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THE EFFECT OF IMPORTS ON EMPLOYMENT UNDER RATIONAL EXPECTATIONS--ETC(U)
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Robert A. Levy
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INTRODUCTION

A number of studies have concluded that the demand for labor depends on both current and expected future output [5, 7, 16, 20].^c Though many of these studies rely on the assumption of rational expectations, none has recognized and made use of a unique characteristic of the theory of rational expectations: that in the process of generating measures of expectations information is automatically created on the extent to which different variables affect expectations. Hence, the differing response to alternative causes of output change can be estimated.

In this paper, we focus on imports as a distinct cause of output change. We test the hypothesis that employment reacts more rapidly to output changes when they are due to changes in imports than when they are due to the business cycle or other influences.

It has been standard practice to use input-output studies to predict the effect of imports on the domestic demand in specific industries. The input-output model assumes that a change in output will cause proportional and immediate effects on industry employment, no matter what caused the change in output. Thus,



rising imports will cause large, sudden decreases in output. In response to this perceived problem, programs have been designed to provide federal aid to workers hurt by imports.

The assumption of immediate and proportional adjustment to imports does not accord with empirical evidence that employment adjusts gradually to changes in output and that labor output elasticities are less than one. Imports would have a special effect if firms, upon seeing competing imports enter their market, interpret the change as permanent. They would completely revise their view of the future and adjust their workforce accordingly, even if skilled workers (i.e., workers with high hiring and training costs) are involved.

The labor demand model is applied to 11 industries at the two-digit SIC level. This disaggregation is important for theoretical reasons. Industry output may differ in its response to various determinants, including imports. The speed of adjustment will also tend to differ between industries: Industries with a more skilled labor force will tend to adjust less rapidly to avoid the possibility of rehiring and training costs.

THE DEMAND FOR EMPLOYMENT

The model of labor demand begins with the assumption that adjustment costs and the inverse production function are quadratic.¹ Adjustment costs are described by the equation:

$$\phi_t = \frac{\phi}{2}(N_{t+1} - N_t)^2, \phi_N > 0, \phi_{NN} < 0. \quad (1)$$

The inverse production function is given by:

$$K_t = a + bN_t + \frac{c}{2} N_t^2 + dN_t Q_t + \frac{e}{2} Q_t^2 \quad (2)$$

It can be shown that minimizing the discounted flow of expected costs² into the infinite future

¹Quadratic adjustment costs imply marginally increasing costs of changing employment levels so that changes occur gradually (a linear function, for example, leads to instantaneous adjustment). A quadratic inverse production function is used to derive linear (in variables) employment decision rules.

²The cost function is:

$$C_t = w_t N_t + q_t K_t + \frac{\phi}{2} (N_{t+1} - N_t)^2$$

Substituting equation (2) into the cost function to eliminate K_t and minimizing the present value (expected) of costs leads to the labor demand equation. For the derivation, see the larger version of this paper [8]. The derivation is similar to that in [16].

leads to the following equation:

$$N_{t+1} = \lambda N_t + \frac{\lambda}{a\phi} \sum_{i=0}^{\infty} \left(\frac{\lambda}{a}\right)^i E_{t+1} Q_{t+1+i}$$

where $a = 1$ plus r , the (real) interest rate

$\lambda =$ a function of r , ϕ , and production function parameters. It can be shown to be less than 1 for any bounded and positive ϕ and greater than 0 for any positive r .

$Q_{t+1} =$ output in period $t+1$

$E_{t+1} =$ expectation operator

The demand for labor in the current ($t+1$ st) period depends upon employment in the previous period and on the current and expected output. The coefficients on future output decline geometrically.¹

THE MODEL FOR GENERATING EXPECTATIONS

Equation (2) indicates that labor demand depends on current output and future outputs in a declining geometric pattern. Employers do not know future output and so must act on the basis of expectations.

¹The equation we estimated may be represented by

$$N_{t+1} = b_4 b_3 N_t + b_2 b_3 \sum b_3^i E_{t+1} Q_{t+1+i}$$

where $b_3 = \lambda/a$

$b_4 = a (= 1+r)$

$b_2 = 1/\phi$.

