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I. INTRODUCTION

In recent years, scores of studies estimating the elasticity of the demand for labor have been written (for a review see Hamermesh, 1976). Some studies have focused on the elasticity of demand for labor in the economy as a whole (Hamermesh 1986). Others have focused on particular industries (Cotterill 1975 and Ashenfelter and Ehrenberg 1975). A third group of studies has investigated the elasticity of demand for particular skill groups (Nadiri and Rosen 1974). Finally, a fourth group of studies has drawn attention to differences in the elasticity of demand for labor between different race/gender/age groups (Grant and Hamermesh 1981).

One area that has been virtually ignored has been specific estimates of elasticity of demand for labor at the state level. One possible explanation for the lack of attention to state demand variations is that analysts have implicitly assumed that the elasticity of demand was roughly the same for the nation as for individual states. While this assumption may be valid for some states, it does not seem to be a tenable generalization. Specific comparisons between state and national labor demand models are necessary to determine whether state employment is affected by the same factors and to the same degree as national employment. Differences in industrial mix and demographic composition could contribute to differences in demand elasticity. The purpose of this study is to examine the elasticity of demand for labor in Ohio's manufacturing sector and to compare the estimate with national studies.

Labor demand estimates have important implications for policy formation (Hamermesh, 1976; Hamermesh and Grant, 1979; and Killingsworth, 1985). For example, if one wished to analyze Ohio's employment impact from a change in Old Age, Survivors, Disability and Health Insurance (OASDHI) taxes, employment tax credits, the taxable base for unemployment insurance, or tax on employer group health insurance premiums, one needs to know the elasticity of demand for labor.

Knowledge of possible differences between the demand elasticity for labor between Ohio and the U.S. could be extremely important to policy makers. At the federal level, knowledge of differences in state demand elasticities will allow more detailed estimates of the impact of a variety of programs that affect wages and output. This would allow policy makers to target job creation programs using discretionary policy. In addition, knowledge concerning the impact of wage subsidies and taxes in the state would be extremely useful given Ohio's active role in formulating economic development policy. (Blair and Premus 1987). In particular it would give state officials a better idea of the job creating potential of various economic development policies.

In the second section, a theoretical framework for analyzing the demand for labor is presented. In Section III, this framework is used to develop a model that is well suited to analyze the elasticity of demand for labor in Ohio and the United States. In Section IV, the data is discussed and empirical estimates of the model are presented. The Ohio and United States demand models are compared. We show that the demand estimates for Ohio and the United States are very similar.

II. THE DEMAND FOR LABOR

Following Hamermesh (1976) and Killingsworth (1985), we assume that the supply of labor and capital is infinitely elastic at prevailing input prices and that labor and capital are both normal goods. The demand for labor and the marginal cost in the aggregate are given as follows:

$$L = F(w,r,q) \tag{1}$$

(2) $\mu = M(w,r,q)$

where L is labor, w is the wage rate, r is the cost of capital and q is output. Furthermore, it is assumed that $F_w < 0$ holding r and q constant; i.e., the substitution effect is negative and $F_r > 0$, so an increase in the price of capital causes an increase in the demand for labor. $F_q > 0$ so increases in output necessarily increase the demand for labor, and it is also assumed that μ, marginal cost, increases as w and r increase holding output constant.

The demand for market output is given by:

(3) $P = H(q)$

where $H_q < 0$, implying that the demand curve is downward sloping.

In equilibrium, it is assumed that price is equal to marginal cost, thus:

(4) $H(q) = M(w,r,q)$.

Totally differentiating equations 1 and 4 holding r constant we obtain:

(5) $dL = F_w\, dw + F_q\, dq$

(6) $H_q\, dq = M_w\, dw + M_q\, dq$

Dividing both 5 and 6 by dw and substituting 6 into 5 we obtain the following:

(7) $dL/dw = F_w + F_q\, M_w/(H_q - M_q)$.

