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ABSTRACT

This paper investigates the importance of markup behavior in Japanese manufacturing. According to the evidence presented, Japanese firms have varied the markups of prices over marginal costs in order to limit the effects of exchange rate changes on output. This behavior is quite different from that found in U.S. manufacturing where output and employment have borne the main impact of recent exchange rate changes.

The paper examines markups in nine sectors of manufacturing which are major producers of exports. In all nine sectors, Japanese prices prove to be highly sensitive to foreign prices and exchange rates as well as to more traditional demand and supply variables. The paper shows that variable markups rather than high price elasticities account for this price behavior, since output is relatively insensitive to prices or exchange rates.

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PRICE AND OUTPUT ADJUSTMENT IN JAPANESE MANUFACTURING

by William H. Branson and Richard C. Marston

In the last fifteen years, manufacturing firms in the United States and Japan have had to cope with large fluctuations in real exchange rates. Firms in the two countries are said to have responded quite differently to these fluctuations. As shown in Branson and Love (1988), output and employment in U.S. manufacturing have varied quite sharply in response to changes in the real value of the dollar. But Japanese manufacturers are said to have varied prices, particularly the yen prices of exports, to limit the effects of changes in the real exchange rate of the yen on Japanese output and employment. This paper will study price adjustment in Japanese manufacturing to determine to what extent price behavior has shielded Japanese output from fluctuations in the yen.

When there are variations in real exchange rates, manufacturers can respond in two different ways. They can vary production in the home country, perhaps shifting between home and offshore plants. Or they can vary the markups of prices over marginal costs in order to stabilize the foreign currency prices of exports. In that case, profit margins rather than output and employment absorb the impact of the variations in real exchange rates.

If the yen appreciates, for example, Japanese firms can hold down the foreign currency prices of their exports by squeezing profit margins at home. The markups of the yen prices of their products over marginal costs are reduced in order to remain competitive in foreign markets. As a result, only a fraction of the yen appreciation is "passed through" into Japanese export prices expressed in dollars and other foreign currencies. Manufacturing firms may even follow a differential pricing policy where they reduce the yen prices of their exports more than they reduce domestic prices. Such differential pricing, which involves varying markups for the export market more than domestic markups, has been called "pricing to market" by Krugman (1987) and others.[1]

This paper will examine price and output behavior in nine sectors of Japanese manufacturing which rely substantially on export markets. For each industry, separate equations will be estimated for Japanese wholesale prices and export prices in order to measure the sensitivity of markups to changes in foreign prices. And for each of these industries, demand equations will also be estimated to determine the sensitivity of output to changes in real exchange rates.

The first section of the paper derives reduced form equations for prices in an individual industry. The key departure from earlier studies is the introduction of markup behavior which alters the relative response of prices and output to changes in real exchange rates. The second section presents equations for domestic and export prices by industry, and the third section presents demand equations. The final section of the paper discusses the overall pattern of price and output adjustment found in Japanese manufacturing.

I. A Model of Markup Behavior

When markups are variable, firms may respond to a rise in foreign prices by raising their markups rather than by increasing output and employment. In general, the more responsive are markups to foreign prices, the less effect do foreign prices have on output. Because markups are of such central importance, we develop a model of demand and cost behavior which focuses specifically on markup behavior.

A. The Markup Function

Consider the behavior of a firm producing a good i for both the domestic and export markets. This firm has a short run marginal cost function of the form:

$$C_1\ (Z_{it},\ W_t,\ R_t,\ t), \qquad (1)$$

where C_{11}, C_{12}, $C_{13} > 0$, $C_{14} < 0$,[2] and

Z_{it} = output of good i,

W_t = nominal wage,

R_t = raw materials price,

t = time.

Marginal cost is assumed to increase as output or factor prices increase, but to decline over time in response to productivity growth. Marginal cost in also assumed to be homogeneous of degree one in wages and raw materials prices, so that Euler's law holds: $C_{12} W_t + C_{13} R_t = C_1$.[3] The firm faces a demand curve of the form:

$$(2) \qquad Z_{it} = h\,[P_{it}/(S_t\, Q_{it}),\; Z_t,\; Y_t],$$

where h_1 , 0, h_2, $h_3 > 0$, and

P_{it} = price of good i,

Q_{it} = price of a competing good in foreign currency,

S_t = exchange rate (domestic currency price of foreign currency),

Z_t = total domestic output,

Y_t = total foreign output.