Expectations of future output are rational if they are generated by the same statistical process that generates output. To represent this process, we use an economic model which incorporates some simplifying assumptions: imported goods are perfectly substitutable with domestic products and are exogenous.¹

The model for industry output was designed to represent the demand for a durable product (whether an intermediate manufactured good or a final consumption good). The durability introduces an accelerator effect which implies that cyclical variation is a determinant of demand. The total demand for industry output (domestic output plus imports), therefore depends on the level of real GNP (included to represent consumption demand), changes in GNP (representing cyclical factors), the relative price of the industry's output relative to some aggregate manufacturing price (measured as industry WPI/manufacturing WPI), a time trend, and seasonal dummy variables. Demand for the domestic

¹The assumption of perfect substitutability is necessitated by the absence of import price at the two digit SIC level. The assumption of exogenous import quantity is made to ease the calculation of expectations.

product is calculated as the difference between total output and (exogenously determined) imports.

The output demand equation is used to generate expected output for use in the labor demand equations. To use the output demand equations in this way requires forecasting the explanatory variables in the total demand equation. Equations for real GNP, industry imports, and industry relative price were specified as autoregressive distributed lags.^{1,2}

A summary of the output model is given by the following five equations:³

$$\ln D_t = \alpha_0 + \alpha_1 \ln Y_t + \alpha_2 \ln Y_t / Y_{t-1} + \alpha_3 \ln P_t \quad (4) \\ + \alpha_4 D1 + \alpha_5 D2 + \alpha_6 D3 + \alpha_7 t$$

¹An autocorrelation adjustment in the estimates and forecasts was made when appropriate.

²We did include other variables in the import equation, such as relative prices, to allow for an upward sloping supply. Adding the price term did not change appreciably the overall fit or other coefficients and so the distributed lag version was used.

³These equations represent the basic version of the model. To capture differences among industries the actual regression equations include only significant terms. Some include alternative specifications of key variables (e.g., to capture cyclical elements, the variable $\ln(Y_t/Y_{t-4})$ may be used instead of $\ln(Y_t/Y_{t-1})$).

$$\ln Y_t = \gamma_0 + \gamma_1 \ln Y_{t-1} + \gamma_2 \ln Y_{t-2} + \gamma_3 D1 + \gamma_4 D2 + \gamma_5 D3 + \gamma_6 t \quad (5)$$

$$\ln M_t = \delta_0 + \delta_1 \ln M_{t-1} + \delta_2 \ln M_{t-2} + \delta_3 D1 + \delta_4 D2 + \delta_5 D3 + \delta_6 t \quad (6)$$

$$\ln P_t = \eta_0 + \eta_1 \ln P_{t-1} + \eta_2 \ln P_{t-2} + \eta_3 D1 + \eta_4 D2 + \eta_5 D3 + \eta_6 t \quad (7)$$

$$Q = D - M \quad (8)$$

Q is domestic production
 D is total demand for an industry's products (includes both domestic production and imports)
 M is imports
 Y is constant dollar GNP
 P is the wholesale price index for the industry's output; relative to the overall wholesale price index

D1, D2, D3 are dummy variables used to account for seasonal factors
 t is a time trend
 AP is the average value of P over the current and three preceding periods

All variables except the dummy variables, the time trend, and GNP are specific to the individual industries.

Since rational expectations are made according to the same statistical process that generates the actual variable, the model above is also a model of expectations. The model can be used to form expectations one period forward based on the current and past information. For example, imports one period forward are projected from the import equation (6) with the values for $t+1$ substituted for values in t . In other words, the expected value of M_{t+1} (denoted by M_{t+1}^*) is calculated using equation (6) with M_t substituting for M_{t-1} and M_{t-1} substituting for M_{t-2} . Imports two periods forward are generated in the same way except that M_{t+1}^* substitutes for M_{t-1} and M_t for M_{t-2} . To obtain expectations of output for all desired future periods, the same recursive technique is used, i.e., forecasts several periods forward are formed by making use of nearer term forecasts.¹

