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# THE REAL EXCHANGE RATE, EMPLOYMENT AND OUTPUT IN MANUFACTURING IN THE U.S. AND JAPAN

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## ABSTRACT

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. Since then, the dollar has depreciated substantially, but remains above its 1980 level. During the same period, the Japanese yen first depreciated by 12 percent in real terms from 1981 to 1982, and then appreciated by some 30 percent to 1986. These swings in real exchange rates effects on the relative competitiveness of U.S. and Japanese industry, and have effects on employment and output in sectors producing tradeable goods. This paper presents estimates of these effects.

Using time series data for the period 1970 to 1986, we use a simple model of supply and demand to estimate the impact of swings in the effective real exchange rate of the dollar and the yen on manufacturing employment and output in the U.S. and Japan, disaggregated by industry sectors, and by production and non-production workers in the case of the U.S. employment. These results are part of a larger research project to estimate the effects of the movements in the real exchange rate on world manufacturing industries.

We find significant and substantial effects of the dollar appreciation on employment and output in U.S. manufacturing. In particular, we find that exchange rate movements have had important effects on the durable goods sectors, including primary metals, fabricated metal products, and non-electrical machinery. Other sectors that suffer large employment and output losses when the dollar appreciates are stone, clay and glass products, transportation, instruments, and chemicals. Estimates are also presented for non-production and production workers in the U.S. employment of the latter is more sensitive to the real exchange rate, especially in the durable goods sectors. This suggests the possibility of hysteresis in trade.

For Japan, we find significant effects of movements in the yen on employment and output in the durable goods sectors, especially those producing machinery. In particular, yen appreciation causes substantial losses in employment and output in fabricated metal products, general machinery, and electrical machinery. The results for Japan are not as clear as for the U.S., perhaps because we have only annual data for Japan, but quarterly data for the U.S.. Nevertheless, the importance of movements in the real exchange rate for employment and output in manufacturing is evident in both cases.

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## 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. Since then, the dollar has depreciated substantially, but remains above its 1980 level. The causes for this movement are described in Branson (1985). During the same period, the Japanese yen first depreciated by 12 percent in real terms from 1981 to 1982, and then appreciated by some 30 percent to 1986. These swings in real exchange rates have effects on the relative competitiveness of U.S. and Japanese industry, and would be expected to influence employment and output in sectors producing tradeable goods. This paper presents estimates of these effects.

Using time series data for the period 1970 to 1986, we use a simple model of supply and demand to estimate the impact of swings in the effective real exchange rate of the dollar and the yen on manufacturing employment and output in the U.S. and Japan, disaggregated by industry sectors, and by production and non-production workers in the case of U.S.

employment. These results are part of a larger research project to estimate the effects of movements in the real exchange rate on world manufacturing industries.

Section II of the paper provides a brief theoretical background for the estimation procedure. In section III we discuss the estimating equation and the data. Section IV presents the basic results for U.S. employment and output at the 2-digit level of manufacturing. In section V we present the estimates for non-production and production workers in the U.S., and find that employment of the latter is more sensitive to the real exchange rate, especially in the durable goods sectors. This raises the possibility of hysteresis in trade. In section VI we present the results for employment and output for Japan.

We find significant and substantial effects of the dollar appreciation on employment and output in U.S. manufacturing. In particular, we find that exchange rate movements have had important effects on the durable goods sectors, including primary metals, fabricated metal products, and non-electrical machinery. Other sectors that suffer large employment and output losses when the dollar appreciates are stone, clay, and glass products, transportation, instruments, and chemicals. We also find especially significant effects on production workers.

For Japan, we find significant effects of movements in the yen on employment and output in the durable goods sectors, esprcially those producing machinery. In particular, yen appreciation causes substantial losses in employment and output in fabricated metal products, general machinery, and electrical machinery. The results for Japan are not as clear as for the U.S., perhaps because we have only annual data for Japan, but quarterly data for the U.S. Nevertheless, the importance of movements in the real exchange rate for employment and output in manufacturing is evident in both cases.

## II. Theoretical Outline

In this section we sketch the theoretical basis for the estimating equations. 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 $e_0$ $EP^*/P$, 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 real exchange rates of the U.S. and Japan in the short run, and attempt to estimate the consequences.

An appreciation of the home currency, 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:

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

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:

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

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 home currency, 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 sections IV-VI 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 attempt 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. If the production function is $Q=Q(N,K)$, with the capital stock K fixed in the short run, variations in output are given by $dQ = Q_n \, dN$, where $Q_n$ is the marginal product of labor. Then the employment equation in variation terms would be the output equation (3) divided by $Q_n$, which is positive. 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).

## 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 solutions will have the same form as (3). 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, that is, the home currency appreciates.

Again, in principle we should include <u>all</u> product wages in <u>each</u> 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. 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 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 $Q_m$ and $Q_n$ are equation (3) with no term in $Y^*$ and the subscripts on the elasticities altered appropriately. The employment equations, again, are 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 $d_n$.

## III. The Model to be Estimated

In the following sections we report the empirical estimates of the relationship between movements in the real exchange rate and employment and output in manufacturing in the U.S. and Japan. We take the manufacturing sector to represent both import-competing and exportable goods. Inital estimates for non-traded goods for the U.S. are reported in Branson and Love (1986, Table 2). For the U.S., employment within the manufacturing sector is disaggregated by the 20 industries defined by the Standard Industrial Classification [SIC] system, and output is measured by the index of industrial production. For Japan, employment and real value added are disaggregated into 13 manufacturing sectors in the national accounts datd. We have not modeled each industry within the manufacturing sector individually, taking into account the special sectoral demand shocks and cost effects that may be important. A general reduced form model is applied to all manufacturing sectors.

The left-hand dependent variables are the natural logarithms of employment and output. 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 variable is time [TREND]. For the U.S., the cyclical variable is the natural logarithm of the national unemployment rate [LURT]. For Japan, the cyclical variable is a constructed series of deviations from trend in real GNP. Details on its construction are given in an Appendix. Inclusion of these variables in the estimating equation is meant to catch the effect of fluctuations in aggregate demand. The coefficients of the real exchange rate therefore give the distributive effects of exchange-rate movements adjusted for cyclical movements in total demand. These coefficients are the effects of relative price changes of traded and non-traded goods, compensated for income effects.

The structural variable is the natural logarithm of an index to measure the real price of energy [LRENGY]. For the U.S., this is the ratio of the energy component of the CPI to the total CPI. For Japan, it is an index of the dollar price of petroleum times the yen-dollar exchange rate divided by the Japanese GNP deflator. This variable is meant to catch the effects of shifts of energy costs on employment and output by sector. The net effects of a given change in the real exchange rate is therefore the coefficient of the exchange rate plus the coefficient of the relative energy price times the effect of the movement of the exchange rate on the energy price. The exchange rate variables are the natural logarithms of indexes that measure the real U.S. and Japanese trade-weighted exchange rate [LREX].[1] The exchange rate used here is the IMF index of relative unit labor costs. We considered the inclusion of a foreign demand variable, but found that deviations from trend growth in foreign demand were so highly correlated with changes in domestic demand in the case of the U.S. that no additional explanatory power came from foreign demand.[2] We have not yet experimented with a foreign demand variable in the case of Japan. The form of the estimating equation for the U.S. is

$$(4)\quad y_{it} = \wedge_0 + \wedge_1 t + \sum_{j=0}^{4} \wedge_{2j} LURT_{t-j} + \sum_{k=0}^{4} \wedge_{3k} LRENGY_{t-k} + \sum_{l=0}^{6} \wedge_{4l} LREX_{t-l} + \mu_t,$$

where:

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

t = the TREND variable time,

LURT = the log of the national 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,

$\mu_t$ = the stochastic error term,

and the $\wedge$'s are the parameters to be estimated. The estimating equation for Japan has the same form, but with only one lag at most, because the Japanese data are annual, while the U.S. are quarterly.

The U.S. equations are estimated over a period that ends in the first quarter of 1986.[3] In most cases the equations were estimated over the periods beginning at first quarter 1970. Longer and shorter time periods were tested and are reported in Branson and Love (1987). The 1970:1 to 1986:1 estimates have 65 observations and 46 degrees of freedom. The Japanese equations are estimated over the period 1970 to 1985. These estimates have 15 observations and 12 degrees of freedom.

