \eta^{\mathbf{d}}W_j\Sigma_i q_{ij}(1/P_i)$$

where: $N_{.j}$ = employment in area j

2. Labor Supply

Consider individual m living in area j. The individual maximizes utility by choosing how much of each good to consume and whether or not to work. Assume that individual m's utility function has the following form.

(A5) $U_m = \Sigma_i C_{im} - \psi_m D_m$

where: U_m = utility for individual m
C_{im} = individual m's consumption of good i
D_m = 1 if individual m works, 0 otherwise.

Utility is linear in all goods. Individuals value all goods equally. Individual m's disutility from working equals ψ_m. The individual maximizes equation (A5) subject to his or her budget constraint.

(A6) Max U_m s.t. $\Sigma_i P_i C_{im} = Y_m + W_j D_m$

where: Y_m = individual m's non labor income

Because utility is linear in all goods, each good's demand curve is perfectly elastic. A change in a good's production function does not affect the good's price; preferences alone determine the price of each good. Individuals value all goods equally, so the price of each good can be set equal to one.

Individual m from area j works if W_j is greater than ψ_m. Labor supply for area j equals the number of individuals who choose to work at a given value of W_j. Assume that, among individuals in area j, ψ_m follows a uniform distribution between ν_j and $b+\nu_j$. The random variable ν_j accounts for labor supply conditions that are specific to area j. Let the mean of ν_j equal ν_0, $\nu_0>0$. Assume that ν_j is uncorrelated across areas, and assume that ν_j is uncorrelated with the number of firms from industry i in area j.

Define L_j as the number of individuals living in area j, and assume that L_j is large for all j. Labor supply in area j equals the following.

(A7) $N_{.j} = L_j Pr[D_m=1]$
$= (1/b)L_j W_j - (1/b)L_j \nu_j$

3. Equilibrium

Area j's equilibrium wage rate is found by setting area j's labor demand equal to area j's labor supply. Define $q_{.j}$ as the total number of firms in area j.

$$\text{(A8)} \quad q_{.j} = \Sigma_i q_{ij}$$

where: $q_{.j}$ = Number of firms in area j

To simplify the model's solution, assume that firms and individuals are allocated to areas such that the ratio of the number of firms in an area to the number of individuals living in the area is the same for all areas. That is, assume $q_{.j}/L_j$ equals a constant λ for all j. Factors of production other than labor are fixed, so the number of firms in an area proxies for the quantity of an area's non-labor factors of production. Thus, I assume that the ratio of an area's non labor factors of production to the area's population is the same for all areas. Setting equation (A7) equal to equation (A4) gives the wage rate for area j.

$$\text{(A9)} \quad W_j = [\eta^{\mathbf{d}}/(\eta^{\mathbf{d}}+\eta^{\mathbf{s}})]\Sigma_i(q_{ij}/q_{.j})\phi_i + [\eta^{\mathbf{s}}/(\eta^{\mathbf{d}}+\eta^{\mathbf{s}})]\nu_j$$

where: $\eta^{\mathbf{s}} = (\lambda b)^{-1}$

In equation (A4), the slope of an area's labor demand curve, $\eta^{\mathbf{d}}q_{.j}$, depends on the total number of firms in area j. Similarly, in equation (A7), the slope of an area's labor supply curve, $(1/b)L_j$, depends on the number of individuals living in area j. However, with the assumption that $q_{.j}/L_j$ equals λ in all areas, the rescaled labor supply parameter $\eta^{\mathbf{s}}$ is constant across areas.

The average value of ϕ_i across firms, $\Sigma_i(q_{ij}/q_{.j})\phi_i$, determines area j's wage rate. Plugging the wage rate from equation (A9) into equation (A4) gives employment for area j, expressed in equation (A10) as a ratio to the number of firms in area j.

$$\text{(A10)} \quad N_{.j}/q_{.j} = [\eta^{\mathbf{d}}\eta^{\mathbf{s}}/(\eta^{\mathbf{d}}+\eta^{\mathbf{s}})]\Sigma_i(q_{ij}/q_{.j})\phi_i - [\eta^{\mathbf{d}}\eta^{\mathbf{s}}/(\eta^{\mathbf{d}}+\eta^{\mathbf{s}})]\nu_j$$

All firms in area j pay the same wage rate, so the solution for W_j gives employment for industry i in area j, expressed in equation (A11) as a ratio to the number of firms from industry i in area j.

