Employment versus Wage Adjustment and the U.S. Dollar

ABSTRACT

Using two decades of annual data, we explore the links between real exchange rates and employment, wages and overtime activity in U.S. manufacturing industries. Especially in industries with lower price-over-cost markups, exchange rates have statistically significant effects on industry wages, with the magnitude of these effects rising as industries increase their export orientation and declining as imported input use becomes more important. Exchange rate implications for jobs and hours worked are smaller and less precisely measured. We find a much higher response of overtime wages and overtime hours to transitory exchange rates movements.

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Jose Manuel Campa
Stern School of Business, N.Y.U.
and N.B.E.R.

Linda S. Goldberg
Federal Reserve Bank of New York
and N.B.E.R.

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Address correspondences to Linda S. Goldberg, Federal Reserve Bank of NY, Research Department, 33 Liberty St, New York, NY 10045. Tel: 212-720-2836; fax: 212-720-6831; email: Linda.Goldberg@ny.frb.org.

I. INTRODUCTION

Researchers have long been faced with the challenge of pinning down the specific implications of exchange rates for the real economy. One key area of interest is the labor market effects, and the channels through which dollar movements bring about these effects. This paper examines this issue, specifically addressing the effects of exchange rates on employment, wages, and overtime activity over the past twenty-five years for manufacturing industries of the United States. Two relevant economic changes have prevailed during this period: the external orientation of the U.S. manufacturing sector has increased and large movements in exchange rates have occurred. The goal of this paper is to identify the effects that these exchange rate movements -- both their permanent and transitory components -- have had on U.S. manufacturing jobs and wages, given the changing external orientation of U.S. industries.

Our evidence supports a significant response of industry wages to exchange rates, and a weaker relationship between employment and the dollar. The average industry real wage elasticity to a permanent real exchange rate change was 0.06 for all manufacturing during this period, while the average employment elasticity was only -0.01. There are systematic differences across industries in these responses. Some industry features that are strongly correlated with the relative importance of exchange rates for labor markets include: the industry competitive structure; the skill level of an industry's labor force; and various forms of trade orientation. Low price-over-cost-markup industries – industries like textiles, lumber and wood products, and primary metal or fabricated metal products – exhibit more statistically significant responses to exchange rates than do higher-markup industries. The real wage elasticities of response are systematically larger as industries increase their export-orientation and systematically smaller (and even turn negative) as industries rely more heavily on imported productive inputs. Controlling for levels of external orientation, the scale of exchange rate implications across industries is higher for higher markup industries. Industries with more college-educated workers as a proportion of their labor force have lower wage and employment elasticities of response to exchange rates.

We also provide the first documentation of the effects of transitory exchange rate movements on overtime activity in U.S. manufacturing industries. Transitory exchange rate movements have statistically significant effects on overtime hours and overtime wages. The elasticity of overtime real wages to transitory exchange rate changes is positive for most industries, averaging 0.15. Within lower-markup industries, these effects have increased substantially with increased industry export orientation and have been offset, to some degree, by increased imported input shares. Overtime employment also is highly sensitivity to exchange rates. Our estimate of the average overtime employment elasticity for the sample is 0.3. Across all industries, the implied overtime effects of exchange rates are larger for industries with larger price-over-cost markups and less skill-intensive production. Rankings of industries according to unionization rates and capital intensity are not correlated significantly with rankings of industries according to wage, employment or overtime activity responsiveness to exchange rate fluctuations.

There is a limited amount of prior research on exchange rates and labor markets. Branson and Love (1988), using data for the 1970s and early 1980s, found that real exchange rate movements were associated with large changes in manufacturing sector employment: dollar appreciations (depreciations) were associated with significant output and employment losses (gains) mainly in durable goods sectors. Revenga (1992), using a sample of three- and four-digit manufacturing industries over the 1977 to 1987 period, also found that exchange rates have significant implications for employment in the United States, and smaller but still significant effects on wages. Those estimates came from a sub-sample of manufacturing industries and focused on the effects of import competition into the United States: the higher the import share of an industry, the more an import price decline or dollar appreciation hurt domestic labor markets.[1]

Our estimated real wage elasticities with respect to exchange rates are quantitatively similar to those reported by Revenga, but our employment estimates differ sharply with those from both Branson and Love, and Revenga. Our analysis concludes that differences in the data

[1]International evidence on the effects of exchange rates on labor markets is provided in Dekle (1998), who focuses on Japan, and in Burgess and Knetter (1998), who focus on the G-7 countries (the United States, Germany, the United Kingdom, Japan, Canada, France, and Italy). Burgess and Knetter focus exclusively on employment adjustment to exchange rate movements and emphasize two themes. First, they confirm differences across countries in employment elasticities with respect to exchange rates and differences across industries in speeds of employment adjustment. Second, they assert that those industries with a high degree of pricing to market exhibit weaker linkages between exchange rate and employment fluctuations. Dekle shows that exchange rates significantly influence employment in Japan, with larger implications observed in industries with higher export shares. Brunello (1990) provides further insights regarding Japanese labor market adjustments.

intervals across the studies do not explain these differences in results.[2] To understand why we reach starkly different conclusions on employment response we investigate the importance of three potential explanations: time period examined, levels of aggregation of data in the studies, and methodology used for detecting dollar implications.

Our findings that industry wages are considerably more responsive than jobs (and hours worked) to exchange rate movements is based on analysis of a broader set of 2-digit industries covering all of manufacturing for a longer sample period -- the early 1970s through mid-1990s. We find that industry wage responsiveness has been growing larger over time, in particular as U.S. industries have become more export oriented. The growth of imported input use by producers has provided some (but an incomplete) offset to the producer profitability and labor demand pressures arising from dollar movements. When industry trade orientation is taken into account, it is clear that the most significant wage effects are apparent in those industries that have lower price-over-cost markups and relatively less-skilled workforces.

Employment effects from exchange rate changes are concentrated in a much smaller group of industries. This pattern of employment consequences of dollar movements is a robust feature of the industry level data. We confirm the robustness of these results to the type of exchange rate used (aggregate versus industry-specific and real exchange rates; actual versus decomposed into permanent and transitory components) and at alternative levels of industry aggregation (2-digit versus 4-digit SIC). These robustness checks with respect to aggregation issues might be important if the higher level of industry aggregation misses some of the adjustments that occur *within* the 2-digit but *across* the more narrowly defined 3- and 4-digit industries. Such patterns of employment reallocation would generate low net employment elasticities to exchange rates at the 2-digit level, despite higher gross reallocation and turnover within that industry. Low net employment fluctuations in the 2-digit industry could be consistent with high rates of job creation

[2] We estimated our equations for the intervals used in the Branson-Love and in the Revenga studies. Our empirical results for the 1972 to 1984 interval, used in Branson and Love, were not qualitatively different from our full sample results. For the 1977 to 1987 interval, used in Revenga, our wage significance results continued to be similar to what is reported in the paper. Even in this limited sample period, we find that both employment and hours have weak statistical relationships with exchange rates. Any significance that we detect works in the opposite direction – suggesting that a dollar depreciation reduces rather than stimulates manufacturing employment.

and destruction within the industry.[3] The more disaggregated the data, the more likely that net employment will register as responsive to industry shocks. These issues of aggregation are probably less problematic in measurement of real wage elasticities. Even when there is job destruction and hiring within a sector, worker earnings can still adjust substantially.[4]

To investigate whether the data aggregation issue drives the differences across studies in employment responsiveness, we examine the labor market series that are the closest available at a 4-digit level of industry disaggregation. Regressions over the 4-digit industry data (representing the 450 4-digit industries that aggregate to the 20 2-digit industry groups) confirm that employment elasticities on average continue to be small but significantly responsive to exchange rate movements. Our conclusion is that the levels of aggregation of the net industry-level data are not the driving force behind differences in employment sensitivity across studies.