For the U.S., the exchange rate variable LREX includes the current observation plus six quarters of lagged observations. The real energy price LRENGY and the unemployment rate LURT variables both include the current value plus four quarters of lags. For Japan, LREX and LRENGY are entered into the equation with a one-period lag. Since the Japanese data are annual, it is likely that last year's LREX and LRENGY affect this year's employment and output. We attempted to separate trend from cycle in real GNP in Japan, as described in the Appendix. But the estimated coefficients of the cycle variable were generally insignificant and frequently negative. Since we found that simply using actual real GNP did not worsen the results, we report estimates below that use real GNP instead of separate trend and cycle variables for Japan. For the U.S., the numbers we report are the sums of the coefficients on the lag distributions and the test statistics on these sums. For Japan, single coefficients and their t-ratios are reported.

The coefficient for the TREND variable (t) in the U.S. equations 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. For the U.S., a coefficient for TREND of -.001 means that, holding everything else constant, the dependent variable will decline at the percentage rate of 0.1 percent each quarter.

The coefficients for the real exchange rate, the real price of energy, and the unemployment rate for the U.S. and real GNP for Japan can be interpreted as elasticities, since the equations are estimated in log-linear form. For example, a coefficient of -.3 for the real exchange rate variable LREX in an employment equation means that a 10 percent <u>increase</u> in the exchange rate will lead to a 3 percent <u>decrease</u> in the number of workers employed.

For the U.S. equations, the source of the data on employment is the Bureau of Labor Statistics' (BLS) <u>Employment and Earnings</u>. The employment variable here includes all workers, to be comparable to the Japanese equations. Results for production vs non-production workers are reported in Branson and Love (1987) for the 2-digit SIC manufacturing sectors. The data on output are the Federal Reserve Board's indexes of industrial production. The real exchange rate index is the IMF index of relative unit labor costs.[4] 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.[5]

For the Japanese equations, the data on employment and value-added are taken from the Economic Planning Agency's National Accounts tables. The other data are taken from the IMF's International Financial Statistics data base. As for the U.S., the real exchange rate index for

Japan is the IMF index of relative unit labor costs. The relative energy price was described above, and the cyclical variable is described in the Appendix.

## IV. Results for Employment and Output in the U.S.

Table 1 reports the results of the econometric estimates for total employment in the twenty 2-digit SIC manufacturing sectors. It provides the results from the equations that use "all workers" as the dependent variable, estimated over the period 1970:1 to 1986:1. The table reports 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 sum of the coefficients is zero, using a two-tailed t-test. The standard error [SE] for the sum of the exchange rate coefficients is also reported.

The RHO is positive and large for most of the sectors indicating a high degree of serial correlation in employment. The variable TREND is positive for 12 of the industries, and statistically significant at the .05 level in 16 of the regressions. Among the durable goods sectors, only primary metal industries [SIC32] and miscellaneous [39] had negative trend terms over the sample period. The cyclical variable LURT measures the impact of cyclical movements in the national economy; the predicted sign for this variable is negative, as high sectoral employment is associated with lower national unemployment rates. In the regressions, LURT is negative in all 20 sectors, and is significant at the .05 level 17 times.

The real price of energy variable LRENGY is positive 11 times, and significant 8 times. The predicted sign of this variable is ambiguous. An increase in the relative energy price increases cost in all sectors, reducing employment. But some sectors produce outputs that substitute for energy, or are inputs to energy-substitute products. In five of the eight cases where this variable is statistically significant, the sign is positive [SIC 28, 29, 31, 35 and 38].

The real exchange rate variable LREX is negative for 18 of the 20 sectors, and statistically significant at the .05 level 14 times. In 13 of the 14 sectors where the exchange rate coefficient is statistically significant, the sign of the coefficient is negative, the sole exception being print and publishing [SIC 27]. The exchange rate has its greatest impact on primary metal industries [SIC 33], with an elasticity of -.57, and non-electrical machinery [SIC 35], with an elasticity of -.41. Fabricated metal industries [SIC 34], petroleum and coal products [SIC 29], stone, clay and glass products [SIC 32], and miscellaneous manufacturing [SIC 39], all have elasticities grouped between -.25 and -.30. We observe somewhat smaller, but important, effects on textiles and apparel [SIC 22 and 23], chemicals and allied products [SIC 28], rubber and miscellaneous products [SIC 30], lumber and wood products [SIC 24] transportation equipment [SIC 37], and instruments and related products [SIC 38].

The LREX coefficients for food and kindred products [SIC 20], tobacco manufactures [SIC 21], leather and leather goods [SIC 31], furniture and fixtures [SIC 25], and electrical and electronic equipment [SIC 36] are negative, but not statistically different from zero. Only paper and allied products [SIC 26] and print and publishing [SIC 27] have positive signs, and only the latter is statistically significant.

Table 2 reports the results of the econometric estimates for industrial production in the U.S. at the two-digit level. It follows the same format as Table 1, except that in Table 2 the dependent variable is the log of industrial production in each sector. The variable TREND is positive in 18 of the 20 sectors, and significantly so in 16 of the 18. The only sector with a significant negative trend is leather and leather goods [SIC 31]. This illustrates the generally upward trend in output in U.S. manufacturing over the sample period 1970-86.

The cyclical variable LURATE [the same as LURT in Table 1] enters negatively in all 20 sectors, and is not significant only in apparel and other textile products [SIC 23] and leather and leather goods [SIC 31]. This illustrates the cyclical nature of industrial production in U.S. manufacturing. The real price of energy is significantly positive only in leather and leather goods. It is significantly negative in 5 sectors: chemicals [SIC 28], furniture [25], fabricated metal products [34], stone, clay and glass products [32], and transporttation equipment [37].

The real exchange rate is negative in 15 of the 20 sectors, and the coefficient is significant in 11 of the 15. Of the 5 positive coefficients,only those for food [SIC 20] and print and publishing [27] are significant. The results for industrial production are consistent with those for employment, in that there is no sector where the LREX coefficient has different signs, both significant, in the two sets of estimates. As in the employment estimates, primary metal industries [SIC 33] has the largest elasticity of industrial production with respect to the exchange rate. A 50 percent real appreciation of the dollar reduces industrial production in the sector by 27.5 percent. Among the other durable goods sectors, instruments [SIC 38] stands out with a substantially larger coefficient in the industrial production equation [-0.41] than in the employment equation [-0.15].

Overall, the results confirm the sensitivity of employment and output in U.S. manufacturing to changes in the real exchange rate. That sensitivity is greater in the durable goods sectors than in non-durables, as expected. Some puzzles remain, such as the positive coefficients in the print and publishing sector, and the insignificant ones in the electrical and electronic equipment sector. Print and publishing will remain a puzzle, but the breakdown between production and non-production workers will help us understand electrical and electronic equipment.

## V. Production Workers and Non Production Workers

The empirical results presented in Section IV relate to total employment in the U.S.. The Bureau of Labor Statistics also provides a series for the employment of production workers. The complement of this series, all workers minus the production workers, will be referred to here as non-production workers. Production workers include employees who are directly engaged in the physical processes of production of manufactured goods--workers on assembly lines. The "non-production" series includes workers who are involved in research and development, marketing, transportation, secretarial and clerical tasks, and management activities.

If the market structure is such that the industry has a fixed ratio of production to non-production workers and if production and non-production workers are both domiciled in the United States, then a movement in the real exchange rate would have the same percentage impact on production and non-production workers. If, on the other hand, the industry was characterized by increasing returns to scale or if the results of the production workers' activities are more tradeable than is the case for non-production workers, then exchange rate movements may have much different impacts on the production and non-production workers.

In Tables 3 through 5 the two time series are compared. In Table 3 the estimated coefficients of our same estimating equation for production workers are presented. The results for non-production workers are presented in Table 4. The two sets of coefficients for the real exchange rate are compared in Table 5. This table also shows the percentage change in employment of the two types of worker in each sector estimated to be due to the appreciation of the dollar from 1980 to 1985.

The comparison between the production and non-production worker results in Table 5 shows that in fifteen of the twenty industries, the difference between the LREX coefficients is greater than two standard errors for the production worker series. Moreover, the signs of the coefficients are different for 8 of the 20 industries.

Within the non-durable goods industries the results are mixed. For half the industries, the exchange rate elasticities are more negative for production workers than is the case for non-production workers. Within the durable goods industries, the LREX coefficients are more negative in nine of ten sectors, suggesting that production workers provide services that are more tradeable than the services provided by non-production workers. Indeed, for three durable goods industries--electrical and electronic equipment, transportation equipment, and instruments and related products--the coefficients are negative and statistically significant for production workers, and positive and statistically significant for non-production workers. Thus for the instruments and related products industry, for example, the dollar appreciation from 1980 to 1985 is estimated to have caused a <u>decrease</u> of 11.3 percent for production workers, but an <u>increase</u> of 3.5 percent for non-production workers. Since the level of overall unemployment is controlled for in the estimates, the relative increase in non-production workers is not surprising.