(A11) $N_{ij}/q_{ij} = \eta^{\mathbf{d}}\phi_i - \eta^{\mathbf{d}}[\eta^{\mathbf{d}}/(\eta^{\mathbf{d}}+\eta^{\mathbf{s}})]\Sigma_i(q_{ij}/q_{.j})\phi_i - [\eta^{\mathbf{d}}\eta^{\mathbf{s}}/(\eta^{\mathbf{d}}+\eta^{\mathbf{s}})]\nu_j$

The results in equations (A9), (A10), and (A11) match the intuition from Figure 2. Average labor demand among industries in an area determines the area's wage rate and total employment. A combination of an industry's labor demand and average labor demand among industries in an area determines employment for the industry in the area.

Aggregate employment for industry i equals the sum of employment in industry i across areas.

(A12) $N_{i.} = \Sigma_j N_{ij}$

where: $N_{i.}$ = employment for industry i

Define $q_{i.}$ as the total number of firms from industry i.

(A13) $q_{i.} = \Sigma_j q_{ij}$

The number of areas is assumed to approach infinity. Assume further that the number of firms for an industry in any one area is small relative to total number of the firms for the industry. More formally, assume that $\Sigma_j(q_{ij}/q_{i.})^2$ approaches zero as the number of areas approaches infinity for all i. Then, from equation (A11), aggregate employment for industry i equals the following, expressed as a ratio to the number of firms from industry i.

(A14) $N_{i.}/q_{i.} = \eta^{\mathbf{d}}\phi_i - \eta^{\mathbf{d}}[\eta^{\mathbf{d}}/(\eta^{\mathbf{d}}+\eta^{\mathbf{s}})]\Sigma_j(q_{ij}/q_{i.})[\Sigma_i(q_{ij}/q_{.j})\phi_i] - [\eta^{\mathbf{d}}\eta^{\mathbf{s}}/(\eta^{\mathbf{d}}+\eta^{\mathbf{s}})]\nu_0$

For all industries, $\Sigma_j(q_{ij}/q_{i.})\nu_j$ equals ν_0. However, because the number of industries is finite, $\Sigma_j(q_{ij}/q_{i.})[\Sigma_i(q_{ij}/q_{.j})\phi_i]$ will not equal ϕ_0. Let $W_{i.}$ equal the average wage across firms from industry i.

(A15) $W_{i.} = [\eta^{d}/(\eta^{d}+\eta^{s})]\Sigma_{j}(q_{ij}/q_{i.})[\Sigma_{i}(q_{ij}/q_{.j})\phi_{i}] + [\eta^{s}/(\eta^{d}+\eta^{s})]\nu_{0}$

Equations (A14) and (A15) imply the following.

(A16) $\phi_i = (\eta^{d})^{-1}(N_{i.}/q_{i.}) + W_{i.}$

Under the model's assumptions, an industry's labor demand shock ϕ_i can be expressed as a linear function of $N_{i.}/q_{i.}$ and $W_{i.}$. Thus, for the empirical work in Section IV, an industry's U.S. employment and U.S. average hourly earnings instrument for the industry's labor demand in a metropolitan area.

4. Empirical Specification

To estimate the area model's parameters, structure must be placed on the time paths of technology (labor demand) and preferences (labor supply). For the area model, replace ϕ_i from equation (A1) with ϕ_{ijt}, where t indexes for time periods. Assume that $\phi_{ijt}-\phi_{ijt-1}$ is the sum of three random variables;

(A17) $\phi_{ijt}-\phi_{ijt-1} = \varepsilon_t + \varepsilon_{it} + \varepsilon_{ijt}$

ε_t is common to all industries in all areas, ε_{it} is common to an industry in all areas, and ε_{ijt} is unique to an industry in an area. To identify the model's parameters, assume the expected value of ε_{ijt} is zero and that ε_{ijt} is uncorrelated with ε_t and ε_{it} for all i, j, and t. Also, assume there is no correlation among the ε_{ijt}'s for observations from different areas or for observations from the same area but different time periods. The ε_{ijt}'s may be correlated for observations from the same area and time period but different industries.

Replace ν_j from equation (A7) with ν_{jt}, where $\nu_{jt}-\nu_{jt-1}$ is the sum of two random variables;

(A18) $\nu_{jt}-\nu_{jt-1} = \pi_t + \pi_{jt}$

π_t is common to all areas, while π_{jt} is unique to an area. Assume the expected value of π_{jt} is zero and that π_{jt} is uncorrelated with π_t for all j. Also assume that there is no correlation among the π_{jt}'s.