Demand is negatively related to its own relative price, and positively related to output in either country.

The firm is assumed to set P_{it} to maximize profits according to the first order condition:

$$(3) \qquad h_1 \frac{P_{it}}{S_t\, Q_{it}} + h(.) - h_1 \frac{C_1}{S_t\, Q_{it}} = 0.$$

The <u>markup</u> of price over marginal cost can be obtained by rearranging this first order condition as follows:

$$(3') \qquad \frac{P_{it}}{C_1} = 1 \,/\, [\, 1 + \frac{h(.)\; S_t\, Q_{it}}{h_1\, P_{it}} \,].$$

$$= M\,(\frac{P_{it}}{S_t\, Q_{it}},\; Z_t,\; Y_t).$$

Notice that the markup is a function of the same variables as the demand function on which it is based. The markup can also be written in terms of the price elasticity of demand,

$\epsilon = -(h_1 P_{it}) / (Z_{it} S_t Q_{it}) > 0$ as follows:

$$M(.) = \epsilon / (\epsilon - 1).$$

If the demand elasticity is constant (case 1 below), then the markup is also constant. For many demand curves, however, the elasticity increases and the markup falls as prices rise (case 2 below).

In order to determine how demand and cost functions interact to determine prices, we totally differentiate the first order conditions and solve for the domestic price. In the next section, the elasticities of the price with respect to each of the independent variables are described in detail.

B. Price Behavior

The price of good i can be expressed in terms of the factors influencing both demand and cost behavior. The reduced form equation for P_{it} is expressed in terms of percentage changes, so the coefficients represent elasticities of price with respect to the demand and cost variables. In the equation below, all prices are deflated by the wage in order to reduce colinearity between the independent variables in the estimation to follow:

$$(4) \quad \frac{d\, P_{it}}{P_{it}} - \frac{d\, W_t}{W_t} = \alpha_{i1} \left[\frac{d\, S_t Q_{it}}{S_t Q_{it}} - \frac{d\, W_t}{W_t}\right] + \alpha_{i2} \left[\frac{d\, R_t}{R_t} - \frac{d\, W_t}{W_t}\right] + \alpha_{i3} \frac{d\, Z_t}{Z_t} + \alpha_{i4} \frac{d\, Y_t}{Y_t} + \alpha_{i5}\, d\, t.$$

where $\alpha_{i1} = 1 - (S_t Q_{it}) / H,$

$$\alpha_{i2} = (S_t\, Q_{it}\, R_t\, C_{13}) / (H\, C_1),$$

$$\alpha_{i3} = [Z_t\, S_t\, Q_{it}\, (C_1\, M_2 + M(.)\, C_{11}\, h_2)] / (H\, P_{it}),$$

$$\alpha_{i4} = [Y_t\, S_t\, Q_{it}\, (C_1\, M_3 + M(.)\, C_{11}\, h_3)] / (H\, P_{it}),$$

$$\alpha_{i5} = [S_t\, Q_{it}\, C_{14}] / (H\, C_1), \text{ and}$$

$$H = [S_t\, Q_{it} - C_1\, M_1 - M(.)\, C_{11}\, h_1] > 0.$$[4]

Among the independent variables is one which measures the relative competitiveness of industry i: $S_t\, Q_{it} / W_t$. The coefficient of this relative price, which we call the sectoral real exchange rate, measures the influence of foreign prices on domestic prices in the same industry. The size of this real exchange rate coefficient depends on two different factors, the price elasticity of demand (ϵ) and the elasticity of the markup with respect to prices (which we label δ). In order to investigate the influence of these two elasticities, we consider two special cases:

Case 1: Constant markups with increasing marginal cost.

If the elasticity of demand is constant, which would be the case if the demand curve is loglinear, then the markup is also constant ($M_1 = M_2 = M_3 = 0$). So the coefficient of the real exchange rate reduces to

$$\alpha_{i1} = 1 - \frac{1}{[1 + \epsilon\, (C_{11}\, Z_{it}/C_1)]}.$$

As long as marginal cost increases with output ($C_{11} > 0$), then this coefficient lies between zero and one. An appreciation of the yen, by raising export prices in foreign currency, reduces output demanded. So marginal costs fall, and so do prices in _yen_. But since there is no change in the markup of prices over marginal costs, the fall in prices is accomplished only through variations in output leading to reductions in marginal cost. So this case cannot explain the lack of output adjustment in Japan; with constant demand elasticities, there is no tradeoff between price adjustment and output adjustment.