These results suggest that a dollar appreciation may cause U.S. firms to move production facilities out of the United States, thus leading to a larger proportional reduction in production workers. This may mean that the jobs will not return to the U.S. now that the real value of the dollar has declined relative to foreign currencies. This may also imply that to some extent our model may be mis-specified, due to hysteresis effects.

Hysteresis reflects the dependence of present employment not only on the levels of the independent variables, but also the path of those variables over the past. Industries or sectors where hysteresis effects may be important include industries where economies of scale or learning by doing are important, and where there are "sunk" costs for R&D, relocation, marketing efforts, capital investments, or other items that could represent a strategic barrier to entry in a market. It may be that once the initial costs of relocating production workers in foreign countries have been incurred, it will not be cost-effective to relocate the workers back in the U.S. after the dollar depreciates. Thus, while our model is useful in decomposing the causes of the changes in employment from 1980 to 1985, for some industries it may not be a good predictor of the employment changes that will occur in the more recent period of dollar depreciation.

## VI. Results for Employment and Output in Japan

We now turn to the data for Japan. The annual data (1970-85) on employment and value added for 13 manufacturing sectors are taken from the Economic Planning Agency's Tables on national income, and were provided by Richard Marston (1987), who used them to analyze the relative competitiveness of the U.S. and Japan. The real exchange rate is the IMF's relative unit labor cost for Japan. The real energy price is the world price of petroleum in dollars, converted to yen using the yen-dollar exchange rate, expressed as a ratio to the GNP deflator. These data are taken from the International Financial Statistics data base. They enter the estimating equations in log form.

The Appendix describes our construction of a cyclical variable as the deviation from trend in real GNP. A three-part equation for trend real GNP was estimated to account for the break in the growth path of real GNP after the 1973 oil price shock. Separation of real GNP into trend and cycle components did not improve the results, however, so we used just real GNP as a regressor. We also experimented with a variable for real world imports, less Japan. This was collinear with Japanese real GNP, and gave worse results when it was used as an alternative.

Since the data for Japan are annual, we do not estimate lag distributions, but simply enter the current value for the log of real GNP and the once-lagged values of the logs of the real exchange rate and the real energy price. The dependent variables are the logs of employment and output by sector. A list of the sectors, and their weights in real GDP is given in Table 6.

The estimated equations for employment in manufacturing in Japan are shown in Table 7. The format is slightly different from that of Tables 1-4.[6] Table 7, and Table 8 for output, show the coefficient for each variable and its t-ratio as the significance test. Also shown are the the adjusted $R^2$ and the Durbin-Watson statistic. The equations in Tables 7 and 8 are not adjusted for serial correlation. This is done in Tables 9 and 10. Estimates are shown for each of the 13 sectors, for a machinery aggregate that combines sectors 8 through 12, and for total manufacturing.

The real GNP coefficients [LRGNP] in Table 7 represent a combination of trend and cycle influences. For non-durables they are mixed, with two significantly positive and two significantly negative. For durables, only one is negative, and the two aggregates have significantly positive real GNP coefficients. The real energy variable is negative in all sectors except food and beverages, but significantly so only in fabricated metal products [8] and electrical machinery [10].

The variable of direct interest here, LREX, shows a similar pattern to the U.S. results. The signs are negative for all durable goods sectors except transport equipment [11], and there the coefficient is insignificant. The general machinery [9], electrical machinery [10], and aggregate machinery [8-12] sectors all have significabtly negative coefficients. A 20 percent appreciation of the yen reduces employment in the electrical machinery sector by 12.6 percent, and in aggregate machinery production by 5.6 percent. Thus movements in the real effective yen exchange rate seem to have significant effects on employment in the durable goods sectors within a year.

The results for output in manufacturing in Japan are shown in Table 8, which has the same format as Table 7. The positive coefficients of real GNP for all sectors except petroleum and coal products [5] are striking. Electrical machinery [10] shows an elasticity of 5.6 with respect to GNP growth. The difference between the real GNP terms in Tables 7 and 8 is a rough measure of productivity growth. As noted by

Marston (1987), productivity grew rapidly in the expanding sectors, with electrical machinery in the lead, and fell slightly in food and beverages [1] and petroleum and coal products [5]. The elasticity of productivity in the machinery aggregate with respect to growth in real GNP is 2.3, on these estimates. Marston (1987), who focussed directly on estimating productivity growth, showed the same pattern across sectors, with an average of 6 percent per year for the machinery aggregate. The real energy price is generally negative, except in the petroleum and coal products sector [5], where it is significantly positive, as expected.

The real exchange rate coefficients show more mixed results for output than for employment. The fabricated metal [8] and general machinery [9] sectors have very significant negative coefficients, as do both aggregates. The marginally insignificant coefficient for electrical machinery [10] is puzzling, given its highly significant negative value in the enployment regressions. Why would appreciation reduce employment significantly more than output in the electrical machinery sector?

The large negative coefficient for LREX in the equation for the machinery aggregate implies a larger elasticity of output in response to changes in the real exchange rate in Japan than in the U.S. In Table 2, the largest of the estimates in the group SIC 34-38 is -0.41 in instruments [SIC 38], where in Table 8, it is -0.60 for the machinery aggregate. The remaining puzzle is why the disaggregated machinery sectors 10-12 do not show greater sensitivity of output to the exchange rate, given the estimate for the aggregate. Marston (1987) suggests that this is due to absorption of exchange rate changes in profits. but he shows this effect in the machinery sector to be greatest in general machinery [9], which has the largest negative coefficient in Table 8. So while we find significant effects of changes in the real exchange rate on output in the durable goods sectors in Japan, the pattern of coefficients across sectors remains somewhat puzzling.

The Durbin-Watson statistics in Tables 7 and 8 indicate substantial serial correlation in the error terms, especially in the employment equations for durables. So all the regressions were re-estimated using alternatively the Cochrane-Orcutt adjustment for serial correlation and a lagged dependant variable to reflect partial adjustment.[7] The serial correlation results are presented in Tables 9 and 10. The results with the lagged dependant variable, represented by LY(-1), are shown in Tables 11 and 12.

Comparing the employment estimates in Tables 9 and 11, we see that the lagged dependant variable performs better than the serial correlation correction. With the exceptions of sectors 1-3 [food, textiles, and paper], the serial correlation RHO coefficients in Table 9 are all significantly positive, as are the lagged dependant variables in Table 11, with the further exception of sector 13 [miscellaneous]. But the Table 11 equations fit better and have Durbin-Watson statistics closer to 2 than the Table 9 equations. Thus the evidence favors the partial adjustment model for employment in Japan.[8] The coefficients for the real exchange rate and the relative energy price in the employment equations for sectors 4-12 in Table 11 should be interpreted as representing one-year adjustment. The long-run coefficients can be obtained by dividing these by one minus the coefficient of the lagged dependant variable. In Table 11, the exchange rate coefficients for the durable sectors and the two aggregates are uniformly negative, as are those for the energy price in all sectors but food.

The evidence is less clear in the output equations in Tables 10 and 12. Both the RHO and the coefficients of the lagged dependant variables are smaller than those for employment, and most often insignificant. The adjusted $R^2$ and D statistics are about the same in the two tables. The real exchange rate coefficients in the fabricated metal and machinery-producing sectors [8-10] are large and negative in both tables. In Tables 10 and 12, the output elasticity with respect to LREX in the electrical machinery sector [10] is larger than the employment elasticity in Tables 9 and 11, providing a possible dynamic explanation of the apparent puzzle from Tables 7 and 8. With the serial correlation correction in Table 10, the output elasticity with respect to LREX of -.44 for the machinery aggregate is closer to the estimate from the U.S. data in Table 2. In Table 12, this elasticity is -.33 in one year, and -.50 in the long run. These bracket the elasticity of SIC 38 in the U.S. estimates.

With only 15 annual observations in this data set, further exploration of the dynamics of adjustment in manufacturing in Japan would be inconclusive.[9] It does appear that lagged adjustment of employment is supported more strongly by the data than lagged adjustment of output. This is consistent with employment-smoothing in Japan. The pattern of coefficients for the real exchange rate in Tables 7-12 for Japan is broadly similar to that in Tables 1-2 for the U.S., with negative coefficients for durables, and mixed results for non-durables. Thus, while the dynamic specification is still not precise, the results for Japan show sensitivities of employment and output in manufacturing to the real exchange rate that are not unlike those of the U.S.

## References

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1. 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 home currency.

2. 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.

3. The Beach-Mackinnon (1978) maximum likelihood procedure for correcting first order autocorrelation was used in estimating the U.S. equations. The Cochrane-Orcutt procedure was used for the Japanese equations.

