NBER WORKING PAPER SERIES

DOLLAR APPRECIATION AND MANUFACTURING EMPLOYMENT AND OUTPUT

William H. Branson

James P. Love

Working Paper No. 1972

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 1986

The research reported here was supported by the National Science Foundation's Division of Policy Research and Analysis. We would like to thank the participants of the March 21, 1986 NBER conference on International Economic Problems Confronting the United States and Japan, for helpful comments on an earlier draft of this paper. The research reported here is part of the NBER's research program in International Studies. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

Working Paper #1972
July 1986

Dollar Appreciation and Manufacturing Employment and Output

ABSTRACT

This paper examines the impact of the movements in the real exchange rate on employment and output in U.S. manufacturing industries. We use a simple model of supply and demand to estimate the elasticity of manufacturing employment and output with respect to the real exchange rate, at different levels of aggregation. The data are quarterly, covering two time periods--1963:1 to 1985:1 and 1972:1 to 1985:1. The employment estimates include 20 manufacturing sectors at the 2-digit SIC level, 125 sectors at the 3-digit SIC level, 176 sectors at the 4-digit SIC level. In addition, we disaggregate manufacturing employment regionally by the 50 states plus the District of Columbia. The output estimates include 80 sectors of industrial production at different levels of aggregation. We check for consistency by considering the impact of aggregation among the 2-,3-, and 4-digit employment estimates, and by comparing the estimates for employment to those for output. We find that exchange rate movements have had important effects on the manufacturing sector, and in particular, the durable goods sector, including primary metals, fabricated metal products, and non-electrical machinery. Other sectors that suffer large employment loses when the dollar appreciates are stone, clay and glass products, transportation, instruments, textiles and apparel, chemicals, rubber and leather goods.

William H. Branson
Woodrow Wilson School
Princeton University
Princeton, NJ 08544

James P. Love
Woodrow Wilson School
Princeton University
Princeton, NJ 08544

William H. Branson
James P. Love
July 1986

DOLLAR APPRECIATION AND MANUFACTURING EMPLOYMENT AND OUTPUT

I. Introduction and Summary

In the spring of 1981 the U.S. dollar began a four-year period of real appreciation that took it to a peak of more than 50 percent by first quarter 1985 (see Table 1 below). By 1982 the dollar was nearly 25 percent over its 1980 value. By mid-1984 the dollar appreciation was about 40 percent over its 1980 value, and by first quarter 1985 the dollar was more than 50 percent higher.[1] The appreciation of the dollar in real terms was part of the adjustment process by which the increase in the structural budget deficit in the U.S. was financed. By mid-1985, the current account deficit was about $120 billion at an annual rate, providing a significant source of finance for the $200 billion Federal budget deficit. The links from the shift in the budget to the appreciation of the dollar are discussed in Branson (1985).

The appreciation of the dollar in real terms reduces the competitiveness of U.S. output in all U.S. industry that is

---

[1] The index in Table 1 uses the IMF trade weighted exchange rate index deflated by relative unit labor costs. Different weighting methods or price deflators change the metric of the index somewhat.

directly or indirectly substitutable for foreign output. It is these effects that are the topic of this paper.

The appreciation of the dollar was a prolonged, but, temporary phenomena that is reversible when the structural deficit is reduced or when international investors resist absorption of additional dollar-denominated debt into their portfolios. This reversal apparently began in late 1985, as the dollar has fallen sharply in the past year.[2] The depression of output and employment in previously-competitive U.S. industries may not be completely reversible, however. The protracted period of a high dollar has provided an opportunity for non-U.S. competitors in industries with increasing returns--due to fixed costs, learning, or other factors--to establish themselves in the world market. Thus, when the dollar returns to its 1980 level in real terms, U.S. firms will face new international competition that has worked its way down its cost curves while the dollar was high. The estimates provided in this paper of the effects of real appreciation on employment and output do not take this potential asymmetry into account.