Rather, we conclude that testing methodology plays an important role. In contrast to prior studies, our methodology emphasizes the different channels of exchange rate exposure of an industry, instead of a maintained assumption of time-invariant exposure or exposure exclusively through one particular channel, import competition. Revenga's motivation and sample of industries were targeted at estimation of the effects that import competition in the United States had on U.S. labor markets resulting in a sample of industries that was not representative of the U.S. manufacturing sector and that emphasize the sensitivity of employment to exchange rates.[5] Given our alternative emphasis on decomposing the sources of currency exposure of an industry into the major components (revenue exposure through export orientation and import competition, cost exposure through imported inputuse), we generate a richer and more representative picture of how employment sensitivity has evolved both over time and across manufacturing industries.

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[3] Davis and Haltiwanger (1999) provide relevant evidence in their study of the substantial allocative employment effects of oil price shocks. Using information at the plant level from census data, they show that there is job churning in response to oil shocks. The amount of this churning differs across the 4-digit versus 2-digit level of industry aggregation of employment data. At the 2-digit level, within manufacturing sector adjustment accounts for 67 percent of the total job re-allocation. At the 4-digit level, however, within sector reallocation is only 45 percent of the total.

[4] Kletzer (2000, Table 6) provides insightful data relevant to this point: a matrix of post-job displacement employment by sector between 1979 and 1994 shows that displaced workers are most likely to find new positions within their old sector, and this re-employment is almost always (on average) associated with mean wage declines.

Thus, in much the same way that these methodological issues have informed our understanding of investment and stock price sensitivity to exchange rates,[6] they now enrich our understanding of the consequences of exchange rates for labor markets.

In Section II, we develop a simple model of dynamic labor market equilibrium that explicitly incorporates the multiple channels through which exchange rates influence labor markets. Through the demand side of the labor market, we show that industry features -- including trade orientation, costs of adjustment, skill mix of workers, and product market competitive structure -- should influence the level and timing of labor market adjustments to exchange rates.[7] All else equal, optimal adjustments to labor demand in response to exchange rates movements increase in the industry export orientation and import competition. An industry's use of imported inputs enters more ambiguously since domestic labor and imported inputs may be either substitutes or complements in the production function. More "competitive" industries (i.e. those with lower price-over-cost markups) are expected to have more responsive labor demand than more oligopolistic industries. The remainder of the paper, Sections III and IV, describe the data and provide the results from the empirical estimation of the effects of exchange rates on industry wages, employment, and overtime activity in the United States. Section V concludes.

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[5] The sample of industries included in Revenga (1992) represented 72 percent of total manufacturing imports in 1980 while they only accounted for 35 percent of manufacturing employment.

[6] Industry stock prices and investment responses to exchange rates across various international markets are more sensitive in low price-over-cost markup industries. Campa and Goldberg (1995, 1999) provide evidence on investment responses across countries. Allayannis and Ihrig (forthcoming) and Bodnar, Dumas, and Marston (1998) provide evidence on stock prices.

[7] Hammermesh (1993, chapter 7) provides a survey of related studies of labor market adjustments.

II. Labor Markets and Exchange Rates

In this section we present a dynamic model of the labor market, wherein each year some combination of employment and wage adjustments equilibrate labor markets in response to shocks. Exchange rate shocks influence labor demand by affecting the marginal revenue product of labor. These effects arise through changes in a producer's domestic and foreign sales and in its costs of imported inputs into the production process. The elasticity of marginal revenue product with respect to exchange rates depends on industry pass-through elasticities, i.e. the price elasticities with respect to exchange rates in both domestic and foreign markets.

Theoretically, these coefficients should be sensitive to industry trade orientation and to industry competitive structure (see Dornbusch 1987, Marston 1990, and Bodnar, Dumas and Marston 1998). Industry structure matters because producer profitability will be most affected by exchange rates in industries where producers have little ability to counter shocks by exerting price-setting abilities. The trade orientation of the industry matters since greater export orientation broadens the positive stimuli to revenues arising from a dollar depreciation. Heavy imported input use can either expand or reduce labor demand sensitivity to exchange rates, depending on the assumed structure of production activity and product demand. Other industry characteristics, including those that alter an industry's costs of adjusting it's workforce, will influence the timing of wage versus employment response, and the degree of short-term reliance on overtime work efforts.

A. Exchange Rates and Labor Demand: Profit maximizing producers selling to both domestic and foreign markets are faced with current and future demand shocks. In our context, the unknowns to the producer at date *t* are aggregate demand in domestic and foreign markets, denoted by y_t and y_t^*, and the exchange rate, e_t, defined as domestic currency per unit of foreign exchange. Production uses three factors: domestic labor L_t, domestic capital and other domestic inputs Z_t, and imported productive inputs, Z_t^*. Respective factor prices in domestic currency units are denoted by w_t, s_t, and $e_t s_t^*$.

Within an industry, the representative producer chooses factor inputs and total output in order to maximize the expected present discounted value of the flow of current and future profits, p (equation 1). The optimization is subject to the constraints posed by its production structure (equation 2), given demand for its products in domestic and foreign markets (equation 3) and the additional costs involved in changing its level of domestic labor (equation 4). Profits are garnered from sales in the home market, q_t, and sales in the foreign market, q_t^*, which depend on aggregate demand conditions in the respective markets, y_t and y_t^*.

$$p\left(y_t, y_t^*, e_t\right) = \max_{q_t, L_t, Z_t^*, Z_t} \sum_{t=0}^{\infty} f_t \begin{bmatrix} p\left(q_t : y_t, e_t\right) q_t \\ +e_t p^*\left(q_t^* : y_t^*, e_t\right) q_t^* \\ -w_t L_t - e_t s_t^* Z_t^* - s_t Z_t \\ -c\left(\Delta L_t\right) \end{bmatrix} \tag{1}$$

subject to $$Q_t = q_t + q_t^*, \quad Q_t = L_t^{\,b} Z_t^{*a} Z_t^{1-a-b}, \tag{2}$$

and $$p(q_t : y_t, e_t) = a(y_t, e_t) q_t^{-1/h} \quad \text{and} \quad e_t p^*\left(q_t^* : y_t^*, e_t\right) = a^*\left(y_t^*, e_t\right) q_t^{*-1/h^*} \tag{3}$$

and $$c(\Delta L_t) = w_t \frac{b}{2}\left(L_t - L_{t-1}\right)^2 \tag{4}$$

The time-varying discount factor is f_t. In equation (2), a Cobb-Douglas production structure is assumed for simplicity, but our main results also hold under a more general CES production structure.

In equation (3) the parameters h and h^* are, respectively, the domestic and foreign product demand elasticities facing producers in their own industries. The demand curves in domestic and foreign markets include multiplicative demand shifters, $a\left(y_t, e_t\right)$ and $a^*\left(y_t^*, e_t\right)$, which allow for independent roles of local real income and exchange rates. Exchange rate movements

[8] The assumption of homogeneous labor precludes us from considering the linkage between exchange rate movements and the wage gap between skilled and unskilled workers.

influence demand by potentially shifting the relative price of home products versus those of foreign competitors[9] and therefore affecting the residual demand faced by the domestic firm.

Our focus in the paper is mainly on one input, domestic labor. We model changes in the use of labor as subject to a partial adjustment cost. For simplicity, we assume that labor is a homogeneous input[10] and that the levels of capital and foreign inputs can be fully and costlessly adjusted in the short run. In equation (4) the costs of adjusting an industry's labor input are assumed to be quadratic and fixed per worker in wage units, reflecting labor force adjustment costs that rise in proportion to wages. The parameter *b* reflects the costs of adjustment of the level of labor and should be viewed as being industry specific. This type of quadratic formulation for adjustment costs is standard in the literature and implies that firing and hiring costs are identical. It's strength is as a convenient simplification which allows straightforward empirical implementation of the labor demand equation.