4. In an early version of this paper [Branson and Love (1986)] 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 weighing 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.

5. 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.

6. The regressions reported in Tables 1-4 were performed on a PC using the GAUSS package, but the regressions reported in Tables 7 and 8 were performed on the Unisys at the IMF.

7. The same tests on the U.S. equations yielded long-run coefficients for the real exchange rate with the lagged dependant variable that were equal to the sums of the six-quarter lags reported in Tables 1-4. Thus in the U.S. case, the evidence supported the serial correlation correction, once a 6-quarter lag was introduced.

8. We attempted to test the two alternatives by adding lagged values of the independant variables to the regressions, but the results were mixed and inconclusive. With 13 observations and 7 regressors, degrees of freedom become insufficient to obtain clear results.

9. In collaboration with Richard Marston, we are now working with a monthly data set to explore the dynamics of adjustment in Japan more thoroughly.

TABLE 1

DEPENDENT VARIABLE IS LOG OF EMPLOYMENT (ALL WORKERS), U.S.
DATA ARE SEASONALLY ADJUSTED

MODEL: AR1(METHOD=MAXL) 70,1 86,1 DOF: 46
CONSTANT TREND LREX(0,6) LURT(0,4) LRENGY(0,4)

| | SIC | RHO | TREND | SIG | LREX | SE | SIG | LURT | SIG | LRENGY | SIG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | NON DURABLE GOODS | | | | | | | | |
| FOOD AND KINDRED PRODUCTS | 20 | 0.92 | -0.001 | 0.03 | -0.00 | 0.04 | 0.92 | -0.05 | 0.01 | 0.01 | 0.87 |
| TOBACCO MANUFACTURES | 21 | 0.70 | -0.004 | 0.00 | -0.07 | 0.06 | 0.27 | -0.03 | 0.59 | -0.03 | 0.86 |
| TEXTILE MILL PRODUCTS | 22 | 0.73 | -0.006 | 0.00 | -0.16 | 0.03 | 0.00 | -0.09 | 0.00 | 0.01 | 0.84 |
| APPAREL & OTHER TEXTILE PROD | 23 | 0.74 | -0.004 | 0.00 | -0.11 | 0.03 | 0.00 | -0.09 | 0.00 | 0.05 | 0.48 |
| PAPER AND ALLIED PRODUCTS | 26 | 0.84 | 0.001 | 0.19 | 0.00 | 0.03 | 0.91 | -0.13 | 0.00 | -0.00 | 0.98 |
| PRINT AND PUBLISHING | 27 | 0.94 | 0.006 | 0.00 | 0.12 | 0.02 | 0.00 | -0.13 | 0.00 | 0.02 | 0.52 |
| CHEMICALS AND ALLIED PRODUCTS | 28 | 0.93 | 0.000 | 0.90 | -0.10 | 0.03 | 0.00 | -0.11 | 0.00 | 0.10 | 0.02 |
| PETROLEUM AND COAL PRODUCTS | 29 | 0.47 | -0.004 | 0.00 | -0.25 | 0.06 | 0.00 | -0.07 | 0.18 | 0.37 | 0.01 |
| RUBBER AND MISC PLASTICS PROD | 30 | 0.73 | 0.007 | 0.00 | -0.19 | 0.05 | 0.00 | -0.27 | 0.00 | -0.23 | 0.06 |
| LEATHER AND LEATHER GOODS | 31 | 0.93 | -0.013 | 0.00 | -0.14 | 0.11 | 0.21 | -0.04 | 0.43 | 0.34 | 0.02 |
| | | | DURABLE GOODS | | | | | | | | |
| LUMBER AND WOOD PRODUCTS | 24 | 0.72 | 0.003 | 0.00 | -0.13 | 0.05 | 0.01 | -0.20 | 0.00 | -0.28 | 0.01 |
| FURNITURE AND FIXTURES | 25 | 0.88 | 0.004 | 0.00 | -0.05 | 0.05 | 0.31 | -0.21 | 0.00 | -0.23 | 0.01 |
| STONE, CLAY AND GLASS PROD | 32 | 0.88 | 0.000 | 0.74 | -0.28 | 0.04 | 0.00 | -0.19 | 0.00 | -0.20 | 0.01 |
| PRIMARY METAL INDUSTRIES | 33 | 0.70 | -0.007 | 0.00 | -0.57 | 0.06 | 0.00 | -0.35 | 0.00 | 0.14 | 0.28 |
| FABRICATED METAL PRODUCTS | 34 | 0.75 | 0.000 | 0.37 | -0.29 | 0.03 | 0.00 | -0.32 | 0.00 | -0.03 | 0.63 |
| MACHINERY, EXCEPT ELECTRICAL | 35 | 0.69 | 0.002 | 0.00 | -0.41 | 0.03 | 0.00 | -0.37 | 0.00 | 0.32 | 0.00 |
| ELECTRICAL & ELECTRONIC EQUIP | 36 | 0.92 | 0.005 | 0.00 | -0.03 | 0.05 | 0.53 | -0.33 | 0.00 | 0.05 | 0.51 |
| TRANSPORTATION EQUIPMENT | 37 | 0.36 | 0.003 | 0.00 | -0.19 | 0.04 | 0.00 | -0.39 | 0.00 | -0.09 | 0.32 |
| INSTRUMENTS AND RELATED PROD | 38 | 0.93 | 0.006 | 0.00 | -0.15 | 0.04 | 0.00 | -0.25 | 0.00 | 0.24 | 0.00 |
| MISC MANUFACTURING INDUSTRIES | 39 | 0.77 | -0.001 | 0.02 | -0.28 | 0.03 | 0.00 | -0.16 | 0.00 | -0.12 | 0.10 |

TABLE 2

DEPENDENT VARIABLE IS LOG OF INDUSTRIAL PRODUCTION , U.S.

MODEL: AR1(METHOD=MAXL) 70,1 86,1 DOF: 74
CONSTANT TREND LREX(0,6) LURATE(0,4) LRENGY(0,4)