A higher demand elasticity increases the real exchange rate coefficient. And as this elasticity approaches infinity, α_{i1} approaches one, while all other coefficients in (4) approach zero. So in this polar case where domestic and foreign goods are perfect substitutes, the price equation collapses to the law of one price (in percentage changes): $d(P_{it})/P_{it} = d(S_t Q_{it})/(S_t Q_{it})$. Short of this polar case, higher demand elasticities result in _greater_ output variation, since any movement in relative prices leads to changes in output proportional to this elasticity.

Case 2: Variable markups with constant marginal cost.

A second special case focuses specifically on markup behavior. We assume that markups _decline_ with increases in prices (i.e., $M_1 < 0$). Such markup behavior is characteristic of any demand curve less convex (more linear) than the loglinear curve, including the linear case itself.[5] To isolate the role of markups, assume that marginal cost is constant ($C_{11} = 0$) so that the last term in the denominator of α_{i1} involving the elasticity of demand is zero. Then the coefficient of the real exchange rate is given by:

$$\alpha_{i1} = 1 - \frac{1}{[1 - \delta]},$$

where δ is the elasticity of the markup with respect to price: $\delta = (M_1 P_{it})/(M(\cdot) S_t Q_{it}) < 0$. As δ increases in absolute value, α_{i1} also increases. So as the demand curve becomes more linear, the effect of higher foreign prices is enhanced.

Consider the effects of an appreciation of the yen once again. This appreciation raises the foreign currency price of exports. But the exporting firm reduces the markup to limit the rise in that price. So the firm's price in domestic currency falls. If the firm "prices to market", then it may reduce the domestic currency price of its exports more than the price of its domestic goods. A greater sensitivity of the markup to prices (i.e., a higher δ in absolute value) increases the response of the firm's prices to the appreciation. And it reduces the impact of the appreciation on output. So in this case of a variable markup, there is a tradeoff between price variations and output variations.

In the case of a linear demand curve, we can also relate the size of δ to the elasticity of demand through the equation: $\delta = -(1 + \epsilon)/(\epsilon - 1) < 0$. Since an increase in the elasticity of demand reduces the absolute value of δ, it also reduces α_{i1}. So in contrast to case 1, the lower the demand elasticity, the higher is α_{i1}, the coefficient of the real exchange rate. Consider the implications for the behavior of output. If markup behavior is responsible for a high coefficient for the real exchange rate, then output may be relatively unresponsive to the real exchange rate because of low demand elasticities even though domestic prices are highly responsive to the real exchange rate.

General Case: Variable markups and increasing marginal cost.

We now consider the more general case where markups are allowed to fall as prices rise and where marginal costs may increase with output: $M_1 \leq 0$, $C_{11} \geq 0$.[6] The coefficient of the real exchange rate can be written as follows:

$$\alpha_{i1} = 1 - \frac{1}{[1 - \delta + \epsilon(C_{11} Z_{it}/C_1)]} .$$

The denominator of the fraction above must be positive.[7] So α_{i1} must lie between zero and one. As in case 1, moreover, an increase in ϵ, given δ, increases α_{i1}, while as in case 2 an increase in the absolute value of δ, given ϵ, also increases α_{i1}. So if we find that α_{i1} is large in the equations estimated below, we can attribute the response of domestic prices to the real exchange rate to one of two influences: high demand elasticities or variable markup elasticities. Only by examining output behavior will we be able to distinquish between these two influences.

To round out the analysis of the price equation, we note that α_{i2} can be written as

$$\alpha_{i2} = \frac{R_t C_{13}}{C_1} (1 - \alpha_{i1}) .$$

So $0 \leq \alpha_{i2} < 1$. An increase in ϵ or in the absolute value of δ, moreover, reduces the size of this coefficient. The coefficients of domestic and foreign output, α_{i3} and α_{i4}, are positive as long as the markup derivatives, M_2 and M_3, are positive or zero.[8] Finally, the coefficient of time, α_{i5}, is negative, since increasing productivity reduces marginal costs.