EMPIRICAL RESULTS

Empirical estimation of the model proceeded in two parts. First, for each industry, the three-equation system used to generate expectations ((3), (5), (6)) was estimated. In the interest of brevity, the

¹The statistical theory behind this technique is discussed in an appendix available on request (or in Sargent [17], or Malinvaud [11]).

regression equations and a description of the data are not shown here but are available in [8]. The estimated equations were then solved to generate forecasts of output. Second, labor demand was estimated using nonlinear least squares with the distributed lead in expected output truncated at eight quarters.¹ Rather than present estimates of all of the parameters, we shall concentrate on the coefficient of greatest importance in estimating short- and long-run elasticities of labor demand with respect to output-- λ/a . This is the coefficient that is taken to increasing powers to generate the distributed lead in expected output. A high value implies a strong effect of future output on current labor demand. In seven of the 11 industries, this coefficient was significantly different from 0. Estimates (and t-statistics) of $\frac{\lambda}{a}$ for the seven industries are presented in table 1.²

¹Experimentation with longer leads yielded similar results.

²The procedure used to obtain regression parameters and the actual results in all 11 industries are more fully explained in [8]. The same paper discusses estimation that included a correction for autocorrelation. Results were similar and so for the simulation, the original estimates were used.

TABLE 1

ESTIMATES OF $\frac{\lambda}{a}$ BY INDUSTRY

| <u>Industry</u> | <u>Coefficient (t-statistic)</u> |
|-------------------------------|----------------------------------|
| Textile (SIC 22) | .791 (3.16) |
| Paper (26) | .703 (3.38) |
| Stone (32) | .333 (2.48) |
| Primary Metals (33) | .454 (2.52) |
| Fabricated Metals (34) | .831 (3.30) |
| Machinery (Except Elec.) (35) | .820 (3.06) |
| Electrical Machinery (36) | .484 (2.50) |

These estimates, together with the relevant industry parameters obtained from the output regressions, enable us to determine whether labor adjusts faster to a change in imports or to changes in GNP. The next section describes how this is done.

The Calculation of Short-Run Elasticities

In order to estimate the speed of adjustment of employment to imports and compare it to other sources of output change, the model is used to evaluate the derivative of employment with respect to current output. The long-run elasticity assumes a steady state for N and Q and is calculated as

$$e_L = \frac{dN}{dQ} \frac{\bar{Q}}{\bar{N}} \quad (9)$$

where $\frac{dN}{dQ}$ is calculated from the regression coefficients and \bar{Q} , and \bar{N} are sample means.¹

The short-run elasticity, on the other hand, uses only the derivative of current employment (N_0) with respect to current output Q_0 :

$$e_S = \frac{dN_0}{dQ_0} \frac{\bar{Q}}{\bar{N}}, \text{ where } dN_0/dQ_0 = b_2 b_3 \quad (10)$$

The speed of adjustment is calculated as $\frac{e_S}{e_L}$. The estimate of e_S will incorporate the effect of current output on expected output, which then feeds back to current employment. Separate calculations are made for a change in current output attributable to imports and a change attributable to a change in GNP. In both cases, the decrease in current output is the same, so that differences in the response of employment were due to differences in expectations. As noted earlier, the hypothesis to be tested is that changes in current imports represent a more permanent change, the effect on expected output and current employment will be greater. Calculations are only made for those industries where expectations of output are important.

¹

Specifically, $\frac{dN}{dQ}$ is calculated as $\frac{b_2 \sum b_3^i}{1 - b_3 b_4}$, to fully take account of output changes in the future. See the footnote on page 4.

The derivative of current employment with respect to current output (via a change in imports) was estimated by totally differentiating the nonlinear model. The change in labor demand arises from a change in imports, both current and expected, leading to changes in domestic output.