| | SIC | RHO | TREND | SE | SIG | LREX | SE | SIG | LURATE | SE | SIG | LRENGY | SE | SIG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NON-DURABLE GOODS | | | | | | | | | | | | | | |
| FOOD AND KINDRED PRODUCTS | 20 | 0.58 | 0.008 | 0.000 | 0.00 | 0.06 | 0.02 | 0.00 | -0.06 | 0.02 | 0.00 | 0.07 | 0.05 | 0.18 |
| TOBACCO MANUFACTURES | 21 | 0.09 | 0.000 | 0.001 | 0.92 | -0.24 | 0.04 | 0.00 | -0.09 | 0.03 | 0.01 | 0.17 | 0.10 | 0.10 |
| TEXTILE MILL PRODUCTS | 22 | 0.62 | 0.004 | 0.001 | 0.01 | -0.04 | 0.07 | 0.56 | -0.12 | 0.06 | 0.06 | 0.04 | 0.17 | 0.81 |
| APPAREL & OTHER TEXTILE PROD | 23 | 0.38 | 0.003 | 0.002 | 0.04 | 0.04 | 0.11 | 0.75 | -0.09 | 0.08 | 0.22 | 0.07 | 0.20 | 0.74 |
| PAPER AND ALLIED PRODUCTS | 26 | 0.64 | 0.008 | 0.001 | 0.00 | 0.08 | 0.05 | 0.09 | -0.16 | 0.04 | 0.00 | 0.04 | 0.11 | 0.74 |
| PRINT AND PUBLISHING | 27 | 0.80 | 0.012 | 0.001 | 0.00 | 0.18 | 0.05 | 0.00 | -0.20 | 0.04 | 0.00 | 0.02 | 0.10 | 0.81 |
| CHEMICALS AND ALLIED PRODUCTS | 28 | 0.71 | 0.012 | 0.001 | 0.00 | -0.25 | 0.05 | 0.00 | -0.13 | 0.04 | 0.00 | -0.30 | 0.11 | 0.01 |
| PETROLEUM AND COAL PRODUCTS | 29 | 0.62 | 0.002 | 0.001 | 0.09 | -0.43 | 0.06 | 0.00 | -0.12 | 0.05 | 0.03 | -0.27 | 0.14 | 0.07 |
| RUBBER AND MISC PLASTICS PROD | 30 | 0.72 | 0.017 | 0.002 | 0.00 | -0.16 | 0.09 | 0.07 | -0.26 | 0.07 | 0.00 | -0.31 | 0.19 | 0.12 |
| LEATHER AND LEATHER GOODS | 31 | 0.52 | -0.012 | 0.001 | 0.00 | -0.14 | 0.06 | 0.04 | -0.08 | 0.06 | 0.17 | 0.56 | 0.16 | 0.00 |
| DURABLE GOODS | | | | | | | | | | | | | | |
| LUMBER AND WOOD PRODUCTS | 24 | 0.70 | 0.008 | 0.002 | 0.00 | 0.06 | 0.09 | 0.52 | -0.15 | 0.08 | 0.05 | -0.33 | 0.20 | 0.10 |
| FURNITURE AND FIXTURES | 25 | 0.83 | 0.013 | 0.002 | 0.00 | -0.01 | 0.10 | 0.94 | -0.23 | 0.07 | 0.00 | -0.40 | 0.19 | 0.04 |
| STONE, CLAY AND GLASS PROD | 32 | 0.64 | 0.009 | 0.001 | 0.00 | -0.22 | 0.04 | 0.00 | -0.24 | 0.04 | 0.00 | -0.42 | 0.10 | 0.00 |
| PRIMARY METAL INDUSTRIES | 33 | 0.56 | -0.001 | 0.003 | 0.75 | -0.55 | 0.14 | 0.00 | -0.51 | 0.12 | 0.00 | -0.23 | 0.34 | 0.49 |
| FABRICATED METAL PRODUCTS | 34 | 0.82 | 0.007 | 0.001 | 0.00 | -0.32 | 0.06 | 0.00 | -0.35 | 0.04 | 0.00 | -0.32 | 0.13 | 0.02 |
| MACHINERY, EXCEPT ELECTRICAL | 35 | 0.85 | 0.013 | 0.001 | 0.00 | -0.29 | 0.09 | 0.00 | -0.46 | 0.06 | 0.00 | 0.14 | 0.18 | 0.42 |
| ELECTRICAL & ELECTRONIC EQUIP | 36 | 0.92 | 0.016 | 0.002 | 0.00 | -0.05 | 0.12 | 0.64 | -0.34 | 0.06 | 0.00 | 0.08 | 0.19 | 0.69 |
| TRANSPORATION EQUIPMENT | 37 | 0.07 | 0.013 | 0.001 | 0.00 | -0.22 | 0.04 | 0.00 | -0.35 | 0.04 | 0.00 | -0.78 | 0.11 | 0.00 |
| INSTRUMENTS AND RELATED PROD | 38 | 0.87 | 0.015 | 0.001 | 0.00 | -0.41 | 0.06 | 0.00 | -0.24 | 0.04 | 0.00 | -0.04 | 0.11 | 0.70 |
| MISC MANUFACTURING INDUSTRIES | 39 | 0.75 | 0.003 | 0.001 | 0.02 | -0.30 | 0.08 | 0.00 | -0.16 | 0.06 | 0.01 | -0.09 | 0.17 | 0.58 |

FILE: PW70

TABLE 3

PRODUCTION WORKERS

DEPENDENT VARIABLE IS LOG OF EMPLOYMENT [PRODUCTION WORKERS], U.S.
DATA ARE SEASONALLY ADJUSTED

MODEL: AR1(METHOD=MAXL) 70,1 86,1 DOF: 46
CONSTANT TREND LREX(0,6) LURT(0,4) LRENGY(0,4)

| | SIC | RHO | TREND | SIG | LREX | SE | SIG | LURT | SIG | LRENGY | SIG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | NON DURABLE GOODS | | | | | | | | |
| FOOD AND KINDRED PRODUCTS | 20 | 0.88 | -0.000 | 0.54 | 0.01 | 0.04 | 0.78 | -0.06 | 0.01 | 0.00 | 0.96 |
| TOBACCO MANUFACTURES | 21 | 0.74 | -0.005 | 0.00 | -0.14 | 0.08 | 0.10 | -0.01 | 0.92 | -0.17 | 0.36 |
| TEXTILE MILL PRODUCTS | 22 | 0.72 | -0.006 | 0.00 | -0.15 | 0.03 | 0.00 | -0.10 | 0.00 | 0.02 | 0.80 |
| APPAREL & OTHER TEXTILE PROD | 23 | 0.72 | -0.004 | 0.00 | -0.09 | 0.03 | 0.01 | -0.10 | 0.00 | 0.07 | 0.38 |
| PAPER AND ALLIED PRODUCTS | 26 | 0.80 | 0.001 | 0.29 | 0.03 | 0.03 | 0.26 | -0.16 | 0.00 | -0.00 | 0.94 |
| PRINT AND PUBLISHING | 27 | 0.92 | 0.005 | 0.00 | 0.17 | 0.02 | 0.00 | -0.17 | 0.00 | -0.02 | 0.66 |
| CHEMICALS AND ALLIED PRODUCTS | 28 | 0.87 | -0.001 | 0.09 | -0.13 | 0.03 | 0.00 | -0.12 | 0.00 | 0.09 | 0.08 |
| PETROLEUM AND COAL PRODUCTS | 29 | 0.39 | -0.004 | 0.01 | -0.40 | 0.07 | 0.00 | -0.11 | 0.11 | 0.29 | 0.15 |
| RUBBER AND MISC PLASTICS PROD | 30 | 0.74 | 0.008 | 0.00 | -0.20 | 0.06 | 0.00 | -0.29 | 0.00 | -0.27 | 0.07 |
| LEATHER AND LEATHER GOODS | 31 | 0.92 | -0.014 | 0.00 | -0.17 | 0.11 | 0.11 | -0.03 | 0.60 | 0.35 | 0.03 |
| | | | DURABLE GOODS | | | | | | | | |
| LUMBER AND WOOD PRODUCTS | 24 | 0.76 | 0.003 | 0.00 | -0.12 | 0.05 | 0.03 | -0.21 | 0.00 | -0.33 | 0.01 |
| FURNITURE AND FIXTURES | 25 | 0.85 | 0.004 | 0.00 | -0.07 | 0.05 | 0.18 | -0.23 | 0.00 | -0.26 | 0.01 |
| STONE, CLAY AND GLASS PROD | 32 | 0.79 | -0.000 | 0.73 | -0.31 | 0.04 | 0.00 | -0.20 | 0.00 | -0.27 | 0.00 |
| PRIMARY METAL INDUSTRIES | 33 | 0.68 | -0.008 | 0.00 | -0.62 | 0.06 | 0.00 | -0.40 | 0.00 | 0.09 | 0.57 |
| FABRICATED METAL PRODUCTS | 34 | 0.71 | 0.000 | 0.46 | -0.31 | 0.03 | 0.00 | -0.35 | 0.00 | -0.12 | 0.08 |
| MACHINERY, EXCEPT ELECTRICAL | 35 | 0.72 | 0.000 | 0.73 | -0.55 | 0.04 | 0.00 | -0.47 | 0.00 | 0.28 | 0.00 |
| ELECTRICAL & ELECTRONIC EQUIP | 36 | 0.93 | 0.003 | 0.01 | -0.16 | 0.07 | 0.04 | -0.35 | 0.00 | -0.06 | 0.60 |
| TRANSPORTATION EQUIPMENT | 37 | 0.37 | 0.003 | 0.01 | -0.32 | 0.05 | 0.00 | -0.43 | 0.00 | -0.30 | 0.04 |
| INSTRUMENTS AND RELATED PROD | 38 | 0.90 | 0.004 | 0.00 | -0.34 | 0.06 | 0.00 | -0.30 | 0.00 | 0.22 | 0.02 |
| MISC MANUFACTURING INDUSTRIES | 39 | 0.67 | -0.002 | 0.00 | -0.33 | 0.03 | 0.00 | -0.18 | 0.00 | -0.17 | 0.03 |