In this paper, using time series data through the first quarter 1985, we use a simple model of supply and demand to

---

[2] By the first quarter of 1985 the dollar was trading, in nominal terms, for more than 10 French francs, 3.25 West German marks, and 260 Japanese yen. By June 1986, the dollar was trading for about 7 French francs, 2.2 West German marks, and less than 170 Japanese yen. The dollar's fall was not as broadly based as is commonly thought, however. For example, over that same time period, the U.S. dollar actually appreciated against the Canadian dollar. For a discussion of the heterogeneity of recent currency movements see Hartman (1986).

estimate the impact of the recent dollar appreciation on manufacturing employment and output, disaggregated by region and industry sectors. These initial results are part of a larger research project underway to estimate the effects of movements in the real exchange rate on U.S. manufacturing industries.[3] Section II of the paper is the theoretical background for the estimation procedure, and Section III summarizes the data and the estimates, which are reported in tables at the end of the paper.

We find significant and substantial effects of the dollar appreciation on employment and output in U.S. manufacturing.[4] The evidence is strengthened by the consistency of the effects across sectors as we go down in aggregation to the three and four-digit SIC levels. In particular, we find that exchange rate movements have had important effects on the durable goods sector, including primary metals, fabricated metal products, and non-electrical machinery. Other sectors that suffer large employment loses when the dollar appreciates are stone, clay, and glass products, transportation, instruments, textiles and apparel, chemicals, rubber and leather goods.

---

[3] Research is underway to explain the differences in the impact of exchange rate movements among industry sectors, and to estimate the permanent effects of prolonged deviations from equilibrium real exchange rates on manufacturing industries, using more recent data that includes the recent period of dollar depreciation.

[4] Compare, for example, Robert Solomon (1985).

II. Theoretical Outline.

In this sector we sketch the theoretical basis for the estimating equations on which the empirical results of section III are based. The discussion is brief, as the basic ideas are well known from trade and computable general equilibrium (CGE) models that distinguish three sectors: exportables X, import-competing goods M, and non-traded goods N. We employ this sectorization for two reasons. First, to study output and employment effects, we must focus on exportables and import-competing production, rather than on trade in exports and imports. Second, given this focus, we must provide a minimum model of the non-traded sector the economy to ensure consistency.

The general line of the analysis can be stated simply. In each of the three sectors, demand is sensitive to the relative price of home and foreign goods. In the short run at least, we assume that a change in the nominal exchange rate E moves that relative price, which we interpret as the "real" exchange rate $e \equiv EP^*/P$, where $P(P^*)$ is the relevant home (foreign) price. It is important to note the limiting force of this assumption. If we were to assume that exportables and import-competing goods were perfect substitutes in demand for foreign goods, then a change in the nominal rate E would have no effect on the relative price e, since $P_x = eP^*$ and $P_m = eP^*$, where P^* is the relevant home (foreign) price. Even in this case, in the short run we would see a change in the relative price of non-traded goods when E changes. In the long run, as wages adjust to the change in goods prices, a cost-based model of pricing in the non-traded goods sector would result in the restoration of the original relative price in that sector. The change in P_m would be equal to the initial change in E, in percentage terms. A rational-expectations model with instantaneous market-clearing would collapse in this long run into the short run, leaving no effect of E on e in any of the three sectors. We do not assume perfect substitution or instantaneous market-clearing in the empirical work, but rather assume that changes in the nominal rate move the U.S. real exchange rate in the short run, and attempt to estimate the consequences.

An appreciation of the home currency (the U.S. dollar), reducing e, reduces the relative price of foreign to home goods. This tends to shift demand from home to foreign goods, reducing output and employment in all three producing sectors. Changes in home and foreign real income, Y and Y^* respectively, also enter the demand for exportables, while we assume that only home income Y is relevant for importables and non-traded goods.

On the supply side, we assume that the output of each sector depends on its price relative to the nominal wage. As the real product wage falls, supply increases. We do not attempt to model inter-sectoral supply reactions as relative prices change, given the common nominal wage rate. The supply functions below should, in theory, contain all relative prices.

In the theoretical background to our empirical work, then, is a model of supply and demand in each of the three sectors with supply sensitive to the product wage, and demand sensitive to the relative price of home and foreign goods and the relevant income variable. A log-linear model of demand and supply of exportables is described below, with analogous results for import-competing goods and non-tradeables.