II. Empirical Price Equations

In this section, we report equations explaining price changes in Japanese manufacturing as a function of changes in foreign prices as well as other variables. We focus on those sectors of manufacturing with significant reliance on exports for which there are series for export prices as well as domestic prices available. Nine sectors in all are studied: textiles, chemicals, three metal sectors, and four machinery sectors. The machinery sectors alone (general machinery, electrical machinery, transport equipment, and precision instruments) account for over half of Japanese exports.

A. Description of the Data

The data appendix describes the series used in the estimation and reports the source of each series. This section briefly describes these series and outlines the specification of the price equations.

For the nine sectors studied, the Bank of Japan reports prices for the export market separate from prices for the domestic market. The domestic prices are those reported at the primary wholesale level for sale in Japan, while the export prices are FOB export prices expressed <u>in yen</u>. The product categories are listed in Table 1. The price equations to be estimated have as a dependent variable the domestic or export price for that sector relative to the wage in Japanese manufacturing. (The relative domestic price is denoted PW_{it}, while the relative export price is denoted PXW_{it}). To reduce spurious correlation between the price series, all variables are expressed as first-differences (of their log values).

The independent variables include a sectoral real exchange rate (RW_{it}) defined as the U.S. producer price for that sector, converted into yen, deflated by the Japanese manufacturing wage. It would have been preferable to use a weighted average of many countries' prices in forming this sectoral real exchange rate, but it is difficult to obtain disaggregated prices defined on a consistent basis across countries. The coefficient of this sectoral real exchange rate measures the elasticity of the domestic or export price with respect to a one percent change in the foreign price or exchange rate. This coefficient should be larger in the export price equation than in the domestic price equation if Japanese firms "price to market", varying export price markups more than domestic markups as foreign prices change.[9]

The second independent variable is the relative price of imported raw materials (RM_{it}) defined as the import price of petroleum, coal and natural gas expressed in yen relative to the wage.[10] Japanese output (Y_t) also enters as an independent variable. To reduce colinearity between output and the time trend, this variable is expressed as the cyclical deviation from a time trend, formed by fitting a time trend to the log of Japanese industrial production.[11] A variable representing cyclical movements in U.S. industrial production was also included in the equation, but proved to be statistically insignificant throughout the estimation. Cyclical output should have a positive coefficient, since this variable reflects the influence of higher demand on prices and higher markups due to that increased demand. With cyclical output replacing actual output, the time trend (t) now reflects two influences, productivity growth and the trend growth in demand. Since the price equation is expressed in first differences, the constant in this equation measures any trend influence on prices.

The equation estimated for sector i has the following form:

$$(5) \quad PW_{it} = \Sigma_j \, a_{i1j} \, RW_{i,t-j} + \Sigma_j \, a_{i2j} \, RM_{i,t-j} + \Sigma_j \, a_{i3j} \, CIP_{t-j} + a_{i0} + U_{it},$$

where the dependent variable is either

PW_{it} = the change in the log of the Japanese domestic wholesale price for sector i less the wage in manufacturing, or

PXW_{it} = the change in the log of the Japanese wholesale price for exports (in yen) for sector i less the wage in manufacturing,

and where

RW_{it} = the change in the log of the U.S. wholesale price for sector i converted into yen at the current spot rate less the wage in manufacturing,

RM_{it} = the change in the log of the price of imported petroleum, coal, and natural gas less the wage in manufacturing, and

CIP_t = the change in the log of Japanese cyclical production (measured as the deviation from the log trend of industrial production).

The period of estimation begins in January 1974, following the start of generalized floating, and ends in December 1986, so there are 156 monthly observations. Since the data are not seasonally adjusted,[12] we include seasonal dummy variables in each equation.[13]

B. Estimation Results

Table 1 reports the price equations for the nine sectors of Japanese manufacturing with significant export activity. The table reports the coefficients for the relative price terms, output terms, and constant as well as four summary statistics: the adjusted R^2, the standard error of the equation, the serial correlation coefficient (Rho) when it is statistically significant, and the Durbin-Watson statistic.