FILE: NOTPW

TABLE 4

NON PRODUCTION WORKERS

DEPENDENT VARIABLE IS LOG OF EMPLOYMENT, U.S.
DATA ARE SEASONALLY ADJUSTED

MODEL: AR1(METHOD=MAXL) 70,1 86,1 DOF: 46
CONSTANT TREND LREX(0,6) LURT(0,4) LRENGY(0,4)

| | SIC | RHO | TREND | SIG | LREX | SE | SIG | LURT | SIG | LRENGY | SIG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NON DURABLE GOODS | | | | | | | | | | | |
| FOOD AND KINDRED PRODUCTS | 20 | 0.97 | -0.003 | 0.00 | -0.03 | 0.03 | 0.34 | -0.03 | 0.02 | 0.04 | 0.28 |
| TOBACCO MANUFACTURES | 21 | 0.20 | 0.000 | 0.81 | 0.20 | 0.06 | 0.00 | -0.14 | 0.02 | 0.59 | 0.00 |
| TEXTILE MILL PRODUCTS | 22 | 0.78 | -0.004 | 0.00 | -0.20 | 0.04 | 0.00 | -0.04 | 0.16 | 0.01 | 0.94 |
| APPAREL & OTHER TEXTILE PROD | 23 | 0.88 | 0.001 | 0.30 | -0.21 | 0.05 | 0.00 | -0.07 | 0.02 | -0.02 | 0.81 |
| PAPER AND ALLIED PRODUCTS | 26 | 0.89 | 0.000 | 0.49 | -0.07 | 0.05 | 0.12 | -0.04 | 0.17 | 0.03 | 0.66 |
| PRINT AND PUBLISHING | 27 | 0.95 | 0.007 | 0.00 | 0.04 | 0.03 | 0.15 | -0.07 | 0.00 | 0.06 | 0.14 |
| CHEMICALS AND ALLIED PRODUCTS | 28 | 0.96 | 0.001 | 0.10 | -0.08 | 0.04 | 0.08 | -0.10 | 0.00 | 0.12 | 0.02 |
| PETROLEUM AND COAL PRODUCTS | 29 | 0.78 | -0.004 | 0.01 | -0.06 | 0.08 | 0.47 | -0.03 | 0.60 | 0.49 | 0.00 |
| RUBBER AND MISC PLASTICS PROD | 30 | 0.57 | 0.007 | 0.00 | -0.16 | 0.02 | 0.00 | -0.21 | 0.00 | -0.08 | 0.13 |
| LEATHER AND LEATHER GOODS | 31 | 0.89 | -0.009 | 0.00 | 0.05 | 0.12 | 0.68 | -0.13 | 0.06 | 0.49 | 0.01 |
| DURABLE GOODS | | | | | | | | | | | |
| LUMBER AND WOOD PRODUCTS | 24 | 0.75 | 0.004 | 0.00 | -0.17 | 0.05 | 0.00 | -0.14 | 0.00 | -0.00 | 0.96 |
| FURNITURE AND FIXTURES | 25 | 0.87 | 0.006 | 0.00 | 0.02 | 0.05 | 0.71 | -0.12 | 0.00 | -0.12 | 0.25 |
| STONE, CLAY AND GLASS PROD | 32 | 0.94 | 0.002 | 0.05 | -0.19 | 0.06 | 0.00 | -0.15 | 0.00 | -0.01 | 0.89 |
| PRIMARY METAL INDUSTRIES | 33 | 0.89 | -0.006 | 0.00 | -0.40 | 0.05 | 0.00 | -0.14 | 0.00 | 0.29 | 0.00 |
| FABRICATED METAL PRODUCTS | 34 | 0.92 | 0.001 | 0.14 | -0.21 | 0.03 | 0.00 | -0.20 | 0.00 | 0.20 | 0.00 |
| MACHINERY, EXCEPT ELECTRICAL | 35 | 0.79 | 0.004 | 0.00 | -0.20 | 0.03 | 0.00 | -0.20 | 0.00 | 0.37 | 0.00 |
| ELECTRICAL & ELECTRONIC EQUIP | 36 | 0.80 | 0.007 | 0.00 | 0.19 | 0.02 | 0.00 | -0.28 | 0.00 | 0.31 | 0.00 |
| TRANSPORTATION EQUIPMENT | 37 | 0.79 | 0.004 | 0.00 | 0.09 | 0.04 | 0.02 | -0.34 | 0.00 | 0.33 | 0.00 |
| INSTRUMENTS AND RELATED PROD | 38 | 0.91 | 0.008 | 0.00 | 0.11 | 0.04 | 0.01 | -0.18 | 0.00 | 0.32 | 0.00 |
| MISC MANUFACTURING INDUSTRIES | 39 | 0.79 | 0.001 | 0.09 | -0.14 | 0.04 | 0.00 | -0.07 | 0.02 | 0.04 | 0.68 |

FILE: PWVNOT

TABLE 5

PRODUCTION WORKERS AND NON PRODUCTION WORKERS, U.S.
MODEL: AR1(METHOD=MAXL) 70.1 86.1 DOF: 46
CONSTANT TREND LRENGY(0.4) LURT(0.4) LREX(0.6)

| | | EXCHANGE RATE ELASTICITIES | | | | | | EMPLOYMENT CHANGE DUE TO EXCHANGE RATE AS PERCENTAGE OF 1980 EMPLOYMENT | |
|---|---|---|---|---|---|---|---|---|---|
| | | PRODUCTION WORKERS | | | NON PRODUCTION WORKERS | | | PRODUCTION WORKERS | NON PRODUCT WORKERS |
| | SIC CODE | LREX | SE | SIG | LREX | SE | SIG | | |
| | | NON-DURABLE GOODS | | | | | | | |
| FOOD AND KINDRED PRODUCTS | 20 | 0.01 | 0.04 | 0.78 | -0.03 | 0.03 | 0.34 | -0.2% | -1.1% |
| TOBACCO MANUFACTURES | 21 | -0.14 | 0.08 | 0.10 | 0.20 | 0.06 | 0.00 | -3.1% | 6.3% |
| TEXTILE MILL PRODUCTS | 22 | -0.15 | 0.03 | 0.00 | -0.20 | 0.04 | 0.00 | -5.9% | -7.0% |
| APPAREL & OTHER TEXTILE PROD | 23 | -0.09 | 0.03 | 0.01 | -0.21 | 0.05 | 0.00 | -3.8% | -7.4% |
| PAPER AND ALLIED PRODUCTS | 26 | 0.03 | 0.03 | 0.26 | -0.07 | 0.05 | 0.12 | 0.9% | -1.8% |
| PRINT AND PUBLISHING | 27 | 0.17 | 0.02 | 0.00 | 0.04 | 0.03 | 0.15 | 5.3% | 1.3% |
| CHEMICALS AND ALLIED PRODUCTS | 28 | -0.13 | 0.03 | 0.00 | -0.08 | 0.04 | 0.08 | -4.0% | -1.8% |
| PETROLEUM AND COAL PRODUCTS | 29 | -0.40 | 0.07 | 0.00 | -0.06 | 0.08 | 0.47 | -15.1% | -0.7% |
| RUBBER AND MISC PLASTICS PROD | 30 | -0.20 | 0.06 | 0.00 | -0.16 | 0.02 | 0.00 | -5.9% | -4.9% |
| LEATHER AND LEATHER GOODS | 31 | -0.17 | 0.11 | 0.11 | 0.05 | 0.12 | 0.68 | -7.2% | 1.8% |
| | | DURABLE GOODS | | | | | | | |
| LUMBER AND WOOD PRODUCTS | 24 | -0.12 | 0.05 | 0.03 | -0.17 | 0.05 | 0.00 | -4.3% | -5.7% |
| FURNITURE AND FIXTURES | 25 | -0.07 | 0.05 | 0.18 | 0.02 | 0.05 | 0.71 | -2.7% | 0.2% |
| STONE, CLAY AND GLASS PROD | 32 | -0.31 | 0.04 | 0.00 | -0.19 | 0.06 | 0.00 | -10.9% | -5.9% |
| PRIMARY METAL INDUSTRIES | 33 | -0.62 | 0.06 | 0.00 | -0.40 | 0.05 | 0.00 | -21.3% | -13.2% |
| FABRICATED METAL PRODUCTS | 34 | -0.31 | 0.03 | 0.00 | -0.21 | 0.03 | 0.00 | -9.9% | -7.0% |
| MACHINERY, EXCEPT ELECTRICAL | 35 | -0.55 | 0.04 | 0.00 | -0.20 | 0.03 | 0.00 | -18.5% | -6.6% |
| ELECTRICAL & ELECTRONIC EQUIP | 36 | -0.16 | 0.07 | 0.04 | 0.19 | 0.02 | 0.00 | -4.9% | 5.6% |
| TRANSPORTATION EQUIPMENT | 37 | -0.32 | 0.05 | 0.00 | 0.09 | 0.04 | 0.02 | -8.9% | 2.1% |
| INSTRUMENTS AND RELATED PROD | 38 | -0.34 | 0.06 | 0.00 | 0.11 | 0.04 | 0.01 | -11.3% | 3.5% |
| MISC MANUFACTURING INDUSTRIES | 39 | -0.33 | 0.03 | 0.00 | -0.14 | 0.04 | 0.00 | -11.2% | -3.4% |
| | | | | | | | TOTAL | -7.1% | -1.4% |

TABLE 6.LIST OF SUBSECTORS FOR MANUFACTURING , Japan

1: Food and beverages
2: Textiles
3: Pulp, paper, and paper products
4: Chemicals
5: Petroleum and coal products
6: Non-metallic mineral products
7: Basic metal
8: Fabricated metal products
9: General machinery
10: Electrical machinery, equipment and supplies
11: Transport equipment
12: Precision instruments
13: Other

M: Total for manufacturing

SHARE OF WEIGHTS OF REAL GDP BASED ON 1980 VALUES

| SECTOR | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAPAN | 0.113 | 0.036 | 0.029 | 0.077 | 0.037 | 0.039 | 0.127 | 0.047 | 0.107 | 0.109 | 0.113 | 0.020 | 0.147 |
| U.S. | 0.104 | 0.064 | 0.097 | 0.079 | 0.072 | 0.033 | 0.073 | 0.083 | 0.133 | 0.099 | 0.113 | 0.034 | 0.016 |

Note: the U.S. figures exclude two sectors of manufacturing not found in the Japanese data, for lumber and wood products and furniture and fixtures.