Exportables

The demand for exportables is written in log-linear form as:

$$(1)\ \ln Q_x = \ln c_1 + d_x \ln (EP^*/P_x) + g_{x1} \ln Y + g_{x2} \ln Y^*.$$

Here Q_x is the quantity demanded, EP^*/P_x is the relative price of exportables and foreign goods, and $Y(Y^*)$ is home (foreign) real income. The parameter d_x is the positive price elasticity of demand, and the g's are the income elasticities. The supply of exportables is assumed to be an inverse function of the product wage:

$$(2)\ \ln Q_x = \ln c_2 + s_x \ln(P_x/W).$$

Here W is the nominal wage rate and s_x is the price elasticity of supply. As P_x/W increases Q_x supplied increases.

The demand and supply equations (1) and (2) can be solved to obtain the "reduced form" expressions for Q_x and P_x, give E, P^*, W, Y, and Y^*. The solution for Q_x, the output of exportables, is given by:

(3) $$\ln Q_x = A_{1x} + \frac{s_x d_x}{s_x+d_x} \ln \frac{EP^*}{W} + \frac{s_x}{s_x+d_x} \; g_{x1} \ln Y + g_{x2} \ln Y^*$$

where $A_{1x} = \dfrac{s_x c_1 - d_x c_1}{s_x + d_x}$ is the constant term.

Both coefficients in the reduced form are positive, given the way d_x was defined in equation (1). An appreciation of the dollar, expressed as the fall in the exchange rate E, reduces competitive prices EP^* relative to domestic costs W, reducing Q_x. Growth in Y or Y^* increases demand and production.

The estimating equations in Section III below follow (3). The real exchange rate EP^*/W is inverted in those equations, since the data use the inverse IMF definition of the exchange rate. This makes the estimated coefficients for the real exchange rate negative. The domestic income variable is broken into trend and cyclical components, to identify a cyclical output elasticity.

The equation for employment N_x in the exportable sectors takes the same form as the output equation, with the two tied by a production function. Since all the estimated equations below have a separate trend term, differential productivity growth trends across sectors are included in the controlled variable set. The employment equations are the same as the output equations with $\ln N_x$ replacing $\ln Q_x$ on the left-hand side of the equation (3).

In a later phase of research, we will estimate the effects of movements in the real exchange rate on real wages and profits in the manufacturing sectors. It will be useful then to have the solution for P_x from (1) and (2):

$$(4)\quad \ln P_x = A_{2x} + \frac{1}{s_x + d_x}[g_{x1}\ln Y + g_{x2}\ln Y + d_x \ln(EP^*) + s_x \ln W]$$

where $A_{2x} = \dfrac{\ln c_1 + \ln c_2}{s_x + d_x}$ is the constant term.

The usual "small-country" results can be obtained from equations (3) and (4) by setting the price-elasticity of demand d_x at infinity. In (3), this eliminates income effects and sets the relative price coefficient equal to s_x. The output of exportables reacts along the supply function as the real exchange rate moves exogenously. In the price equation (4), setting d_x at infinity sets the coefficients of Y, Y*, and W at zero, and the coefficient of EP* at unity. Exportable prices are fixed by the world market in the small-country case. The assumptions maintained in the empirical work is that the U.S. is not a small country, in the sense of being a price-taker on world markets.

Import-Competing and Non-Traded Goods

The basic demand and supply equations for import-competing and non-traded goods will have exactly the same form as (1) and (2) for exportables, so the quantity and price solutions will have the same form as (3) and (4). For both sectors we will eliminate the foreign output variable from the demand function, although in principle it (and many others) should be included. In both sectors supply is again an inverse function of the product wage, and demand depends on the price of own output relative to competing foreign goods, represented in general by EP^*. As EP^* rises, we expect substitution towards both domestic production of import-competing goods and non-traded output, and vice-versa as EP^* falls, the dollar appreciates.