The solution to the firm's optimal labor demand problem is a dynamic equation. This equation is derived from the first-order conditions in each factor, and equates the marginal revenue product from an additional unit of labor today to the marginal cost of that unit for the firm. The marginal cost for the firm of an additional unit of labor has three components: 1) the additional wage that has to be paid; 2) the costs incurred in adjusting the level of labor input use by that additional unit; and 3) the present value of the additional costs of changing the optimal labor amount in the future. The resulting equation is a second-order difference equation in units of labor. As a step toward solving this equation, it is convenient to define a new variable $\tilde{L}_t$ as that level of labor input which would be the optimal amount chosen by the firm at time *t* in the absence of adjustment costs, i.e. at *b*=0. Following Nickell (1986), under reasonable assumptions the stable root of the resulting fundamental equation implies a partial adjustment path of optimal employment:

$$L_t = mL_{t-1} + (1-m)(1-dgm)\sum_{j=0}^{\infty}(dgm)^j \tilde{L}_{t+j} \qquad (5)$$

[9] Our demand structure here is similar to that of Burgess and Knetter (1998).

[10] The assumption of homogeneous labor precludes us from considering the linkage between exchange rate movements and the wage gap between skilled and unskilled workers.

where g denotes expected real wage growth rate (assumed to be a constant), δ denotes the constant discount rate, and m denotes the stable root of the fundamental equation for employment. m is increasing in b and decreasing in the wage sensitivity of marginal revenue product.

Equation (5) shows that the target level of current employment is a convex combination of last period's employment and a weighted sum of all future values of $\tilde{L}_t$. The weights on future values of $\tilde{L}_t$ decline geometrically. The "speed of adjustment" of labor demand to the levels that would exist in the absence of costly adjustment is given by 1-m. This weighting structure is intuitive: changes in employment will be slower in industries with large adjustment costs and faster in those industries with more wage-sensitive marginal revenue product.

At this point, it is necessary to elaborate on the solution for $\tilde{L}_t$ at any date t. The solution to the first-order conditions of the producer problem, after invoking Euler's theorem, yields optimal labor demand by a firm in the absence of adjustment costs:

$$\tilde{L}_t = \frac{Q_t}{w_t}\left(\begin{array}{l} p\,(q_t : y_t, e_t)\left(1 + h^{-1}\right)\left(1 - c_t\right) \\ \quad + e_t p^*\left(q_t^* : y_t^*, e_t\right)\left(1 + h^{*-1}\right)\left(c_t\right) \\ \quad\quad - e_t s_t^* a \left(\frac{\P Q_t}{\P Z_t^*}\right)^{-1} - s_t\left(1 - a - b\right)\left(\frac{\P Q_t}{\P Z_t}\right)^{-1} \end{array} \right) \qquad (6)$$

where $c_t = p_t^* q_t^* / \left(p_t q_t + p_t^* q_t^*\right)$ is the share of export sales in revenuesEMBED. Equation (6) demonstrates that optimal labor demand in the absence of adjustment costs depends on the structure and importance to the firm of both domestic and foreign demand, and on the substitutability between productive factors in relation to their costs.

Using the optimal labor demand defined by equations (5) and (6) we derive a workable and intuitive relationship between exchange rates -- a variable assumed exogenous to the firm -- and labor demand. Recall from our framework in equation (1) that there are three potential sources of shocks that the firm faces, through aggregate domestic demand, through foreign demand, and through the exchange rate. Differentiating (6) with respect to exchange rates, the resulting elasticity of $\tilde{L}_t$ is:

$$\frac{\partial \widetilde{L}_t}{\partial e_t} \Big/ \frac{\widetilde{L}_t}{e_t} = \frac{1}{b}\begin{pmatrix} p_t(\cdot)\left(1+h^{-1}\right)h^{pe} + c_t\left(e_t p_t^*(\cdot)\left(1+h^{*-1}\right)\left(1+h^{p^*e}\right) - p_t(\cdot)\left(1+h^{-1}\right)h^{pe}\right) \\ -ae_t s_t^*\left(\partial Q_t / \partial Z_t^*\right)^{-1} \end{pmatrix} \quad (7)$$

where $h^{p,e}$ and h^{p^*e} are domestic and foreign price elasticities with respect to exchange rates. This elasticity of response of $\widetilde{L}_t$ to exchange rates depends on the firm's demand elasticities in the home and foreign market. These elasticities are best understood in the context of theories of exchange-rate pass through. For monopolistically competitive markets, the domestic price elasticity with respect to exchange rates is proportional to import penetration of domestic markets: $h^{p,e} \propto kM_t$, with k as a proportionality factor. The foreign price elasticity with respect to exchange rates is proportional to domestic penetration of those markets (Dornbusch 1987). We use these relationships, assume that the law of one price holds ex ante, and assume that the product of any two trade share terms is approximately equal to zero ($c_t M_t = 0$ and $c_t M_t^* = 0$).[11] Under these assumptions, equation (7) reduces to a very clean expression for the elasticity of $\widetilde{L}$ with respect to exchange rates:

$$\frac{\partial \widetilde{L}_t}{\partial e_t} \Big/ \frac{\widetilde{L}_t}{e_t} = \frac{p_t}{b}\left(\left(1+h^{-1}\right)kM_t + \left(1+h^{*-1}\right)c_t - \left(\partial Q_t / \partial Z_t^*\right)^{-1} a\right) \quad (8)$$

Equation (8) clearly highlights the three channels through which optimal labor demand is exposed to exchange rate movements and shows the key roles played by industry features. The three transmission channels are through industry import penetration (M_t), export orientation (c_t), and imported input use, a_t. All else equal, industry features magnify or reduce the importance of these channels: *i*) When production is labor intensive (i.e. b is high), labor demand is less responsive to exchange rates; *ii*) Greater import penetration of domestic markets raises the sensitivity of labor demand to exchange rates; *iii*) Higher export orientation of an industry increases the sensitivity of its labor demand to exchange rates; and *iv*) Industries that rely more heavily on imported inputs into production (higher a) receive a contractionary labor demand impetus following a domestic currency depreciation (since domestic currency depreciation raises the cost of a factor of production).

[11] We also assume that the foreign real input cost equals 1, i.e that $s_t^* / p_t^* = 1$.

Equation (8) also explicitly shows that the role of exchange rates in labor demand is strengthened in industries in which firms have pricing power (i.e., industries with high k and low demand elasticities). All else equal, labor demand is more sensitive to exchange rates if foreign firms have pricing power in domestic markets. The higher the price elasticity of demand facing producers, and the lower the implied price-over-cost markups in the industry, the more responsive will be labor demand to exchange rates.

Using equations (6) and (8) and log-linearizing, optimal labor demand in the absence of adjustment costs can be expressed in reduced form as:

$$\tilde{L}_t = c_0 + c_1 y_t + c_2 y_t^* + (c_{3,0} + c_{3,1} \chi_t + c_{3,2} M_t + c_{3,3} a_t) e_t + c_4 w_t + c_5 s_t + c_6 s_t^* \tag{9}$$

where all variables other than χ_t, M_t and a_t are defined in logarithms.

Using equations (5) and (9) we solve for optimal labor demand at any point in time. Recall that equation (5) shows that the reaction of employment today to an exchange rate shock depends not only on the current shock, but also on all future expected changes of the exchange rate. The actual structure of labor demand response to an exchange rate shock depends on whether the shock is permanent or transitory. If the exchange rate follows a random walk, so that all exchange rate movements are permanent and the current exchange rate is the best predictor of all future exchange rates, a general form for optimal labor demand is given by the reduced form expression:

$$L_t = m L_{t-1} + (1 - m) \begin{pmatrix} c_0 + c_1 y_t + c_2 y_t^* + (c_{3,0} + c_{3,1} \chi_t + c_{3,2} M_t + c_{3,3} a_t) e_t \\ + c_4 w_t + c_5 s_t + c_6 s_t^* \end{pmatrix} \tag{10}$$

where the parameters on the exchange rate terms are increasing in the degree of permanence of the shock. A purely transitory movement in the exchange rate gives rise to a change in labor demand that is a fraction $(1 - dgm) < 1$ of the effect arising from a permanent exchange rate movement.[12]

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[12] A pure transitory shock is defined as a shock to the exchange rate that is expected to be fully reversed the next period. Firms may be inclined to use overtime hours in response to transitory shocks, instead of hiring or firing permanent workers.