Source: Marston (1987).

Table 7.
Dependent Variable is Log of Employment
Annual Data, 1970-85, Japan

| Sector | LRGNP | t | LREX(-1) | t | LRENGY(-1) | t | $\overline{R}^2$ | D |
|---|---|---|---|---|---|---|---|---|
| Non-Durable | | | | | | | | |
| 1 | -.21 | 3.2 | -.07 | 1.1 | .03 | 1.5 | .85 | 1.6 |
| 2 | -.59 | 5.3 | .12 | 1.3 | -.09 | 2.7 | .94 | 1.7 |
| 3 | -.14 | 2.1 | -.07 | 1.2 | -.16 | 0.8 | .74 | 1.7 |
| 4 | -.29 | 1.8 | .02 | 0.2 | -.02 | 0.5 | .57 | 0.7 |
| 5 | .08 | 0.8 | .25 | 3.2 | -.00 | 0.0 | .52 | 1.3 |
| 6 | -.08 | 0.5 | .17 | 1.4 | -.04 | 0.8 | .22 | 0.8 |
| 13 | .21 | 3.8 | .06 | 1.3 | -.02 | 1.1 | .74 | 1.2 |
| Durable | | | | | | | | |
| 7 | -.34 | 3.5 | -.00 | 0.0 | -.02 | 0.8 | .84 | 1.0 |
| 8 | .06 | 0.6 | -.15 | 1.8 | -.07 | 2.4 | .59 | 0.8 |
| 9 | .15 | 1.2 | -.25 | 2.4 | -.06 | 1.7 | .36 | 0.8 |
| 10 | .86 | 5.1 | -.63 | 4.4 | -.09 | 1.9 | .78 | 0.9 |
| 11 | .17 | 1.9 | .01 | 0.1 | -.02 | 0.7 | .24 | 0.7 |
| 12 | .38 | 3.8 | -.10 | 1.2 | -.04 | 1.5 | .62 | 1.3 |
| 8-12 | .37 | 3.3 | -.28 | 3.0 | -.06 | 1.9 | .50 | 0.8 |
| 1-13 | .15 | 2.2 | -.11 | 1.8 | -.04 | 1.9 | .23 | 0.5 |

Table 8.
Dependent Variable is Log of Output
Annual Data 1970-85, Japan

| Sector | LRGNP | t | LREX(-1) | t | LRENGY(-1) | t | $\overline{R}^2$ | D |
|---|---|---|---|---|---|---|---|---|
| Non-Durable | | | | | | | | |
| 1 | .34 | 1.9 | .49 | 3.3 | -.05 | 1.0 | .78 | 1.9 |
| 2 | .46 | 1.9 | -.20 | 1.0 | .03 | 0.4 | .55 | 1.2 |
| 3 | .12 | 7.9 | -.23 | 1.8 | -.02 | 0.4 | .94 | 2.7 |
| 4 | 2.46 | 11.0 | .01 | 0.1 | -.10 | 1.6 | .97 | 2.0 |
| 5 | -1.14 | 2.6 | .66 | 1.8 | .37 | 3.0 | .40 | 1.9 |
| 6 | .61 | 3.3 | -.06 | 0.4 | -.17 | 3.2 | .36 | 0.7 |
| 13 | .90 | 5.1 | -.22 | 2.6 | -.22 | 0.8 | .95 | 1.5 |
| Durable | | | | | | | | |
| 7 | 1.62 | 10.7 | .26 | 2.0 | -.25 | 5.8 | .93 | 1.9 |
| 8 | 1.66 | 10.3 | -.43 | 3.2 | -.28 | 6.1 | .90 | 1.7 |
| 9 | 2.21 | 10.0 | -.81 | 4.4 | -.04 | 0.6 | .96 | 1.4 |
| 10 | 5.57 | 18.7 | -.38 | 1.5 | -.14 | 1.7 | .99 | 1.3 |
| 11 | 1.12 | 5.7 | .18 | 1.1 | .07 | 1.3 | .94 | 2.1 |
| 12 | 3.42 | 9.0 | -.04 | 0.1 | -.16 | 1.4 | .94 | 1.7 |
| 8-12 | 2.69 | 14.6 | -.60 | 3.8 | -.09 | 1.7 | .98 | 1.4 |
| 1-13 | 1.64 | 21.5 | -.22 | 3.4 | -.07 | 3.0 | .99 | 1.0 |

Table 9. Dependent Variable is Log of Employment, Annual Data 1970-1985, Japan.

First-Order Serial Correlation Correction

| Sector | LRGNP | t | LREX(-1) | t | LRENGY(-1) | t | RHO | t | $\overline{R}^2$ | D |
|---|---|---|---|---|---|---|---|---|---|---|
| Non-Durable | | | | | | | | | | |
| 1 | .21 | 3.0 | -.07 | 1.2 | .03 | 1.6 | -.07 | 0.2 | .80 | 1.6 |
| 2 | -.62 | 4.8 | .07 | 0.6 | -.08 | 2.4 | .18 | 0.7 | .94 | 2.0 |
| 3 | -.17 | 2.9 | -.09 | 1.8 | -.01 | 0.7 | -.11 | 0.4 | .77 | 1.8 |
| 4 | -.01 | 0.0 | .09 | 0.6 | .00 | 0.0 | .85 | 8.0 | .71 | 1.4 |
| 5 | -.03 | 0.3 | .01 | 0.1 | -.03 | 1.4 | .67 | 9.2 | .52 | 2.4 |
| 6 | -.09 | 0.5 | .07 | 0.5 | -.04 | 0.9 | .57 | 2.9 | .47 | 1.5 |
| 13 | .20 | 3.2 | -.00 | 0.0 | -.02 | 1.2 | .43 | 2.1 | .67 | 1.7 |
| Durable | | | | | | | | | | |
| 7 | -.40 | 0.7 | -.07 | 0.7 | -.02 | 0.8 | .47 | 2.6 | .88 | 1.8 |
| 8 | .01 | 0.1 | -.13 | 1.3 | -.06 | 2.3 | .62 | 3.1 | .71 | 1.2 |
| 9 | .12 | 0.7 | -.16 | 1.3 | -.05 | 1.6 | .69 | 3.4 | .56 | 1.3 |
| 10 | 1.02 | 4.3 | -.31 | 1.9 | -.07 | 1.7 | .70 | 5.9 | .87 | 1.4 |
| 11 | .11 | 1.1 | -.08 | 1.0 | -.02 | 1.0 | .60 | 4.3 | .40 | 1.5 |
| 12 | .35 | 2.9 | -.19 | 1.8 | -.05 | 1.7 | .43 | 2.0 | .58 | 1.7 |
| 8-12 | .37 | 2.2 | -.18 | 1.6 | -.05 | 1.8 | .70 | 3.6 | .67 | 1.2 |
| 1-13 | .16 | 1.4 | -.11 | 1.8 | -.04 | 2.5 | .77 | 4.8 | .63 | 0.9 |

Table 10. Dependent Variable is Log of Output,
Annual Data 1970-1985, Japan.