With the assumptions in equations (A17) and (A18), plus the results from equations (A10), (A9), (A11), and (A16), the area model implies the following.

$$(A19)\ (N_{.jt}-N_{.jt-1})/q_{.j} = -[\eta^d\eta^s/(\eta^d+\eta^s)]\pi_t + [\eta^s/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})[(N_{i.t}-N_{i.t-1})/q_{i.}] + [\eta^d\eta^s/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})(W_{i.t}-W_{i.t-1}) + u_{1.jt}$$

where: $u_{1.jt} = [\eta^d\eta^s/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})\varepsilon_{ijt} - [\eta^d\eta^s/(\eta^d+\eta^s)]\pi_{jt}$

$$(A20)\ W_{jt}-W_{jt-1} = [\eta^s/(\eta^d+\eta^s)]\pi_t + [1/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})[(N_{i.t}-N_{i.t-1})/q_{i.}] + [\eta^d/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})(W_{i.t}-W_{i.t-1}) + u_{2jt}$$

where: $u_{2jt} = [\eta^d/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})\varepsilon_{ijt} + [\eta^s/(\eta^d+\eta^s)]\pi_{jt}$

$$(A21)\ (N_{ijt}-N_{ijt-1})/q_{ij} = -[\eta^d\eta^s/(\eta^d+\eta^s)]\pi_t + (N_{i.t}-N_{i.t-1})/q_{i.} + \eta^d(W_{i.t}-W_{i.t-1}) - [\eta^d/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})[(N_{i.t}-N_{i.t-1})/q_{i.}] - \eta^d[\eta^d/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})(W_{i.t}-W_{i.t-1}) + u_{1ijt}$$

where: $u_{1ijt} = \eta^d\varepsilon_{ijt} - \eta^d[\eta^d/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})\varepsilon_{ijt} - [\eta^d\eta^s/(\eta^d+\eta^s)]\pi_{jt}$

Also, for estimation, I relax the area model's restriction that all industries in an area pay the same wage rate by adding a second residual to equation (A20).

$$(A22)\ W_{ijt}-W_{ijt-1} = [\eta^s/(\eta^d+\eta^s)]\pi_t + [1/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})[(N_{i.t}-N_{i.t-1})/q_{i.}] + [\eta^d/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})(W_{i.t}-W_{i.t-1}) + (u_{2ijt}+\xi_{ijt})$$

Assume the expected value of ξ_{ijt} is zero and that there is no correlation among the ξ_{ijt}'s for observations from different areas or for observations from the same area but different time periods. The ξ_{ijt}'s may be correlated for observations from the same area and time period but different industries.

In equations (A19) through (A22), I scale employment changes by the number of firms in the industry and/or the area. For the empirical work, however, I divide the change in employment by the previous period's employment rather than by the number of firms; that is, I use $(N_{ijt}-N_{ijt-1})/N_{ijt-1}$ rather than $(N_{ijt}-N_{ijt-1})/q_{ij}$, etc. Scaling employment changes by the previous period's employment has at least two advantages. First, the model is not rich enough to explain variation in the average size of firms across industries. Scaling employment changes by the previous period's employment rather than by the number of firms abstracts from differences in average firm size among industries and areas. Second, because employment changes are expressed in percent terms, the models' parameters become semi-elasticities. Consequently, η^{s} multiplied by an area's wage rate equals the area's elasticity of labor supply, and η^{d} multiplied by an area's wage rate equals the area's elasticity of labor demand. Moreover, because η^{d} is constant across industries, η^{d} multiplied by an industry's wage rate in an area equals the elasticity of labor demand for the industry in the area. I also replace $\Sigma_{i}(q_{ij}/q_{.j})(\cdot)$ with $\Sigma_{i}(N_{ijt-1}/N_{.jt-1})(\cdot)$.

Equations (A19) through (A22) are rewritten in a more general form as equations (1) through (4) in Section II, with employment changes are scaled by the previous period's employment.

B. Alternative Model

The setup for the alternative model is much the same as the setup for the area model. However, I assume additionally that industry-specific human capital ties an individual to a particular industry, so wage rates may vary among industries in an area.

1. Labor Demand

The labor demand setup for the alternative model is the same as for the area model. Labor demand for industry i in area j equals the following.

(A23) $N_{ij} = \eta^{d}q_{ij}\phi_{i} - \eta^{d}q_{ij}(W_{ij}/P_{i})$

where: W_{ij} = wage rate for industry i in area j

2. Labor Supply

Individual m's utility function again has the following form.

(A24) $U_{m} = \Sigma_{i}C_{im} - \psi_{m}D_{m}$

The individual maximizes equation (A24) subject to his or her budget constraint.