B. Exchange Rates and Labor Supply: To complete our description of the labor market, we also must introduce labor supply conditions. Labor supply has been the focal point of a vast amount of research with a more micro-economic orientation. However, much of the emphasis of that literature – on changes in market demographics and household structure – is orthogonal to our emphasis on exchange rate movements. For simplicity we treat labor supply as an increasing function of wages and decreasing function of aggregate demand conditions, wherein the size of the supply sensitivities depend on worker preferences and characteristics.

$$L_t = a_o + a_1 w_t + a_2 y_t \tag{11}$$

Equating labor demand (equation 10) and labor supply (equation 11), the solution to the simultaneous equations for employment and wages for any industry i is the system of equations given by:

$$w_t^i = w_1^i + w_2^i y_t + w_3^i y_t^* + w_4^i s_t + w_5^i s_t^* + (w_{6,0}^i + w_{6,1}^i c_t^i + w_{6,2}^i M_t^i + w_{6,3}^i a_t^i) e_t + w_7^i L_{t-1}^i \tag{12a}$$

$$L_t^i = l_1^i + l_2^i y_t + l_3^i y_t^* + l_4^i s_t + l_5^i s_t^* + (l_{6,0}^i + l_{6,1}^i c_t^i + l_{6,2}^i M_t^i + l_{6,3}^i a_t^i) e_t + l_7^i L_{t-1}^i \tag{12b}$$

This solution reflects our main arguments regarding equilibrium wage and employment responses to shocks. All else equal, (*i*) those industries where workers have higher labor supply elasticity with respect to wages have smaller wage adjustments and larger employment adjustments; (*ii*) those industries with higher labor demand elasticity with respect to wages have smaller wage and employment responsiveness to shocks; (*iii*) those industries with less elastic product demands have more responsive wages and employment; (*iv*) the wage and employment effects of exchange rate movements are increasing in industry export orientation and home market import penetration; and (*v*) the scale of wage and employment response to exchange rates has an ambiguous relationship with industry use of imported productive inputs.

III. The Data and Regression Specification

The system of equations provided by (12a-12b) form the basis of our estimating equations. We use annual industry-level data for the U.S. labor market variables and the trade shares for the interval 1972 through 1995. Our equations are estimated in first differences, and include common time trends and industry dummy variables. The regressions are run using time-series panels of two-digit manufacturing industries, and are run separately for the individual manufacturing industries.

We have conducted all of our empirical analyses using two alternative types of exchange rate series as source data. The first type of series is a single real multilateral exchange rate index, defined as the dollars per foreign currency with U.S. trade weights on the bilateral real exchange rates of individual country currencies. When this series is used in regressions, a common exchange rate fluctuation is observed by all industries. Alternatively, the second type of exchange rate series are industry-specific constructs for exports and for imports. In each case we use the relevant bilateral real exchange rates of the U.S. trading partners and trade partner weights defined by the annual share of each of 34 partner countries in the export or import activity of each individual industry (see Goldberg and Tracy, 2000). In the regressions, both types of real exchange rate measures yield qualitatively similar results. Thus, in our exposition we provide only the results generated using the real industry-specific multilateral exchange rate measures.[13]

Our regressions introduce exchange rates interacted with the industry-specific and time-varying channels of trade. Although our theoretical exposition details three distinct interacted channels (exports, import competition, and imported inputs), for identification of the parameters we ultimately use two interacted channels: (i) the export to production share in the industry, and (ii) the share of imported inputs into production costs (see Campa and Goldberg, 1997). We are limited to these two channels by the high intra-industry correlations between import penetration and imported input use. These trade shares are lagged one period to avoid issues of simultaneity.

The regressions include the prices of two other inputs: capital and energy. We use the real long-term interest rate (RATE), measured by the yield in long-term U.S. Government bonds minus U.S. inflation, as a measure of the cost of capital. Real oil prices (OIL) are measured by the average annual dollar price per barrel of crude petroleum reported by the International Monetary Fund. The net effect on labor demand of an increase in either of these two prices depends on the substitutability versus complementarities of each of these factors with labor. To the extent that technological substitution between that input and labor is possible, an increase in the input price leads to an increase in the demand for labor. If factors are complements, the sign of this correlation will be negative. Domestic demand (GDP), measured by the U.S. real GDP, and a world demand variable (WGDP), defined as the weighted average of real GDP of the 34 largest partners of the United States, are also included in the regressions. We constrain the industry responses to factor prices and income variables to be the same for all industries.

Our measures of labor market activity are central to the empirical work. The model of labor market equilibrium in Section II did not specify the unit of observation for labor. Labor was a continuous input that could be adjusted continuously as needed. Empirically, labor activity over an interval can be measured by the average number of employees or the total number of hours worked by employees (including overtime effort).

Our times-series data consist of both employment and total hours worked in each 2-digit manufacturing industry, as well as average industry wages and measures of industry overtime activity. The employment series is the total number of non-farm employees in the industry, as reported by the Bureau of Labor Statistics. The total hours series is the product of the employment series and the reported average weekly hours in each industry. Our measure of wages per employee is the average hourly wage in each industry, constructed by dividing the total of wage and salary accruals to all employees in each industry by the number of non-farm employees. Overtime wage is defined as total average hourly wages minus average hourly wages excluding overtime for production and non-supervisory workers as defined by the Bureau of Labor Statistics. Overtime hours are the average weekly overtime hours of production workers. We computed real wages and real overtime wages by deflating their nominal values in two alternative ways: 1) using the aggregate CPI to reflect real wages from the worker's point of view; and 2) using the industry-specific GDP deflators to reflect the real cost of labor to the producer. Both of these measures lead to very similar empirical results. Below we report only the regression results using the CPI deflators.[14]

As detailed in Appendix Table A1, a fair amount of dispersion of wages and employment exists across industries and within industries over time. Wages are less variable within industries over time than across industries at points in time. The variability of wages across industries is almost four times higher than the average variability of wages over time and within each industry. Wage variability across industries is also higher than employment variability across industries.

[13] Additional results are available upon request from the authors.

[14] For robustness checks on the issue of the importance for our findings of the use of 2-digit data, we also have constructed a database of 4-digit SIC industry data drawn from the NBER Productivity Database. Employment is the total number of hours for production workers only. Full data on overtime employment or jobs at the 4-digit level is unavailable.

Finally, industry overtime wages and employment are considerably more volatile than overall wages and employment.

Wage and employment variability across industries are correlated with observable industry and worker characteristics. The extent of wage variability in different industries is positively correlated with the skill intensity of workers, industry unionization rates, and industry capital intensity. High unionization rates are associated with higher wage and employment variability (both total and overtime), while industries with higher price-over-cost markups tend to have lower employment and wage variability.

As surveyed by Hammermesh (1993), a number of factors determine whether a producer's response to stimuli is through hiring (firing) new workers or through an increase (decrease) in the number of hours that the existing staff work. These factors include: the nature of the shock (transitory versus permanent)[15]; the industry costs of hiring/ firing versus expanding/ contracting work effort; and the types of contracts signed with workers. The tendency toward the use of overtime employment instead of changes in the number of employees is expected to be higher when the shocks are temporary, hiring and firing costs are high, and the labor pool is more skilled or requires more job-specific skills. Hiring and firing should be most responsive to permanent shocks, while overtime activity is an important margin of adjustment to transitory shocks.

Because the permanence of shocks matters for the mode of labor market adjustment, we decompose exchange rate movements into their permanent (nonstationary) and transitory (stationary) components. The procedure was first suggested by Beveridge and Nelson (1981) and later employed to exchange rate data by Huizinga (1987), Campbell and Clarida (1987), and Clarida and Gali (1994), among others. (see the Appendix discussion). This variance decomposition shows that the transitory component of the exchange rate accounts for only a small proportion of the variance of our real exchange rate series. The variance of the transitory component of the real exchange rates generally accounts for less than 40 percent of the total variability.[16]

IV. EMPIRICAL RESULTS

[15] Stimuli perceived to be more permanent are expected to be reflected more often in changes in the number of workers than in overtime hours.

[16] This result is consistent with the finding in this literature that real exchange rate shocks tend to be permanent.