Again, in principle we should include all product wages in each supply function, to catch supply-side substitution as any relative price changes. And, we should include all relative prices in each demand function for a similar reason. In the empirical work, we focus on the exogenous event of a major swing in E, producing a swing in the real exchange rate. Therefore, we include the relative price EP^*/P_i for each of the i (x,m,n) sectors.[5] The maintained hypothesis expressed in the exclusion of the other relative prices is that there was no significant exogenous shift amongst them during the sample period, or that

---

[5] In our empirical work we use the real exchange rate to measure changes in import and export prices. Gene Grossman (1984) estimated the impact of exchange rate movements on the U.S. steel industry using a model similar to ours, but with import prices for steel used in the estimating equation rather than an exchange rate index. Although data on import and export prices are available for some sectors, concordance between the price series and employment or output series is poor, making it impossible for us to construct sector specific export or import prices for most of the industry groups we have considered. Moreover, many of the import and export price series do not move in constant proportion with exchange rates, suggesting that for many industries, small country or competitive market behavior assumptions are not realistic. We are currently investigating the relationship between movements in import and export prices, industry sensitivity to exchange rate movements, and industry market structure, and will report our findings in a later paper.

shifts over time are captured by a trend variable. The obvious exception is the energy price, which is included explicitly in the empirical work.

With Y^* excluded from the demand functions, and m and n subscripts denoting import-competing and non-traded output and price, respectively, the reduced-form solutions for Q_m, P_m, Q_n, P_n are equations (3) and (4) with no term in Y^* and the subscripts on the elasticities altered appropriately. The employment equations, again, would be similar to the output equations via a production function. Trend terms will adjust for differences in productivity growth across sectors. The presumed difference in demand substitution against foreign goods among exportable, import-competing, and non-traded goods should come out in the estimated values of the demand elasticities, d_x, d_m, and d_n.

Conclusion on Theory

Since we focus on output and employment, rather than trade, the demand and supply model in each sector has the same basic structure. Demand substitutes to some degree against foreign goods; supply depends upon the product wage. Later in the research project we may attempt to disaggregate between exportables and import-competing goods within manufacturing. In the results reported below, we have only a rough disaggregation between traded and non-traded sectors. The specification of the output and employment equations is an empirical representation of equation (3), with trend and cycle in Y separated, and EP*/W inverted and represented by the IMF relative unit labor cost index.

III. Empirical Results: Employment and Output

In this section we report the empirical estimates of the relationship between movements in the real exchange rate and employment and output in manufacturing for many different industries and regions. As noted above, we have not modeled each industry or region individually, taking into account the special demand shocks and price effects that may be important. We have constructed a rather general reduced form model that is applied to all sectors or regions, at different levels of disaggregation.

The left hand dependent variables are the natural logarithm of employment or industrial production. The right hand independent variables include a constant, three variables to capture secular, cyclical and structural changes in demand, and the real exchange rate. The secular and cyclical variables are time [TREND], and the natural logarithm of the unemployment rate [LURT]. The structural variable is the natural logarithm of an index to measure the real price of energy [LRENGY]. The exchange rate variable is the natural logarithm of an index that measures the real U.S. trade-weighted exchange rate [LREX].[6] The exchange rate used here is the IMF index of relative unit labor

[6] The IMF defines the exchange rate as the inverse of EP*/W from Section II. An increase of the index is an appreciation of the dollar.

costs. We considered the inclusion of a foreign demand variable, but found that deviations form trend growth in foreign demand were so highly correlated with changes in domestic demand that no additional explanatory power came from foreign demand.[7]

The estimating equation was:

$$(5)\quad y_{it} = \beta_0 + \beta_1 t + \sum_{j=0}^{4} \beta_{2j} LURT_{t-j} + \sum_{k=0}^{4} \beta_{3k} LRENGY_{t-k} + \sum_{l=0}^{6} \beta_{4l} LREX_{t-l} + \epsilon_t$$

where:

y_{it} = the log of employment or output in sector i,

t = the TREND variable time,

LURT = the log of the unemployment rate,

LRENGY = the log of the relative price of energy,

LREX = the log of the IMF real exchange rate index, adjusted for changes in changes in relative unit labor costs,

ϵ_t = the stochastic error term

and the ß's are the parameters to be estimated.