First-Order Serial Correlation Correction

| Sector | LRGNP | t | LREX(-1) | t | LRENGY(-1) | t | RHO | t | $\bar{R}^2$ | D |
|---|---|---|---|---|---|---|---|---|---|---|
| Non-durable | | | | | | | | | | |
| 1 | .28 | 1.2 | .44 | 2.9 | .06 | 1.2 | -.03 | 0.1 | .70 | 2.0 |
| 2 | .48 | 1.7 | -.10 | 0.3 | .02 | 0.3 | .44 | 1.8 | .55 | 1.5 |
| 3 | 1.12 | 7.6 | -.29 | 2.3 | -.01 | 0.3 | .03 | 0.1 | .93 | 2.3 |
| 4 | 2.37 | 10.8 | -.06 | 0.3 | -.09 | 1.5 | -.02 | 0.1 | .96 | 1.7 |
| 5 | -1.23 | 2.6 | .57 | 1.4 | .39 | 2.9 | .03 | 0.1 | .32 | 2.0 |
| 6 | .50 | 4.3 | -.30 | 2.0 | -.18 | 4.3 | .58 | 4.6 | .65 | 1.6 |
| 13 | .99 | 7.9 | -.18 | 1.8 | -.03 | 0.8 | .27 | 1.1 | .94 | 1.8 |
| Durable | | | | | | | | | | |
| 7 | 1.61 | 9.7 | .24 | 1.7 | -.25 | 5.5 | .03 | 0.1 | .90 | 2.0 |
| 8 | 1.65 | 5.6 | -.41 | 2.6 | -.28 | 5.6 | .14 | 0.5 | .88 | 1.6 |
| 9 | 2.39 | 1.1 | -.52 | 2.7 | -.06 | 1.1 | .35 | 2.2 | .97 | 2.2 |
| 10 | 5.53 | 15.5 | -.48 | 1.6 | -.17 | 1.9 | .37 | 1.6 | .99 | 2.1 |
| 11 | 1.14 | 5.7 | .23 | 1.4 | -.08 | 1.4 | -.10 | 0.4 | .92 | 2.1 |
| 12 | 3.52 | 8.3 | .01 | 0.0 | -.17 | 1.5 | .08 | 0.3 | .93 | 1.8 |
| 8-12 | 2.85 | 15.0 | -.44 | 2.7 | -.11 | 2.2 | .27 | 1.4 | .98 | 1.8 |
| 1-13 | 1.71 | 18.0 | -.15 | 2.0 | -.07 | 3.4 | .55 | 2.8 | .99 | 1.7 |

Table 11. Dependent Variable is Log of Employment, Annual Data 1970-1985, Japan

Lagged Dependent Variable

| Sector | LRGNP | t | LREX(-1) | t | LRENGY(-1) | t | LY(-1) | t | $\bar{R}^2$ | D |
|---|---|---|---|---|---|---|---|---|---|---|
| Non-Durable | | | | | | | | | | |
| 1 | .06 | 0.3 | -.06 | 0.9 | .03 | 1.6 | .38 | 0.8 | .81 | 1.7 |
| 2 | -.64 | 1.7 | .10 | 0.6 | -.08 | 1.9 | -.03 | 0.1 | .93 | 1.7 |
| 3 | -.19 | 2.6 | -.09 | 1.8 | -.01 | 0.8 | -.17 | 0.6 | .77 | 1.7 |
| 4 | .19 | 1.0 | -.08 | 0.7 | -.05 | 1.4 | .94 | 3.4 | .77 | 2.0 |
| 5 | .04 | 0.6 | .08 | 1.0 | -.02 | 1.1 | .56 | 2.3 | .57 | 2.8 |
| 6 | .18 | 1.1 | -.04 | 0.3 | -.07 | 1.9 | .80 | 2.9 | .57 | 2.2 |
| 13 | .13 | 1.5 | -.01 | 0.1 | -.01 | 0.8 | .33 | 0.7 | .64 | 1.6 |
| Durable | | | | | | | | | | |
| 7 | -.01 | 0.0 | -.06 | 0.8 | -.04 | 1.7 | .68 | 2.4 | .90 | 2.4 |
| 8 | .24 | 4.2 | -.08 | 1.9 | -.08 | 5.7 | .78 | 6.6 | .91 | 2.3 |
| 9 | .28 | 3.5 | -.13 | 1.9 | -.07 | 3.4 | .78 | 5.2 | .80 | 2.1 |
| 10 | .57 | 5.1 | -.31 | 3.3 | -.07 | 2.8 | .64 | 5.4 | .94 | 2.2 |
| 11 | .15 | 2.9 | -.09 | 2.1 | -.04 | 2.8 | .84 | 4.8 | .69 | 2.4 |
| 12 | .31 | 3.3 | -.09 | 1.2 | -.06 | 2.2 | .47 | 2.1 | .65 | 2.0 |
| 8-12 | .31 | 5.2 | -.15 | 2.8 | -.07 | 4.0 | .73 | 6.1 | .88 | 2.1 |
| 1-13 | .16 | 4.9 | -.10 | 3.9 | -.04 | 4.3 | .81 | 7.2 | .86 | 2.3 |

Table 12. Dependent Variable is Log of Output
Annual Data 1970-1985, Japan

Lagged Dependent Variable

| Sector | LRGNP | t | LREX(-1) | t | LRENGY(-1) | t | LY(-1) | t | $\overline{R}^2$ | D |
|---|---|---|---|---|---|---|---|---|---|---|
| Non-Durable | | | | | | | | | | |
| 1 | .25 | 1.2 | .37 | 1.8 | .03 | 0.4 | .19 | 0.6 | .70 | 2.3 |
| 2 | .47 | 2.2 | .01 | 0.1 | -.11 | 1.3 | .83 | 2.5 | .67 | 1.7 |
| 3 | 1.06 | 3.4 | -.29 | 2.2 | -.01 | 0.2 | .05 | 0.2 | .93 | 2.3 |
| 4 | 2.82 | 3.2 | -.00 | 0.0 | -.11 | 1.5 | -.19 | 0.5 | .96 | 1.8 |
| 5 | -1.24 | 2.6 | .40 | 0.9 | .38 | 2.9 | .19 | 0.8 | .36 | 2.3 |
| 6 | .46 | 3.8 | -.24 | 2.3 | -.14 | 4.1 | .51 | 3.6 | .71 | 2.1 |
| 13 | 1.26 | 2.2 | -.24 | 2.2 | -.05 | 0.9 | -.32 | 0.6 | .94 | 1.3 |
| Durable | | | | | | | | | | |
| 7 | 1.47 | 7.2 | .22 | 1.6 | -.25 | 5.4 | .15 | 1.1 | .91 | 2.5 |
| 8 | 1.51 | 4.9 | -.40 | 2.7 | -.26 | 4.9 | .12 | 0.9 | .88 | 1.7 |
| 9 | 1.26 | 2.6 | -.23 | 0.9 | -.06 | 1.3 | .55 | 2.4 | .98 | 1.8 |
| 10 | 3.59 | 5.6 | -.45 | 2.3 | -.18 | 2.7 | .40 | 3.2 | .99 | 2.6 |
| 11 | .92 | 2.5 | .15 | 0.8 | .02 | 0.3 | .29 | 0.8 | .93 | 2.2 |
| 12 | 2.71 | 4.3 | .04 | 0.1 | -.23 | 2.0 | .33 | 1.6 | .95 | 2.0 |
| 8-12 | 1.84 | 6.1 | -.33 | 2.8 | -.11 | 3.2 | .43 | 3.5 | .99 | 2.5 |
| 1-13 | 1.19 | 6.8 | -.17 | 3.2 | -.07 | 3.8 | .34 | 2.9 | .99 | 1.8 |

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The Real Exchange Rate, Employment, and Output in Manufacturing in the U.S. and Japan

## Appendix: Trend and Cycle in Japan

The path of real GNP in Japan is shown as the solid line in Figure A-1. The break in the trend in 1973-74 following the oil price increase is clear. It appears that the growth path both shifted down and decreased in slope. It also appears that the growth paths before 1973 and after 1974 are approximately linear. To compute trend and cycle variables for Japan, we fitted a piece-wise linear regression to the real GNP time series from 1968 to 1986, using two time trends, one (TIM 1) for 1968-73, and one (TIM 2) for 1975-86, and two dummy variables. DUM 1 is unity in 1974 and zero otherwise, and DUM 2 is zero for 1968-74 and unity for 1975-86. The regression, including a constant term, is summarized in Table A-1. The fitted values from the regression are shown as the dashed line in Figure A-1. The cyclical variable LCYC in the regressions for Japan in section VI is the series of residuals from the regression in percentage terms; the trend variable is the log of the fitted value.

Table A-1: Regression for Trend Real GNP, Japan, 1968-86, Trillion Yen, 1980 prices

| Variable | Coefficient | t-ratio |
| --- | --- | --- |
| Constant | 78.2 | 25.2 |
| DUM 1 | 105.1 | 28.6 |
| DUM 2 | -0.5 | 0.1 |
| TIM 1 | 11.9 | 25.6 |
| TIM 2 | 10.0 | 61.7 |
| $\overline{R}^2$ | 0.998 | |
| D | 1.7 | |

Figure A-1: Real GNP in Japan, Actual and Fitted Values, 1968-86, Billion Yen, 1980 Prices