In this section we present the results of several types of regressions. The first sets of regressions consider the role of the exchange rates and other variables in moving industry labor market variables over time and across panels of industries. For the employment and wage regressions, we report the implications of the permanent component of exchange rates. For overtime wages and overtime hours, we report results from using the transitory component of exchange rates. All regression specifications include as regressors a set of industry dummies, the interest rate,[17] the price of oil, the annual values of U.S. GDP and world GDP, and the lagged values of our measure of employment for each industry. All variables other than lagged employment are expressed in log differences (except for the interest rate, which is in percentage differences). We allow for industry specific speeds of adjustment to shocks by letting the coefficient on lagged industry employment be industry specific.

In addition to regressions over the full panel of manufacturing industries, we split the full sample according to the industries median price-over-cost markup. We compare industry responses for two different subsets of industries: Higher- and Lower-markup industries.[18] While levels of markups may change over time within industries, the actual division of industries relative to a median markup is very stable. Finally, we run specifications for individual industries, as opposed to panels of industries. While industry-specific regressions are ultimately what one would want, these regressions have too few observations to stand on their own merits.

Our empirical results section concludes with a discussion of other robustness checks that we have performed. The results are robust to the use of aggregated versus industry-specific real exchange rates, as well as to the choice of manufacturing industry data disaggregated to the 2-digit or 4-digit SIC level. We argue that the estimation method, which allows for time-varying external orientation, is important for identification of significant exchange rate effects.

Pooled Industry Regressions.

[17] We also ran a full system of regressions using a 2SLS procedure wherein interest rates were instrumented by lagged values of the interest rate and other exogenous variables. This instrumenting did not qualitatively change our exchange rate results.

[18] The "Lower" markup group of industries includes: primary metal products, fabricated metal products, transportation equipment, food and kindred products, textile mill products, apparel and mill products, lumber and wood products, furniture and fixtures, paper and allied products, petroleum and coal products, and leather and leather products.

[19] We also ran a full system of regressions using a 2SLS procedure wherein interest rates were instrumented. This instrumenting did not qualitatively change our exchange rate results.

Table 1 reports the estimated coefficients from running equations (12a) and (12b) using total industry wages, total hours employed, and total industry employment. For each dependent variable, the rows of the table provide the results from the full time-series panel of manufacturing industries and from splitting the panel into higher and lower markup industry groups.

As demonstrated by the coefficients and standard errors reported in the first two columns of Table 1, and by the F-test results reported in the last column, permanent exchange rates have significant explanatory power with respect to industry wages in the lower-markup industries. For workers in these industries, a dollar depreciation increases the average wages, especially for those industries more heavily involved in export activity. As industry export orientation rises, so does the importance of the dollar as a force that restrains industry wage growth when the dollar strengthens. In all industry groupings, the negative coefficient on $M^i \Delta ER^i$ implies that reliance on imported production inputs can reverse some of the restraint on wage growth associated with dollar appreciations. All else equal, as an industry increases its reliance on imported inputs – as has been the case over much of the past two decades[20] – dollar depreciations become a less important stimulant to industry wages and appreciations become less important for restraining wage growth. Indeed, in industries with imported input shares exceeding their export shares, appreciations could improve industry competitiveness and expand labor demand, leading to more rather than less real wage growth. The same sign pattern of effects of exchange rates on wages appear for the full panel of industries and for the sub-panel including only high-markup industries. However, for higher-markup industries we reject the hypothesis that the estimated exchange rate effects are jointly statistically significant.

The net effects of a permanent exchange rate change on industry employment, whether through number of jobs or total hours, are smaller than the wage effects. For lower markup industries, the sign pattern on the coefficients on the interacted exchange rate terms is consistent with the theory: employment implications rise as industry export orientation increases and decline with imported input use. The net effects from these channels is quantitatively small for most industries. For example, for a heavily trade-oriented industry characterized by 30 percent export share and 10 percent imported input share, a 10 percent dollar depreciation would lead to a short-

[20] Details of the evolving external orientation of U.S. industries are provided in Campa and Goldberg (1997).

run employment boost of 3 percent.[21] For a lower markup industry with a 15 percent export share and 10 percent imported input share, the short-run employment stimuli would be 0.15 percent. For the higher markup industries, all of the individual exchange rate coefficients are statistically insignificant and the F-tests cannot reject the hypothesis of these coefficients being jointly equal to zero.

The rest of the regressors show consistently significant results across all of the different specifications. Increases in the prices of other inputs are consistently negatively correlated with industry wages and positively correlated with industry employment. Industry employment, as expected, is higher when the economy is in a boom, i.e., when the growth rate of GDP is higher. Wages appear to decline in periods of high economic activity, but this correlation is not statistically significant. Improved world demand conditions are associated with increased jobs and hours in U.S. manufacturing industries and are insignificantly related to wages, with coefficients smaller than on local demand variables.

Table 2 reports the estimated coefficients from analogous regressions using as the dependent variable the measures of industry overtime wages and overtime employment. These regressions are similar in format to those of Table 1 with two notable exceptions. First, we assume that since changes in the amount of overtime activity is a short-run, temporary practice, it is not subject to the same adjustment costs as changes in permanent employment. Therefore, we estimate a static model instead of a partial-adjustment model in the overtime regressions. This implies that changing the size of the labor force through (limited) use of overtime has no cost other than the corresponding wage. We then drop from the estimation the lagged level of industry employment as a regressor. Second, since the model is static, the amount of overtime responsiveness is measured relative to the transitory component of the actual exchange rate.

Overtime wages and overtime employment are both more responsive to exchange rate movements than are total wages and regular employment (Table 1). These results are again most statistically significant in the lower markup industries. For these industries, on average the highly trade-oriented manufacturer (30 percent export share, 10 percent imported input share) faced with a temporary 10 percent dollar depreciation would raise overtime employment by 16 percent and

[21] When industry-specific exchange rates are used without the decomposition into the permanent and transitory components, F-test results show that the pairs of exchange-rate changes enter significantly into the types of regressions reported in Tables 1 and 2.

overtime wages by 11 percent.[22] For the more moderately export-oriented manufacturer (15 percent export share), overtime employment would rise by 7 percent and overtime wages by 4.6 percent.

Industry-Specific Responses.

The results reported above impose common effects of all the explanatory across industries (with the exception of the constant term and lagged employment). It is reasonable to think that some of the underlying parameters in the model outlined in section two, such as the industry demand and cost elasticities, are industry specific. In the time-series panel regressions, we attempted to relax this restriction in one direction by splitting the sample between higher- and lower-markup industries. As seen in Tables 1 and 2, and the implied coefficients do differ as would be expected for industries that are further from and closer to perfectly competitive markets. In this section we provide further insights in the differences in the exchange rate effects by industry.

There are two ways that we attempt to shed light on the industry-specific behavior of adjustment of employment and wages to exchange rate changes. First, we impute industry responses using the estimated exchange rate coefficients reported Tables 1 and 2 for the lower- and higher-markup industries, and the average export share and imported input share of each industry during the sample period. These elasticities, with constructed levels of statistical significance, are reported in Table 3. Second, we estimated our original real wage and employment specifications separately for each industry, using only the data for that specific industry.

The imputed labor market response elasticities to an exchange rate shock vary considerably across industries. An exchange rate depreciation results in an increase in wages in most manufacturing industries (14 out of 20 industries). On average, a 10 percent permanent dollar depreciation will result in an increase in the manufacturing wages of industries by 0.7 percent over the full estimation period,[23] or by 1 percent in 1995. The industry-specific employment responses are small for export-oriented industries and often negative for industries

[22] When the permanent component of exchange rates is used instead, the F-tests easily reject the null hypothesis of no exchange rate effect in all cases, with the exception of overtime employment in higher markup industries (which is only marginally rejected).

that also rely on imported inputs into production. The implications for employment (number of jobs) are much less precisely measured, generally are not statistically different from zero, and are associated with more industries contracting employment than expanding employment.

[23] This is an average across industries, unweighted by the number of employees in the industries.