The data are quarterly. The equations are estimated over a period that ends in first quarter 1985. The equations for employment disaggregated at the 1- and 2-digit SIC level were estimated over the periods beginning at first quarter 1963 and 1972. The equations for output, and employment by state and by 3- and 4-digit SIC codes were estimated over a period beginning

---

[7] We further considered the inclusion of a real interest rate variable, but found, surprisingly, that it had little explanatory power, and did not significantly change the estimated exchange rate elasticities. The lack of explanatory power may be due to mulitcolinarity between the interest rate variable and the three variables TREND, LURT, and LRENGY.

in first quarter 1972. The 1963:1 to 1985:1 estimates have 89 observations and 70 degrees of freedom. The 1972:1 to 1985:1 estimates have 53 observations and 34 degrees of freedom.

The exchange rate variable LREX includes the current plus six quarters of lags. The real energy price LRENGY and the unemployment rate LURT variables both include the current value plus four quarters of lags. The coefficient for the TREND variable (t) is the estimated exponential rate of growth or decline in employment or output that occurs due to secular changes in income, tastes, comparative advantage, or technology. The coefficients for the real exchange rate, real price of energy, and unemployment rate variables can be interpreted as elasticities. The Beach-Mackinnon [Econometrica 1978] maximum likelihood procedure for correcting first order autocorrelation was used.

The Data

The source of the data on employment is the Bureau of Labor Statistics' (BLS) Employment and Earnings. The dependant variable for the employment equations is the natural logarithm of the number of employed workers. In the regional equations, we use the number of workers employed in manufacturing industries, disaggregated by the 50 states plus the District of Columbia. In the industry classifications we use the number of workers employed in each of the 2-digit SIC manufacturing classifications. [SIC codes 20 through 39] To test how sensitive the estimates are to changes in the level of aggregation we have estimated equations for all of the three and four digit manufacturing codes that are included in the BLS Establishment Survey tape. This includes 125 three digit industries and 176 four digit industries.

The dependent variable for the output equations is the industrial production index [IP], provided by the Board of Governors of the Federal Reserve System. We have included 80 industrial production indexes, taken from the Citibank series for manufacturing industries. The concordance between the Federal Reserve's IP index and the BLS SIC industry classifications is not exact, but we have attempted to compare the exchange rate coefficients on the IP series to those from equivalent SIC classifications.

The real exchange rate index is the IMF index of relative unit labor costs.[8] The real energy index is the CPI-Urban index for energy divided by the CPI-Urban index for all consumer goods. The unemployment rate is for all workers.[9]

---

[8] In a previous version of this paper we used a six country index of exchange rates deflated by consumer prices. We have also experimented with an index based wholesale prices and we have used different weighting methods for the countries in the index. In general, changes in the country weights or the price deflators have changed the metric of the estimates, but not the ranking of the coefficients. The index based on unit labor costs tends to fit the data better that indexes based on wholesale or consumer prices.

[9] Detrending of the unemployment rate to account for secular changes in labor force participation rates [a higher "natural rate"] changes the estimated coefficient for the LURT variable and the TREND variable, but does not change the other coefficients.

Results

The results are reported in Tables 2 through 9. The tables report the value of the first order autocorrelation coefficient RHO, the coefficients for each of the independent variables, and a significance statistic. When independent variables are lagged, the coefficient represents the sum of all lagged coefficients. The significance measure [SIG] is the probability that the true value of the coefficient(s) is zero, using a two tailed t test. The standard error [SE] for the exchange rate coefficient is also reported.

Table 2 reports the results for all non agriculture workers and 9 traded and non-traded sectors of the economy, estimated over two periods, 1963:1 - 1985:1 and 1972:1 - 1985:1, with manufacturing disaggregated by durable and non durable goods industries. The RHO is large for nearly all sectors, indicating a serious problem with serial correlation. In the model estimated from 1963:1 to 1985:1 the TREND and cyclical variable LURT are both highly significant for all industry sectors, while the relative price of energy variable LRENGY is only significant at the .05 level for three sectors. The real exchange rate variable LREX is negative for all but the construction and finance sectors, but is statistically significant only for all non agricultural employment, mining, manufacturing, and durable goods manufacturing. When the same equation is estimated over the shorter period that begins in first quarter 1972, the signs of the exchange rate coefficients do not change, but are generally more significant. The largest exchange rate effects are in the mining and manufacturing sectors, as one would expect, with durable goods showing larger effects than non durable goods.