To simplify, we assume that production takes place under constant returns to scale, i.e., that $M_q = 0$. Next, we multiply both sides of 7 by w/L, multiply the right hand side by Pq/Pq and rearrange terms to obtain the following elasticities:

(8) $EL/Ew|_r = EL/Ew|_{q,r} +$

$[EL/Eq|_{w,r}]\ [Eq/EP]\ [EP/Ew|_r]$

where $EL/Ew|_r$ and $Eq/EP < 0$ and $EL/Eq|_{w,r}$ and $EP/Ew|_r > 0$.

The first part of equation 8 represents the substitution effect caused by a change in the wage rate, other things being equal. The second part of equation 8 represents the scale effect which contains three components: the change in the demand for labor caused by the change in the demand for output, the change in the quantity demanded resulting from the price change, and the change in price caused by the change in wages. Unfortunately, the empirical data necessary to measure [Eq/EP] and $[EP/Ew|_r]$ are not available for Ohio. Following other studies on the demand for labor (Hamermesh, 1976; and Clark and Freeman, 1980), we will estimate only the substitution elasticity, $[EL/Ew|_{q,r}]$, and the output elasticity, $[EL/Eq|_{w,r}]$. Our findings will be of interest as long as $[EL/Eq|_{w,r}]$ is not perfectly inversely correlated with [Eq/EP] $[EP/Ew|_r]$ across regions.

III. THE EMPIRICAL MODEL

In order to estimate the partial elasticity of demand for labor with respect to wages and output, we used the following model:

(9) $\ln L_t = \beta_0 + \beta_1 \ln w_t + \beta_2 \ln q_t + \beta_3 \ln np_t$

where,

$\ln L_t$ = log of production workers employment in the ith state in year t,
$\ln w_t$ = log of the real wage in the ith state in year t,
$\ln q_t$ = log of real output in the ith state in year t, and
$\ln np_t$ = log of the ratio of nonproduction to production workers in year t.

If the demand for labor is inelastic, a 1 percent increase in the real wage rate, other things being equal, will cause less than a 1 percent decline in the quantity of labor demanded. Since most studies have shown that the demand for labor is inelastic (see Hamermesh 1986), we expect-1 < β_1 < 0 where β_1 is a direct estimate of the substitution elasticity, $[(EL/Ew)|_{q,r}]$.

An increase in output, other things being equal, will cause an increase in the demand for labor. If the demand for labor, with respect to output, is inelastic, β_2 should be positive but less than one. Again, the partial elasticity of the demand for labor with respect to output $[(EL/Eq)|_{w,r}]$ will be directly estimated by β_2.

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Finally, the ratio of nonproduction to production workers was included in the estimating equation. Clark and Freeman (1980) suggested that nonproduction workers might be included in a labor demand equation for production workers. This is done because the labor demand equation being estimated is based on a two-factor production function when in reality there are other inputs which must be held constant. Ideally, one would like to specify a complete system of factor demand equations, but unfortunately the data needed for such a specification is unavailable. Since nonproduction workers are a substitute for production workers, as the ratio increases, we expect the demand for production workers to decrease. Thus, we expect $\beta_3 < 0$.

Unfortunately, data on interest rates, taxes, depreciation and the cost of capital equipment, which is needed to directly measure the price of capital, is unavailable for Ohio. Therefore, it is impossible to develop a measure of the cost of capital for Ohio. Hamermesh (1976) has argued that failure to include the cost of capital in empirical models imparts a downward bias in estimates of the substitution elasticity but appears to have no impact on the estimate of the output elasticity. However, Clark and Freeman (1980) argue that this result is an artifact of estimating a constrained model where the wage rate and the price of capital are constrained to have equal and opposite signs. Specifically, they have shown that, in the presence of measurement error, the price of capital should be entered as a separate variable in labor demand equations. When this is done, the substitution elasticity appears to be of the same magnitude in studies which include or exclude the price of capital in labor demand questions. Therefore, we believe that the bias caused by omitting this variable will be minimal.