Table 1. Permanent Exchange Rate Changes and U.S. Employment and Wages

	$X_{it-1}\Delta ER_t$	$M_{it-1}\Delta ER_t$	ΔOIL_t	$\Delta RATE_t$	ΔGDP_t	$\Delta WGDP_t$	adj. R2	F-test
Change in Wages								
All industries			-0.02* (0.01)	-0.04* (0.02)	-0.13 (0.09)	-0.01 (0.15)	.10	
	1.53* (0.66)	-1.07 (0.89)	-0.02* (0.01)	-0.03* (0.02)	-0.14 (0.09)	-0.05 (0.16)	.11	3.01*
Higher Price-over-Cost Markup Industries			-0.02* (.01)	-.05* (0.02)	-0.12 (0.15)	0.23 (0.25)	.11	
	1.29 (1.22)	-2.22 (2.75)	-0.02* (0.01)	-0.05** (0.03)	-0.14 (0.15)	0.22 (0.26)	.13	0.72
Lower Price-over-Cost Markup Industries			-0.02* (0.01)	-0.03** (0.02)	-0.15 (0.12)	-0.20 (0.19)	.05	
	3.61* (1.24)	-2.12** (1.13)	-0.02* (0.01)	-0.03 (0.02)	-0.17 (0.12)	-0.23 (0.19)	.08	4.81*
Change in Total Hours								
All industries			0.03* (0.01)	0.01 (0.02)	1.38* (0.09)	0.73* (0.15)	.56	
	-0.43 (0.68)	-1.46 (0.91)	0.03* (0.01)	-0.01 (0.02)	1.37* (0.09)	0.84 (0.16)	.57	5.09*
Higher Price-over-Cost Markup Industries			0.03* (0.01)	0.03** (0.02)	1.31* (0.12)	0.51* (0.21)	.56	
	-0.18 (1.06)	-1.41 (2.40)	0.03* (0.01)	0.03 (0.02)	1.31* (0.12)	0.58* (0.21)	.56	1.21
Lower Price-over-Cost Markup Industries			0.03* (0.01)	-0.02 (0.02)	1.43* (0.14)	0.91* (0.22)	.56	
	1.31 (1.42)	-3.15* (1.29)	0.03* (0.01)	-0.04** (0.02)	1.39* (0.13)	1.09* (0.22)	.58	4.90*
Change in Number of Jobs								
All industries			0.03* (0.01)	0.01 (0.01)	1.05* (0.08)	0.65* (0.13)	.54	
	0.19 (0.62)	-1.29 (0.82)	0.03* (0.01)	0.00 (0.01)	1.04* (0.08)	0.71* (0.13)	.55	2.18
Higher Price-over-Cost Markup Industries			0.03* (0.01)	0.02 (0.02)	0.97* (0.12)	0.43* (0.19)	.50	
	0.13 (1.02)	-1.10 (2.30)	0.03* (0.01)	0.02 (0.02)	0.97* (0.12)	0.46* (0.20)	.50	0.29
Lower Price-over-Cost Markup Industries			0.03* (0.01)	-0.01 (0.02)	1.13* (0.11)	0.83* (0.18)	.57	
	2.02** (1.22)	-2.85* (1.13)	0.03* (0.01)	-0.01 (0.02)	1.10* (0.11)	0.92* (0.18)	.59	3.34*

* significant at 5 percent. ** significant at 10 percent. F-test is of the hypothesis that coefficients on exchange rate terms are jointly non-zero. Standard errors are in parentheses.

Table 2. Temporary Exchange Rate Changes and U.S. Overtime Wages and Hours

	$X_{it-1}\Delta ER_t$	$M_{it-1}\Delta ER_t$	ΔOIL_t	$\Delta RATE_t$	ΔGDP_t	$\Delta WGDP_t$	adj. R2	F-test
Change in Overtime Wages								
All Industries			-0.16* (0.02)	-0.20* (0.06)	3.47* (0.33)	0.75 (0.57)	.41	
	-0.22 (1.82)	2.27 (2.85)	-0.10* (0.02)	-0.16* (0.06)	3.67* (0.32)	0.63 (0.55)	.43	13.95*
Higher Price-over-Cost Markup Industries			-.07* (0.03)	-0.06 (0.09)	4.13* (0.52)	0.70 (0.89)	.40	
	-2.75 (2.61)	9.99 (6.30)	-0.06** (0.04)	-0.07 (0.09)	4.18* (0.52)	0.96 (0.90)	.41	1.65
Lower Price-over-Cost Markup Industries			-0.14* (0.03)	-0.27* (0.07)	3.18* (0.38)	0.52 (0.66)	.52	
	4.59** (2.82)	-2.34 (2.72)	-0.14* (0.03)	-0.27* (0.07)	3.26* (0.38)	0.58 (0.67)	.54	1.99
Change in Overtime Employment								
All Industries			-0.07* (0.02)	-0.10** (0.05)	3.05* (0.31)	1.20* (0.54)	.31	
	3.09* (1.31)	0.61 (1.95)	-0.04* (0.02)	-0.11* (0.05)	3.36* (0.30)	1.45* (0.53)	.35	14.24*
High Price-over-Cost Markup Industries			-0.04 (0.035)	0.01 (0.09)	3.07* (0.51)	1.41 (0.88)	.26	
	0.61 (2.55)	6.74 (6.18)	-0.02 (0.04)	-0.03 (0.09)	3.33* (0.51)	1.90* (0.88)	.29	4.73*
Lower Price-over-Cost Markup Industries			-0.06* (0.03)	-0.16* (0.07)	3.19* (0.37)	0.87 (0.64)	.37	
	6.03* (2.60)	-2.10* (0.57)	-0.05** (0.03)	-0.17* (0.06)	3.34* (0.36)	1.05** (0.63)	.42	5.42*

* significant at 5 percent level. ** significant at 10 percent level. F-test is of the hypothesis that coefficients on exchange rate terms are jointly non-zero. Standard errors are in parentheses.

Table 3: Implied Elasticities of Response of Changes in Industry Labor Market Variables Computed using average export and imported input shares, 1972-1995					
Industry	wages	Total Hours	Total jobs	Overtime wages	Overtime hours
Food & Kindred Products	0.08*	-0.04	-0.01	0.12*	0.19*
Tobacco Products	0.11	-0.07	-0.01	-0.12	0.19
Textile Mill Products	0.08*	-0.07**	-0.04	0.11*	0.20*
Apparel & Other Textile Products	0.08*	-0.01	0.01	0.11*	0.16*
Lumber & Wood Products	0.02*	0.02	0.05	0.24*	0.35*
Furniture & Fixtures	-0.00	-0.11*	-0.08*	0.01	0.06
Paper & Allied Products	0.10*	-0.06	-0.02	0.15**	0.25*
Printing & Publishing	-0.04	-0.03	-0.03	0.24**	0.21
Chemical & Allied Products	0.07	-0.09	-0.03	0.08	0.35*
Petroleum & Coal Products	-0.03	-0.15*	-0.12*	-0.02	0.04
Rubber & Misc. Plastic Products	-0.02	-0.05	-0.03	0.22**	0.28*
Leather & Leather Products	0.01	-0.28*	-0.20*	0.06	0.21
Stone, Clay, and Glass Products	-0.02	-0.04	-0.03	0.21*	0.24*
Primary Metal Industries	0.06**	-0.14*	-0.09*	0.11	0.21*
Fabricated Metal Products	0.07**	-0.12*	-0.07*	0.12	0.22*
Industrial Machinery & Equipment	0.14	-0.15	-0.05	0.09	0.60*
Electronic & Other Electric Equip.	0.03	-0.12	-0.06	0.33**	0.58*
Transportation Equipment	0.32*	-0.07	0.01	0.45*	0.69*
Instruments & Related Products	0.12	-0.11	-0.03	0.02	0.42*
Misc. Manufacturing	-0.02	-0.10	-0.06	0.42**	0.55*
Average Industry Elasticity 1972-95	0.06	-0.01	-0.04	0.15	0.30
Average Industry Elasticity: 1975	0.08	-0.06	-0.02	0.10	0.25
1980	0.10	-0.07	-0.02	0.12	0.30
1985	0.02	-0.12	-0.08	0.14	0.25
1990	0.08	-0.12	-0.05	0.20	0.38
1995	0.10	-0.14	-0.056	0.239	0.44

Note: Reported elasticities are constructed using parameters reported in Tables 1 and 2 for low and high markup industries. Average Industry Elasticities are not weighted by industry size.
* significant at 5 percent level. ** significant at 10 percent level.