Table 3 reports the results of the manufacturing employment estimates, by 2-digit SIC classification, for the period beginning in 1963 and ending in first quarter 1985. The RHO is positive and large for most of the industries again indicating a serious problem with serial correlation. The variable TREND is positive for 15 of the industries, and statistically significant at the .05 level in 14 of the regressions. The cyclical variable LURT has the expected negative sign for all 20 industries, and is significant at the .05 level 17 times. The real price of energy variable LRENGY is negative 11 times, and significant 11 times, including two cases where the sign is positive [SIC 27 and 38].

The real exchange rate variable LREX is negative for 16 of the 20 industries, and statistically significant at the .05 level 11 times. In 10 of the 11 industries where the exchange rate coefficient is statistically significant, the sign of the coefficient is negative. The exchange rate has its greatest impact on primary metal industries [SIC 33], non-electrical machinery [SIC 35], fabricated metal industries [SIC 34], and miscellaneous manufacturing [SIC 39], with somewhat smaller, but important, effects on textiles and apparel [SIC 22 and 23], petroleum and coal products, leather and leather goods [SIC 31], stone, clay and glass products [SIC 32], transportation equipment [SIC 37], and instruments and related products [SIC 38]. Tobacco manufactures [SIC 21] and Rubber and miscellaneous products [SIC 30] have negative coefficients close to .1 that are not statistically significant. The exchange rate coefficient is small in absolute value and statistically insignificant for food and kindred products [SIC 20], lumber and wood products [SIC 24], furniture and fixtures [SIC 25] and electrical and electronic equipment [SIC 36]. Print and publishing [SIC 26] is the only industry where the exchange rate coefficient is both statistically significant and positive.

Table 4 reports estimates for those same 2-digit manufacturing industries, over a shorter time period that begins in first quarter 1972. The differences in the exchange rate coefficient are summarized in Table 5. For many industries the exchange rate coefficients are larger, in absolute value, over the shorter time period, indicating a greater sensitivity to international trade, although the differences in the parameters are not large, and within the range of error for the estimates.

In Table 6 we compute weighted-average exchange rate elasticities for the aggregate durable, non-durable, and all manufacturing sections from the two digit estimates. These can then be compared with the estimated elasticities for the aggregate sectors from Table 2 to see the effects of aggregation on the estimates. Using employment weights from 1980 and the estimating period of 1963:1 to 1985:1, the weighted average elasticity for the non durable goods industry is -.063, compared with the estimated elasticity of -.034. For the durable goods sector, the weighted average elasticity is -.232, while the estimated elasticity is -.206. For the manufacturing sector as a whole, the weighted average elasticity is -.164, while the estimated elasticity is -.140. Table 6 also calculates the actual employment change from 1980 to 1984, and compares that to the change that could be attributed to a 40 percent real appreciation of the dollar. For the manufacturing sector as a whole, a job loss of 1.3 million is attributed to a 40 percent appreciation of the dollar, which compares to an actual job loss of about 1 million. The largest share of the employment decline is attributed to the durable goods sector, where a 40 percent dollar appreciation would account for a loss of 1.1 million jobs. Of these, approximately 700 thousand jobs were lost in just two sectors, primary metals, and non electrical machinery.

Appendix I reports the exchange rate coefficients for manufacturing industries disaggregated at the 2-,3-, and 4-digit SIC code level, estimated over the period beginning in first quarter 1972 to first quarter 1985. These include 20 industries at the 2 digit level, 125 industries at the 3 digit level, and 176 industries at the 4 digit level. The 2-digit estimates are the same as reported in Table 3. Of the 125 3-digit industries, 98 have negative coefficients, and 86 are statistically significant at the .05 level. Of the 86 significant coefficients, 72 are negative. Of the 176 4-digit industries, 131 have negative coefficients, and 108 are statistically significant. Of the 108 significant 4-digit coefficients, 93 are negative.