Since the estimation employs monthly data, we fit polynominal distributed lags to each independent variable. The lags proved to be quite short, however, particularly those for the relative price terms. A linear lag of only two months was found for the sectoral real exchange rates and the relative price of imported materials. This suggests that price changes in Japan occur quite rapidly following changes in exchange rates or foreign prices. In the case of cyclical output, the lag was four

TABLE 1. PRICE EQUATIONS, 1974.01 - 1986.12

SECTOR	Σ RW	Σ RM	Σ CIP	CONS	$\bar{R}^2$ SEE	Rho DW
TEXTILES						
Domestic	.240	.068	.784	-.042	.583	.220
	(4.05)	(1.10)	(3.52)	(-1.98)	.017	1.96
Export	.628	.101	.416	-.037	.773	.468
	(11.2)	(1.70)	(1.96)	(-1.35)	.015	1.95
CHEMICALS						
Domestic	.245	.230	.720	-.036	.676	.287
	(4.51)	(3.89)	(3.43)	(-1.70)	.016	2.17
Export	.890	.121	.496	-.047	.873	.489
	(15.8)	(1.94)	(2.27)	(-1.62)	.016	2.16
IRON & STEEL						
Domestic	.169	.109	.677	-.031	.618	
	(3.32)	(2.07)	(3.45)	(-1.90)	(.017)	1.75
Export	.774	.261	.263	-.040	.721	.280
	(10.6)	(3.25)	(.924)	(-1.39)	.021	1.86
NON-FERROUS METALS						
Domestic	.647	.268	1.34	-.097	.702	.211
	(6.79)	(2.40)	(3.38)	(-2.58)	.031	1.93
Export	.740	.036	.201	-.008	.629	.321
	(9.23)	(.386)	(.597)	(-.226)	.025	1.78
METALLIC PRODUCTS						
Domestic	.309	.248	.439	-.018	.561	.301
	(4.26)	(3.20)	(1.59)	(-.619)	.021	1.67
Export	.438	.220	.247	-.051	.602	.179
	(6.53)	(3.21)	(.972)	(-2.17)	.020	1.93
GENERAL MACHINERY						
Domestic	.270	.161	.332	-.033	.559	.209
	(4.25)	(2.52)	(1.42)	(-1.50)	.018	1.74
Export	.496	.080	.227	-.039	.802	.140
	(11.3)	(1.82)	(1.41)	(-2.78)	.013	1.74

TABLE 1. PRICE EQUATIONS, 1974.01 - 1986.12 (cont.)

SECTOR	Σ RW	Σ RM	Σ Y	CONS	$\bar{R}^2$ SEE	Rho DW
ELECTRICAL MACHINERY						
Domestic	.227	.108	.210	-.048	.552	
	(4.21)	(2.03)	(1.03)	(-2.88)	.017	1.61
Export	.650	-.039	.106	-.065	.830	-.204
	(16.8)	(-1.03)	(.737)	(-5.49)	.012	1.98
TRANSPORT EQUIPMENT						
Domestic	.266	.131	.321	-.039	.569	.233
	(4.61)	(2.15)	(1.43)	(-1.81)	.017	1.84
Export	.494	.037	.206	-.021	.826	
	(13.4)	(.989)	(1.44)	(-1.75)	.012	1.85
PRECISION INSTRUMENTS						
Domestic	.252	.119	.269	-.043	.525	
	(4.14)	(1.97)	(1.21)	(-2.25)	.018	1.68
Export	.255	.130	.360	-.060	.533	.143
	(4.11)	(2.07)	(1.57)	(-2.95)	.018	1.73

Notes: The figures below the coefficients are t-statistics. Seasonal dummy variables are included in each equation, but their coefficients are not reported. Most equations are corrected for serial correlation in which case the serial correlation coefficient (Rho) is reported.

months long. In the table, we report the sum of the coefficients for each lag distribution and the t-statistic for their sum.

The sectoral real exchange rate enters significantly in all eighteen regressions. Recall that the coefficient of this term measures the elasticity of the domestic or export price with respect to changes in the foreign price or exchange rate. In only one equation, the export price equation for chemicals, is the foreign price coefficient insignificantly different from one (at the five percent level), but in many sectors it is much larger than zero. The elasticity varies between 0.169 for domestic iron and steel prices to 0.890 for export prices in the chemical sector.

In all sectors, the foreign price coefficient in the export equation exceeds that in the domestic equation. In many sectors, such as chemicals, iron and steel and electrical machinery, the price sensitivity of export prices is much larger than that of domestic prices, which suggests that there is substantial pricing to market in these sectors.[14]

In seventeen of the eighteen equations, the coefficient of the imported materials price has the expected positive sign, although in only twelve of these equations is the coefficient statistically significant at the five percent level. The coefficients are generally much smaller than those of the foreign price term, which suggests a relatively low dependence on imported materials in these sectors.