In contrast to the small and noisy employment effects, the imputed effects of an exchange rate depreciation (or appreciation) on industry use of overtime activity are statistically significant and sizable (Table 3, columns 4 and 5). All industries expand (contract) overtime hours in response to transitory depreciations (appreciations) and 18 of 20 industries increase overtime wages. All of the statistically significant real wage elasticities are positive. For example, using average trade shares over the past two decades for the respective industries, a 10 percent depreciation would elicit an expansion of overtime wages by 4.5 percent and hours by 6.9 percent in the Transportation Equipment sector. Across most manufacturing sectors, the last column of Table 3 shows that overtime hours adjustments are an important margin of adjustment -- both in terms of size and statistical significance -- especially for the export-oriented industries of the United States.

These average elasticities of response have increased considerably over time. For overtime hours and overtime wages, the average elasticities almost doubled between 1985 and 1995. For total wages, low response levels in the mid-1980s were unusual for the past two decades. By the mid 1990s, real wage elasticities were back up in ranges observed in the early 1980s.

For both regular employment and overtime activity, the relative size of exchange rate effects on industry activity appears to be highly correlated with industry-specific characteristics other than their external orientation. In Table 4 we report the results of correlating the estimated elasticities reported in Table 3 with four different industry characteristics: average industry markup during the sample period, unionization rates, percent of workers without a college degree, and industry capital-to-labor ratios.

A clear pattern of correlation exists between our estimated real wage and employment elasticities and two variables: industry markups and the level of workers' education. Industries with higher price-over-cost markups also have higher wage (actual and overtime) responsiveness to exchange rates, and employment responsiveness (in terms of both hours and jobs). Industries with a higher share of unskilled workers also had relatively smaller wage and employment elasticities. This strong correlation between these specific industry characteristics and exchange rate elasticities suggest that issues such as the degree of education of the labor force, type of education, and competitive pressures in the industry might result in quite different mechanisms for the adjustment across labor markets. We do not find a clear relationship between the degree of employment and wage responsiveness and the industry's capital-to-labor ratios or unionization rates.

Table 4 Estimated Industry Elasticities and Industry Features

Elasticities of response of changes in:	Price-Over-Cost Markup	% Non-College Degree Workers	Unionization Rates	Capital Intensity
Wages	0.208* (2.703)	-0.171* (-2.658)	-0.059 (-0.883)	0.638 (0.527)
Overtime wages	0.126* (2.345)	-0.127** (-1.856)	0.017 (0.254)	-0.329 (-0.275)
Number of jobs	0.123* (3.425)	-0.072* (-1.990)	-0.041 (-1.190)	0.629 (1.009)
Total hours	0.103* (3.110)	-0.031 (-0.891)	-0.038 (-0.031)	0.692 (1.265)
Overtime employment	0.139 (0.979)	-0.279* (-2.615)	-0.027 (-0.238)	-0.111 (-0.055)

Notes: Weighted-least-square regression coefficients are reported. Weights are the inverse of the estimated standard errors from the elasticities. Industry responses use industry average external orientation ratios over 1972-1995. * indicates significance at 5 percent level. ** indicates significance at 10 percent level. Regression t-statistics are in parentheses.

An Alternative Estimation Approach: As an alternative mode of exploring this data, we re-estimated equations (12a-12b) separately for each of the 20 two-digit SIC manufacturing industries. However, because of the limited number of observations and degrees of freedom in each of these regressions, the regressions and estimates have very little power. The parameter estimates are extremely noisy and are appropriately viewed with a great deal of skepticism. In the vast majority of cases, the hypothesis of an insignificant exchange rate effect could not be rejected for regressions using regular wages or employment. There is a strong correlation between the estimated response elasticities for industry wages, overtime wages, and overtime employment reported in Table 4 and those implied from the industry specific regressions. However, the two approaches give nearly uncorrelated results across the two employment measures.

Further Robustness Checks

We also re-estimated equations (12a-12b) using alternative data series as a further robustness check on our results. First, we used as the relevant exchange rate an economy wide trade-weighted exchange rate index, rather than the industry-specific exchange rates. The advantage of the more aggregated index is that it avoids the problem of endogeneity of the trade weights in the industry specific indexes to exchange rate movements. The results from this specification were qualitatively the same to those detailed above.

Next, we explored adjustments in 4-digit industry-level data on labor market outcomes. As more disaggregated series, these data can potentially provide more information on the type of adjustments spelled out in the theoretical section. The main disadvantage of these data is that the available 4-digit series limit the thoroughness of the potential analysis. Hours and wages (from the NBER Productivity Database) are only for production workers, as opposed to the broader group of workers for whom we have data at the 2-digit level. The employment measure is the total number of hours for production workers only (not of total employees as in the 2-digit data), from the NBER Productivity Database. Finally, the overtime employment and overtime wages data are not available at the 4-digit level. Another disadvantage is that we cannot compute the appropriate imported input shares, since the input-output classification does not have a one-to-one correspondence with the 4-digit SIC classification. In the regressions, we proxied for imported-input shares using three different alternatives: the 4-digit import-to-consumption ratios; the 2-digit imported-input ratios; and by instrumenting the 2-digit SIC data with the 4-digit import-to-consumption ratios in constructing new imported-input shares.

These regressions using 4-digit industry data support the conclusions presented in the context of the 2-digit industry case. F-test results always reject the null hypothesis of exchange rate terms being jointly insignificant. Employment and jobs always on average expand (contract) with dollar depreciations (appreciations). In these regressions, the signs and significance patterns of the wage effects show that, on average, an exchange rate depreciation increases wages. As expected, estimated 4-digit industry elasticities, constructed using parameter estimates from the alternative methodologies previously described, are always positively correlated with those from the 2-digit regressions. The estimated real wage elasticities are more positively correlated than the employment correlations, which capture also different components of the workforce. Nevertheless, the estimated elasticities are very similar. For instance, for an export oriented and lower-markup industry with a 30 percent export share and a 10 percent import share, the estimated employment increase from a 10 percent dollar depreciation using this data is 2.4 percent.

V. SUMMARY AND CONCLUDING REMARKS

In this paper we have examined the effects of exchange rate movements on employment and wages for manufacturing industries in the United States. In theory, exchange rate movements alter industry labor demand to the extent that they affect the marginal profitability of firms in an industry. Consequent movements in the marginal revenue product of labor will depend on the form of external exposure of each particular industry, whether through export orientation, the amount of import competition, or the reliance on imported inputs into production. Other industry characteristics such as an industry's competitive structure, the composition of its labor force, and the characteristics of the production process will also determine the expected size of labor adjustment to an exchange rate shock.

We empirically estimated the effects of exchange rate changes on five different measures of labor market activity: wages, employment (jobs and hours), overtime employment, and overtime wages. The results indicate that labor market adjustments to exchange rate movements tend to be small but statistically significant. We find an average real wage elasticity to exchange rates of 0.06 over 1972 to 1995, which is in line with other estimates from import competition studies (Revenga 1992, Slaughter and Swagel 1998). We also find that the importance of exchange rates for wages has been growing sharply since the mid-1980s. This acceleration reflects the more rapid growth of export markets compared with the growth of imported input use in production. Our estimates of employment elasticities are significantly lower (-0.01 on average) and noisier. We find that exchange rate movements have large significant effects on overtime activity in the labor markets. The average elasticity of overtime wages to an exchange rate depreciation is 0.15 and the employment elasticity is 0.3.

Industry-specific elasticities of response to exchange rate movements are significantly correlated with the skill composition of workers in an industry and the competitive structure of the industry. Employment and wages are more sensitive to exchange rates in lower-markup industries. Industries with a higher proportion of college-educated workers observe lower wage and employment elasticities of response to exchange rates, despite the fact that the skill-intensive industries tend to be more export oriented. The reason may be that skill intensive industries have relatively higher costs of hiring or firing workers. We also find that high price-over-cost markup industries and more skill-intensive industries have relatively larger overtime wage responses to exchange rates. On the margin, more skill intensive industries use overtime activity rather than hiring and firing workers, especially in response to transitory fluctuations.