The results from the 2-digit industries are generally consistent with 3- and 4-digit results. This is particularly true for industry groups that have large negative coefficients at the 2-digit level. For example, within the primary metal group, [SIC 33], there are 15 3- and 4-digit sectors, and 14 have negative coefficients, of which 13 are statistically significant. Within the fabricated metal products group [SIC 34], there are 29 3- and 4-digit industry sectors. 26 of the 29 sectors have a negative exchange rate coefficient. Among the three positive coefficients, only ordinance and accessories [SIC 348] and ammunition [SIC 3483] are statistically significant. Within the non-electrical machinery group [SIC 35], there are 36 3- and 4-digit industry sectors, of which 34 have negative exchange rate coefficients and 31 of those 34 are statistically significant.

Where the 2-digit classification is not statistically significant or small in absolute value, the 3- and 4-digit sectors have a mixture of signs, and fewer statistically significant sectors. For example, within the electrical and electronic equipment group [SIC 36] there are 27 3- and 4-digit industries, of which 17 have negative coefficients, and 10 have positive coefficients. 15 of the 27 coefficients are statistically significant, and which 11 have negative signs.

Table 7 reports the results for manufacturing employment disaggregated by the fifty states and the District of Columbia, with the estimation period running from first quarter 1972 to first quarter 1985. Of the 51 exchange rate coefficients, 46 are negative and 38 are statistically significant at the .05 level. The "rust belt" states such as Michigan, Illinois, Wisconsin, Ohio, Indiana, Pennsylvania, and Minnesota, which have mature industrial bases, all have relatively large [in absolute size] exchange rate coefficients, that are statistically significant at the .01 level, as is the case with several smaller and more rural states. Smaller [in absolute size] exchange rate coefficients that are less statistically significant, are found in states with growth in high technology industries, such as Connecticut, North Carolina, New York, New Jersey, and Massachusetts. States with important service or government sectors, such as Delaware, Florida, Virginia and the District of Columbia, also show fewer declines in manufacturing employment due to an exchange rate appreciation.

Table 8 reports the estimates for output, using 80 Federal Reserve System Industrial Production [IP] catagories, as reported on magnetic tape by Citibank. Of the 80 IP sectors, which include different levels of aggregation, 56 have negative coefficients, and 57 are statistically significant. Of the 57 significant coefficients, 43 are negative. The conditional probability that a coefficient is negative, given that it is significant, is somewhat smaller for the output estimates than for the employment estimates, but the two are generally consistent with each other.

Table 9 compares the output results to the employment results where both estimates are statistically significant at the .1 level. A direct comparison between the IP and the employment estimates is not always possible as the IP and SIC classifications are sometimes different. Of the 44 IP sectors where a match-up is made to a single SIC sector, both estimates have the same sign for 38 sectors. In addition, there are 2 IP sectors have are matched up with 2 or more SIC sectors. In one case the two SIC sectors have different signs. In the second case, the IP sector has a negative sign, as do 3 of the 4 corresponding 3-digit SIC sectors. In the 38 sectors where both estimates have the same sign, the output estimates are larger in absolute value in 13 sectors and smaller in 22 sectors.

IV. Conclusion

We have examined the impact of movements in the real exchange rate on employment and output in U.S. manufacturing industries. A simple model of supply and demand is used to estimate the elasticity of employment or output with respect to movements in the real exchange rate, over different time periods and different level of disaggregation. We find that exchange rate movements have important effects on the manufacturing sector. The estimates of exchange rate effects for output and employment are consistent when checked against each other and when estimates for different levels of disaggregation are compared. Our model does not take into consideration the permanent effect of prolonged swings in the exchange rate on industry sectors. Future research will consider this and other issues.

REFERENCES

Branson, W. H. (1985), "Causes of Appreciation and volatility of the dollar," in Federal Reserve Bank of Kansas City, editor, The U.S. Dollar--Recent Developments, Outlook, and Policy Options, Kansas City, pp. 33-54.

Grossman, Gene (1984), "Imports as a Cause of Injury: The Case of the U.S. Steel Industry," NBER Working Paper, No. 1494, November.

David G. Hartman (1986), "Focus on the Changing International Economic Environment," Focus: World Outlook, Data Resources, Inc., Spring.

Soloman, R. (1985), "Effects of the Strong Dollars," same volume as Branson (1985), pp. 65-88.