(A25) Max U_{m} s.t. $\Sigma_{i}P_{i}C_{im} = Y_{m} + W_{ij}D_{m}$

Individual m from area j works in industry i if W_{ij} is greater than ψ_m. Labor supply for industry i in area j equals the number of individuals who choose to work at a given value of W_{ij}. Assume that, among individuals in area j tied to industry i, ψ_m follows a uniform distribution between ν_{ij} and $b+\nu_{ij}$. The random variable ν_{ij} accounts for labor supply conditions that are specific to industry i in area j. Let the mean of ν_{ij} equal ν_0, $\nu_0>0$, and assume that ν_{ij} is uncorrelated for industry/area combinations from different areas. Define L_{ij} as the number of individuals living in area j tied to industry i, and assume that L_{ij} is large for all i,j. Labor supply for industry i in area j equals the following.

(A26) $$N_{ij} = L_{ij}Pr[D_m=1] = (1/b)L_{ij}W_{ij} - (1/b)L_{ij}\nu_{ij}$$

3. Equilibrium

Under the alternative model's assumptions, setting labor demand equal to labor supply for industry i in area j gives the wage rate for industry i in area j. Assume that firms and individuals are allocated to industries and areas such that the ratio of the number of firms from industry i in area j to the number of individuals living in area j and tied to industry i is the same for all industry/area combinations. That is, q_{ij}/L_{ij} equals a constant λ for all i,j. Setting equation (A23) equal to (A26) gives the wage rate for industry i in area j.

(A27) $$W_{ij} = [\eta^{d}/(\eta^{d}+\eta^{s})]\phi_i + [\eta^{s}/(\eta^{d}+\eta^{s})]\nu_{ij}$$

where: $\eta^{s} = (\lambda b)^{-1}$

Plugging the wage rate from equation (A27) into equation (A23) gives employment for industry i in area j, expressed in equation (A28) as a ratio to the number of firms from industry i in area j.

(A28) $$N_{ij}/q_{ij} = [\eta^{d}\eta^{s}/(\eta^{d}+\eta^{s})]\phi_i - [\eta^{d}\eta^{s}/(\eta^{d}+\eta^{s})]\nu_{ij}$$

The average wage rate and total employment for area j equal the following. Employment for area j is expressed as a ratio to the number of firms in area j.

(A29) $W_{.j} = [\eta^{d}/(\eta^{d}+\eta^{s})]\Sigma_{i}(q_{ij}/q_{.j})\phi_{i} + [\eta^{s}/(\eta^{d}+\eta^{s})]\Sigma_{i}(q_{ij}/q_{.j})\nu_{ij}$

(A30) $N_{.j}/q_{.j} = [\eta^{d}\eta^{s}/(\eta^{d}+\eta^{s})]\Sigma_{i}(q_{ij}/q_{.j})\phi_{i} - [\eta^{d}\eta^{s}/(\eta^{d}+\eta^{s})]\Sigma_{i}(q_{ij}/q_{.j})\nu_{ij}$

Equations (A29) and (A30) are virtually identical to equations (A9) and (A10). However, equations (A27) and (A28) differ substantively from equations (A9) and (A11). In the alternative model, each industry/area combination is a separate labor market. Industry i's employment and wage rate in area j are functions of labor demand only for industry i. Labor demand for other industries in the area is not relevant.

Aggregate employment for industry i equals the following, expressed as a ratio to the number of firms from industry i.

(A31) $N_{i.}/q_{i.} = [\eta^{d}\eta^{s}/(\eta^{d}+\eta^{s})]\phi_{i} - [\eta^{d}\eta^{s}/(\eta^{d}+\eta^{s})]\Sigma_{j}(q_{ij}/q_{i.})\nu_{ij}$

The average wage rate among firms from industry i equals the following.

(A32) $W_{i.} = [\eta^{d}/(\eta^{d}+\eta^{s})]\phi_{i} + [\eta^{s}/(\eta^{d}+\eta^{s})]\Sigma_{j}(q_{ij}/q_{i.})\nu_{ij}$

Equations (A9) and (A10) imply the following.

(A33) $\phi_{i} = (\eta^{d})^{-1}(N_{i.}/q_{i.}) + W_{i.}$

Equation (A33) is identical equation (A16). They restate industry i's labor demand curve. Note, however, that the alternative model implies that $W_{i.}$ and $N_{i.}/q_{i.}$ are perfectly correlated, so the labor demand shock ϕ_{i} could alternatively be expressed as a linear function of either $W_{i.}$ and $N_{i.}/q_{i.}$.

The empirical work in Section IV is based primarily on the area model. Further, the empirical measures of industry's national employment and national wage rate will not correlate perfectly. Therefore, for the empirical work in Section IV, I use both an industry's national employment and an industry's national average hourly earnings to instrument for the industry's labor demand.