Cyclical movements in Japanese output are statistically significant in six of the eighteen equations, and have the correct positive sign in all equations.[15] The coefficients represent elasticities of domestic or export prices with respect to changes in output. In the textile sector, for example, a one percent increase in output above trend leads to a rise in the price by .784 percent.

The constant term in each regression measures the influence of trends on the price level, since the regressions relate changes in prices to other variables. The theoretical model suggests an ambiguous sign for the trend term, since higher output raises demand and therefore raises prices, while higher productivity lowers prices. The influence of productivity growth apppears to be dominant, since the constant is negative in all eighteen equations, although in only eight equations is the coefficient statistically significant at the five percent level. Most of the statistically significant trends occur in the four machinery sectors where productivity growth has been especially rapid.[16]

The fit of these equations is excellent considering that they are estimated in first-difference form. Overall, the results indicate that changes in foreign prices are the most important determinant of price changes in Japan, at least in the export-oriented sectors of manufacturing that are studied here. Other influences are also important, including cyclical movements in output, but domestic and export prices appear to be more systematically related to foreign prices than any other variable.

III. Demand Behavior

The results reported in Table 1 suggest that, for many sectors of Japanese manufacturing, foreign prices and exchange rates have a strong influence on Japanese prices. But as explained in section 1, there are two competing explanations for these results corresponding to the two ways in which foreign prices affect domestic prices. The first involves price elasticities. If demand has a high price elasticity, then Japanese prices will be relatively sensitive to foreign prices.

In this case, output should also be relatively sensitive to foreign prices. The second way involves markup behavior. If markups are relatively responsive to price changes, then Japanese prices will once again be relatively sensitive to foreign prices. But in this case, output should be relatively <u>in</u>sensitive to price changes.

To help distinguish between these two cases, we now investigate the price elasticity of demand (ϵ) by estimating demand equations for each sector. The demand equation (2) is written in terms of percentage changes as follows:

$$(6) \qquad \frac{d\, Z_{it}}{Z_{it}} = -\,\epsilon \left[\frac{d\, P_{it}}{P_{it}} - \frac{d\, S_t\, Q_{it}}{S_t\, Q_{it}} \right] + \mu \frac{d\, Z_t}{Z_t}\ .$$

The last coefficient represents the income elasticity of demand, $\mu = (h_2\, Z_t)/Z_{it}$.

The empirical counterpart of (6) relates (the percentage change in) industrial production in sector i to distributed lags of relative price changes and income changes:

$$(7) \quad IP_{it} = -\,\Sigma_j\, b_{i1j}\, PQ_{i,t-j} + \Sigma_j\, b_{i2j}\, CIP_{t-j} + b_{i0} + V_{it}$$

where IP_{it} = the change in the log of industrial production in industry i,

PQ_{it} = the change in the log of the Japanese export price for sector i relative to the corresponding U.S. wholesale price expressed in yen,

CIP_t = the change in the log of Japanese cyclical industrial production (measured as the deviation of the log of industrial production from its trend).

The series for industrial production represent monthly data disaggregated according to the same nine industry classification as are the wholesale price series. The export price rather than domestic price is employed as an independent variable since it is the export component of demand that is likely to be the most price-sensitive. Because the current export price is likely to be correlated with the error term in this equation, only lagged values of PQ_{it} are included in the equation. The period of estimation extends from January 1974 to December 1986. Since the industrial production series are not seasonally adjusted, we include seasonal dummy variables in each equation. As in the price equation, the constant term reflects the combined influence of productivity growth and the trend growth of demand.

Table 2 reports demand equations for the nine sectors of Japanese manufacturing with significant export activity. The table reports the coefficients for the relative price and output terms, constant, as well as summary statistics. We fit a ten month, second degree, polynominal lag to the price and output terms; the coefficients reported are for the sum of these lags.