IV. DATA AND EMPIRICAL FINDINGS

The model was estimated using annual data for 1954-83 for Ohio and the United States. Data on value added, wages, hours, production workers, nonproduction workers, and the cost of materials were obtained from the Annual Survey of Manufactures and The Census of Manufacturers. For the years 1979-81, individual state data was unavailable and was estimated. The consumer price index and the implicit price deflator for manufacturing were taken from the Economic Report of the President.

Equation 9 was estimated using generalized least squares (Harvey 1981). The result for Ohio are presented in Equation 10 and Equation 11 shows the estimate for the United States.

$$\ln L_t = \underset{(-1.396)}{-1.489} - \underset{(-3.703)}{0.508} \ln w_t + \underset{(8.502)}{0.615} \ln q_t - \underset{(-8.080)}{0.603} \ln np_t \tag{10}$$

$$R^2 = .91 \quad DW = 1.46$$

$$\ln L_t = \underset{(1.204)}{1.49} - \underset{(-2.046)}{0.321} \ln w_t + \underset{(8.600)}{0.504} \ln q_t - \underset{(-8.355)}{0.535} \ln np_t \tag{11}$$

$$R^2 = .90 \quad DW = 1.52$$

Both models explain about 90 percent of employment variations and are consistent with theoretical expectations. For both the Ohio and U.S. models, the estimated coefficient on the wage variable is less than one and statistically significant. The results are consistent with economic theory since they imply that the demand for labor is downward sloping. The estimated coefficient on the output variable was positive and statistically significant at the .01 level for both models. Again, this result is consistent with economic theory, since it implies that increases in output increase the demand for labor. Finally, although the ratio of production to non production workers is not a direct component of demand elasticity, it was a significant determinant of production worker employment in both models.

The substitution elasticity for Ohio appears to be slightly greater than the typical national estimate. The Ohio estimate of $[EL/Ew|_{q,r}]$ was -.508, indicating an inelastic substitution component. Our estimate of the national coefficient -.321 also indicates an inelastic substitution effect. Previous national studies of the employment wage elasticity ranged from -1.09 to -.04 with all but one study showing that the substitution effect was inelastic. In fact, the average value of the substitution elasticity for the fourteen articles (using different model specifications) reviewed by Hamermesh (1976) was -0.37. Clark and Freeman (1980) estimate the substitution elasticity to be between -0.55 and -0.33 depending on the particular measure of the dependent variable used and the inclusion of other independent variables. Thus, our findings seem to be consistent with the literature.

The estimate of Ohio's output employment effect $[EL/Eq|_{w,r}]$ is .615. A 1 percent increase in Ohio's manufacturing output will cause employment to increase by .615 percent. The comparable estimate for the nation was .504. Thus, Ohio's output employment effect appears to be very close to our national estimate. Hamermesh (1976) reported that previous studies estimated the employment output elasticity to be between .49 and 1.46. Again, Clark and Freeman (1980) estimate the output elasticity to be between 0.53 and 0.77 depending on the specification of the model. Thus, our estimates for both Ohio and the nation appear to be consistent with the previous studies. Finally, there was strong similarity between the Ohio and the nation regarding the coefficient on the ratio of production to nonproduction workers. The coefficient for the Ohio model indicates that a 1 percent increase in nonproduction workers will decrease employment among production workers by .603 percent. The comparable coefficient for the U.S. was -.534. As with the wage and output coefficients, the Ohio and national coefficients are similar.

V. CONCLUSION

Previous studies measuring the substitution and output elasticities have used national data. This approach implicitly assumed that the demand elasticities did not differ among states. This paper examined the substitution and output elasticities for manufacturing production workers in Ohio. The substitution elasticity appears to be only slightly greater in Ohio than the typical national estimate. The output effect also indicates an output elasticity very close to the national estimate. In general, the differences between our estimates of the substitution and output elasticities for Ohio and a variety of similar national studies indicate that Ohio is similar to the nation as a whole. At this time we can only speculate about the reasons for the similarity between the elasticity of demand for labor in Ohio and the U.S. One possible explanation might be the diversified nature of the state's manufacturing base. Another might be the similarity between the demographic composition of Ohio and the nation. Clearly, this is a area for future research.

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