REFERENCES

Allayanis, G. and J. Ihrig. Forthcoming "Markups and Exposure," *Review of Financial Studies*.

Beveridge, S. and C. Nelson, 1981. "A New Approach to the Decomposition of Economic Time Series Into Permanent and Transitory Components," *Journal of Monetary Economics,* 33, no.1: 5-38.

Bodnar, G., B. Dumas, and R. Marston (1998). "Pass-Through and Exposure". Weiss Center at Wharton, working paper 98-1.

Branson, W., and J. Love. 1988. "United States Manufacturing and the Real Exchange Rate." In R. Marston, ed., *Misalignment of Exchange Rates: Effects on Trade and Industry,* University of Chicago Press.

Brunello, G. 1990. "Real Exchange Rate Variability and Japanese Industrial Employment," *Journal of the Japanese and International Economies*.

Burgess, S. and M. Knetter. 1998. "An International Comparison of Employment Adjustment to *Review of International Economics* (February): 151-163.

Campa, J., and L. Goldberg. 1995. "Investment, Exchange Rates and External Exposure." *Journal of International Economics* 38 (May): 297-320.

Campa, J., and L. Goldberg.1999. "Investment, Pass-Through and Exchange Rates: A Cross-Country Comparison." *International Economic Review*, vol. 40 no. 2 (May): 287-314.

Campa, J., and L. Goldberg. 1997. "The Evolving External Orientation of Manufacturing: *Economic Policy Review* (July , Federal Reserve Bank of New York).

Campbell, J. and R. Clarida. 1987. "The Dollar and Real Interest Rates: An Empirical Investigation," *Carnegie-Rochester Conference Series on Public Policy*, 27: 103-140.

Clarida, R. and J. Gali. 1994. "Sources of real exchange rate fluctuations: How important are nominal shocks?," *Carnegie-Rochester Conference Series on Public Policy*, 41: 1-56.

Davis, Steven J. and Haltiwanger. 1999. "Sectoral Job Creation and Destruction Responses to Oil Price Changes and Other Shocks." NBER working paper #7095.

Dekle, R. 1998. "The Yen and Japanese Manufacturing Employment." *Journal of International Money and Finance*, 17: 785-801.

Dornbusch, R. 1987. “Exchange Rates and Prices.” *American Economic Review* 77 (March): 93-106.

Goldberg, L. 1993. “Exchange Rates and Investment in United States Industry.” *Review of Economics and Statistics* LXXV, no. 4 (November): 575-88.

Goldberg, L. and J. Tracy. (2000) “Exchange Rates and Local Labor Markets.” In R. Feenstra editor, *The Impact of International Trade on Wages* (NBER and University of Chicago Press). pp. 269-308.

Hammermesh, D. 1993. *Labor Demand*. (Princeton: Princeton University Press).

Huizinga, J. 1987. "An Empirical Investigation of the Long Run Behavior of Real Exchange Rates," *Carnegie-Rochester Conference Series on Public Policy,* 27: 149-215.

Kletzer, L. 2000. “Trade and Job Loss in U.S. Manufacturing, 1979-94” in R. Feenstra editor, *The Impact of International Trade on Wages* (NBER and University of Chicago Press). pp. 349-396.

Marston, R. 1990. “Pricing to Market in Japanese Manufacturing.” *Journal of International Economics* 29 (November): 217-36.

Nickell, S. 1986. Dynamic Models of Labour Demand. in *Handbook of Labor Economics* volume I, edited by O. Ashenfelter and R. Layard:.473-522.

Revenga, A. 1992. “Exporting Jobs? The Impact of Import Competition on Employment and Wages in the U.S. Manufacturing,” *Quarterly Journal of Economics* 107 (1): 255-284.

Slaughter, M. and P. Swagel, 1998. “The Effect of Import Competition on Wages and Employment: Evidence from the Advanced Economies,” mimeo, Dartmouth College.

Data Appendix

All wages were deflated from nominal values to real values using the consumer price index from the IMF *International Financial Statistics,* line 4. The measures of export share, import to domestic consumption share, and imported input share are taken from Campa and Goldberg (1997).

The exchange rate is the average real effective exchange rate index for the industry based on the industry's major trading partners, defined as U.S. dollar per units of foreign currency. This index is computed using industry-specific export and import data for the 20 manufacturing industries and 34 major US trading partners. The trade data for 1972-1994 was downloaded from Robert Feenstra's website (http://polar.ucdavis.edu/~feenstra/index.html) and the post-1994 data come from the US international trade commission website (http: //205.197.120.17/scripts/ user_set.asp). The exchange rate and price data comes from the IMF *International Financial Statistics*. Whenever possible, producer price indexes were obtained; if they were not available, consumer price indexes were used. In cases in which IFS data was not available for a given country, data from the FRBNY INTL database or DRI data was used instead. The interest rate is the real long-term interest rate (IMF *International Financial Statistics*, line 61 minus inflation rate). Oil Price is the real domestic currency price of average price of crude oil IMF *International Financial Statistics*. Real Gross Domestic Product in 1990 prices is from IMF *International Financial Statistics*, line 99b. The World Gross Domestic Product is the weighted average of the real Gross Domestic Product of the top 10 trading partners of the United States. The weights used are currency weights calculated by the Board of Governors (they can be viewed at http://www.federalreserve.gov/releases/H10/weights).

Computation of Permanent Exchange Rates: As derived in the text employment and wages respond to permanent changes in exchange rates while overtime wages and employment respond to temporary changes in exchange rates. The Beveridge-Nelson procedure decomposes an I(1) time series into its transitory and permanent components. We follow Beveridge and Nelson (1981) and Huizinga (1987), and model the exchange rate decomposition using lags of the real exchange rate.[24] In particular, we assume that the first differences of the quarterly (log) real exchange rate

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24 We also tried a multivariate system in which we also included three lags of the country's quarterly inflation rate and GDP growth. The results of the decomposition were very similar, with an average correlation between the permanent

follow an AR(4) process, so that the transitory departure of the real exchange rate from its expected long-run equilibrium, e_t^{BN}, is given by:

$$E_t\left(e_t^{BN}\right) = -E_t\left(\sum_{j=1}^{\infty} \Delta e_{t+j} \mid \Delta e_t, \Delta e_{t-1}, \Delta e_{t-2}, \Delta e_{t-3}\right) \tag{a3}$$

The actual variance decomposition results suggest that the temporary component of exchange rate changes accounts for only a small proportion of the variance of the real exchange rate series.[25] The variance of the transitory component of the real exchange rate accounts for about 40 percent of the total variability of the real exchange rates.

components about 0.9. Given that these exchange rates are trade-weighted multilateral indices, we decided to report and utilize only the univariate decompositions.

25 Similar results are reported in Clarida and Galí (1994).

Appendix Table A1: Relative Variability of Annual Wage, Employment and Overtime Series

	Average Coefficients of Variation (minimum coefficient variation, maximum coefficient variation)	
	Across Industries	Within Industries
Wages	0.242 (0.193, 0.289)	0.066 (0.022, 0.274)
Number of jobs	0.044 (0.022, 0.070)	0.053 (0.023, 0.091)
Total hours	0.051 (0.025,0.081)	0.071 (0.034, 0.132)
overtime wages	0.407 (0.330,0469)	0.158 (0.054, 0.491)
overtime employment	0.309 (0.268,0.362)	0.178 (0.078, 0.388)

	Ratio of within industry Coefficients of Variability for Industries sorted relative to median characteristic			
	High / Low Price-Over-Cost Markup	High/Low % Non-College Degree Workers	High / Low Unionization Rates	High / Low Capital Intensity
Wages	0.950	1.041	1.045	1.095
number of jobs	0.929	0.989	0.924	0.796
total hours	0.901	0.910	1.156	0.9
overtime wages	1.068	0.746	1.160	1.240
overtime employment	0.926	0.895	1.109	1.147