The equations were of the following form:

$$d\ln M_i = g_1 d\ln M_{i-1} + g_2 d\ln M_{i-2}, \quad i=1, \dots, 8$$

$$dQ_i = -dM_i, \quad i=1, \dots, 8$$

$$dN_0 = b_2 \sum_{i=1}^8 b_3^i dQ_i$$

The current period is signified by the zero subscript. The subscript i denotes the number of periods in the future. The equations themselves are the total differential of the estimated equations in the model. Thus, the coefficients g_1 and g_2 are the coefficients on lagged imports in the import equation. A change in current imports is incorporated into forecasts by means of these coefficients. This equation denotes a number of equations referring to expectations at different points in the future.

$$d\ln M_1 = g_1 d\ln M_0$$

$$d\ln M_2 = g_1 d\ln M_1 + g_2 d\ln M_0$$

$$d\ln M_3 = g_1 d\ln M_2 + g_2 d\ln M_1$$

⋮

We start with a dM_0 equal to the dQ_0 obtained above from a 5 percent change in GNP. With this initial dM_0 , the equations are solved for dM_1, \dots, dM_8 , dQ_0, \dots, dQ_8 , and dN_0 . Then, dN_0/dQ_0 is calculated and converted to an elasticity at the sample means.

In order to estimate the corresponding derivative that results from a change in GNP, rather than imports, we use a similar procedure. We start with a 5 percent change in GNP ($d\ln GNP_0$) and solve the following equations for dN_0 :

$$d\ln GNP_i = f_1 d\ln GNP_{i-1} + f_2 d\ln GNP_{i-2}, \quad i=1, \dots, 8$$

$$d\ln Q_i = h_1 d\ln GNP_i + h_2 d\ln \frac{GNP_i}{GNP_{i-1}}, \quad i=1, \dots, 8$$

$$dN_0 = b_2 \sum_{i=1}^8 b_3^i dQ_i$$

Once the alternative derivatives of employment with respect to current output were evaluated, they were then converted to elasticities which are reported in table 2. The symbols e_G and e_M denote the short-run elasticities derived when GNP and imports change, respectively. The symbol e_L is the long-run elasticity given by equation (9). Also, an adjustment parameter (or speed of adjustment), η , is obtained by dividing the short-run elasticity by the long-run elasticity in each case (also denoted by G or M). The

TABLE 2

SHORT-RUN ELASTICITIES AND ADJUSTMENT PARAMETERS
FOR A CHANGE IN GNP and IMPORTS

| <u>industry</u> | <u>e_G</u> | <u>e_M</u> | <u>e_L</u> | <u>Adjustment Parameter</u> | |
|-----------------|----------------------|----------------------|----------------------|---------------------------------|----------------------|
| | | | | <u>η_G</u> | <u>η_M</u> |
| 22 | .256 | .113 | 1.008 | .254 | .113 |
| 26 | .314 | .140 | .684 | .459 | .205 |
| 32 | .636 | .380 | .732 | .869 | .519 |
| 33 | .483 | .326 | .733 | .659 | .431 |
| 34 | .726 | .273 | 1.396 | .520 | .196 |
| 35 | .474 | .089 | .971 | .488 | .092 |
| 36 | .638 | .386 | .845 | .755 | .457 |

adjustment parameter is the fraction of adjustment completed by the firm in each period, toward the equilibrium level N^* . The parameter is analogous to the parameter η in the simple partial adjustment model

$$N_t - N_{t-1} = \eta(N_t^* - N_{t-1})$$

As expected, short-run elasticities are all lower than the long-run elasticities. More surprisingly, in every industry, the short-run change in labor demand is greater for a change in GNP than for imports. Apparently, even though changes in GNP may be thought of by the firm as cyclical changes, and therefore only "temporary," the decrease in labor demand in response to the change is greater and occurs more rapidly. The adjustment of labor to GNP occurs substantially more quickly than the adjustment to a higher level of imports.

CONCLUSION

In this paper, we have illustrated a unique attribute of the assumption of rational expectations: that it automatically contains the information necessary to analyze the differential effects of different sources of output change. Our specific application was to imports. We found no evidence for the hypothesis that output changes due to imports

elicit a faster adjustment of employment (because they are regarded as permanent) than other sources of output change. In fact, we found evidence for the opposite hypothesis, that imports elicit a slower response.

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