4. Empirical Specification

Replace ϕ_i from equation (A23) with ϕ_{ijt}, and assume that $\phi_{ijt}-\phi_{ijt-1}$ is the sum of three random variables;

(A34) $\phi_{ijt}-\phi_{ijt-1} = \varepsilon_t + \varepsilon_{it} + \varepsilon_{ijt}$

Replace ν_{ij} from equation (A26) with ν_{ijt}, where $\nu_{ijt}-\nu_{ijt-1}$ is the sum of two random variables;

(A35) $\nu_{ijt}-\nu_{ijt-1} = \pi_t + \pi_{ijt}$

With the assumptions in equations (A34) and (A35), plus the results from equations (A30), (A29), (A28), and (A27), the alternative model implies the following.

(A36) $(N_{.jt}-N_{.jt-1})/q_{.j} = -[\eta^d\eta^s/(\eta^d+\eta^s)]\pi_t + [\eta^s/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})[(N_{i.t}-N_{i.t-1})/q_{i.}]$
$+ [\eta^d\eta^s/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})(W_{i.t}-W_{i.t-1}) + u_{3.jt}$

where: $u_{3.jt} = [\eta^d\eta^s/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})\varepsilon_{ijt} - [\eta^d\eta^s/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})\pi_{ijt}$

(A37) $W_{.jt}-W_{.jt-1} = [\eta^s/(\eta^d+\eta^s)]\pi_t + [1/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})[(N_{i.t}-N_{i.t-1})/q_{i.}]$
$+ [\eta^d/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})(W_{i.t}-W_{i.t-1}) + u_{4.jt}$

where: $u_{4.jt} = [\eta^d/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})\varepsilon_{ijt} + [\eta^s/(\eta^d+\eta^s)]\Sigma_i(q_{ij}/q_{.j})\pi_{ijt}$

(A38) $(N_{ijt}-N_{ijt-1}/q_{ij}) = -[\eta^d\eta^s/(\eta^d+\eta^s)]\pi_t + [\eta^s/(\eta^d+\eta^s)][(N_{i.t}-N_{i.t-1})/q_{i.}]$
$+ [\eta^d\eta^s/(\eta^d+\eta^s)](W_{i.t}-W_{i.t-1}) + u_{3ijt}$

where: $u_{3ijt} = [\eta^d\eta^s/(\eta^d+\eta^s)]\varepsilon_{ijt} - [\eta^d\eta^s/(\eta^d+\eta^s)]\pi_{ijt}$

(A39) $W_{ijt}-W_{ijt-1} = [\eta^s/(\eta^d+\eta^s)]\pi_t + [1/(\eta^d+\eta^s)][(N_{i.t}-N_{i.t-1})/q_{i.}]$
$+ [\eta^d/(\eta^d+\eta^s)](W_{i.t}-W_{i.t-1}) + u_{4ijt}$

where: $u_{4ijt} = [\eta^d/(\eta^d+\eta^s)]\varepsilon_{ijt} + [\eta^s/(\eta^d+\eta^s)]\pi_{ijt}$

With employment changes scaled by the previous period's employment and $\Sigma_i(q_{ij}/q_{.j})(\cdot)$ replaced with $\Sigma_i(N_{ijt-1}/N_{.jt-1})(\cdot)$, the general specification in equations (1) through (4) from Sections II captures the alternative model's predictions in equations (A36) through (A39).

AIII. Occupation Similarity Measure

S_{ikt} equals one minus a segregation index discussed by Duncan and Duncan (1955). It is defined as follows.

(A40) $S_{ikt} = 1 - (0.5)\Sigma_O|f_{iot} - f_{kot}|$

where: f_{iot} = Proportion of industry i employment in occupation o in year t.
f_{kot} = Proportion of industry k employment in occupation o in year t.

S_{ikt} ranges from zero to one. S_{ikt} equals zero when the two industries employ no workers from the same occupation. S_{ikt} equals one when the two industries have identical occupation distributions, such as when i equals k. I use March CPS surveys from 1975 through 1990 to calculate f_{iot}. The samples include private workers who report a current industry and current occupation. The following lists the occupations. The occupation breakdowns change slightly between 1982 and 1983.

1975-1982

1. Professionals
2. Managers and Administrators
3. Sales workers
4. Clerical workers
5. Protective Service workers
6. Other service workers
7. Craft and kindred workers
8. Transportation operatives
9. Other operatives
10. Laborers

1983-1990

1. Executives and Managers
2. Professionals
3. Technicians
4. Sales workers
5. Administrative support workers
6. Protective service workers
7. Other service workers
8. Precision production and craft workers
9. Machine Operators
10. Transportation Occupations
11. Handlers and Laborers