Unlike the corresponding price equations in Table 1, these demand equations exhibit little sensitivity to foreign prices. In all nine equations, the relative price terms are statistically insignificant, and are positive rather than negative in seven of these equations.[17] The cyclical income terms, in contrast, are all of the correct sign and are statistically significant in seven of the nine equations. The constant terms, moreover, are

TABLE 2. DEMAND EQUATIONS, 1974.01 - 1986.12

SECTOR	Σ PQ	Σ CIP	CONS	$\bar{R}^2$ SEE	Rho DW
TEXTILES	.007	.811	-.005	.949	
	(.090)	(3.78)	(-.474)	.011	2.06
CHEMICALS	.267	.810	.036	.560	
	(1.71)	(1.85)	(1.65)	.022	2.31
IRON & STEEL	.110	1.40	.007	.757	
	(.986)	(4.34)	(.429)	.016	1.84
NON-FERROUS	.197	1.60	.016	.881	
METALS	(1.37)	(4.53)	(.912)	.018	2.14
METALLIC	.058	1.91	.008	.860	-.255
PRODUCTS	(.428)	(4.80)	(.404)	.025	2.06
GENERAL	.146	2.22	.033	.915	-.331
MACHINERY	(.920)	(5.83)	(1.73)	.026	2.10
ELECTRICAL	.301	2.10	.128	.695	-.559
MACHINERY	(.652)	(2.22)	(2.41)	.075	2.29
TRANSPORT	-.176	.716	.023	.881	-.467
EQUIPMENT	(-.800)	(1.54)	(.982)	.035	2.28
PRECISION	-.104	1.90	.104	.761	-.302
INSTRUMENTS	(-.629)	(3.50)	(3.70)	.037	2.06

Note : See Table 1.

positive in all but one equation, although they are statistically significant in only two equations. So income, particularly cyclical income, seems to play a major role in the demand equations, but relative prices do not.

Because demand does not appear to be significantly affected by relative prices, one of the two explanations for the results reported in Table 1 must be rejected. High demand elasticities can hardly account for the price responsiveness reported in that table. Instead, the explanation seems to be that markups are sufficiently variable to account for the high correlation between foreign and domestic prices. As explained earlier, if markups are sufficiently variable, then domestic prices will respond to foreign prices even though demand elasticities are low. And with demand elasticities low, Japanese output will not be very sensitive to relative price changes.

IV. Concluding Comments: An Agenda for Future Research

This paper has suggested that markup behavior may be the key to understanding the patterns of price and output adjustment found in Japanese manufacturing. We have provided evidence that Japanese firms have varied markups systematically in order to limit the effects of exchange rate changes on output. This behavior is quite different from that found in U.S. manufacturing where output and employment has borne the main impact of exchange rate changes.

In future we hope to extend this analysis by examining Japanese demand behavior in more detail. In the model outlined above, we have not distinguished between domestic and foreign demand for Japanese goods. It is possible that the output behavior we observe is due to different markup behavior in the two markets, a possibility consistent with higher coefficients for foreign prices in the export price equations. Consider a model of "pricing to market" in which the markups of export prices in domestic currency over marginal costs are varied systematically so as to limit changes in export prices in <u>foreign</u>

currency. The markups of export prices will vary widely, while those in the domestic market may not vary much at all. To investigate this possibility, we hope to estimate separate demand equations for export and domestic markets if we can obtain quantity data disaggregated by market.

DATA APPENDIX:

Japanese sectoral prices:
Domestic and export price indexes for the following sectors: textile products, chemicals, iron and steel, non-ferrous metals, metal products, general machinery, electrical machinery, transport equipment, and precision instruments. Note that the domestic price indexes are for domestic goods only. (A separate set of "overall" wholesale price indexes is also available). The indexes are calculated using the Laspeyres formula. Source: Bank of Japan, Price Indexes Annual, various issues.

Japanese import price for fuel:
Import price index for petroleum, coal, and natural gas. Source: Bank of Japan, Price Indexes Annual, various issues.

U.S. sectoral prices:
Producer price indexes for the following sectors: apparel, chemicals and allied products, iron and steel, non-ferrous metals, fabricated structural metal products, general purpose machinery and equipment, electrical machinery and equipment, motor vehicles and equipment. Note that the series for general purpose machinery and equipment was used as an explanatory variable in both the general machinery and precision instruments price equations. Source: Department of Commerce, Business Conditions Digest.

U.S. (aggregate) wholesale price:
Producer price index for U.S. manufacturing. Source: Department of Commerce, Business Conditions Digest.

Japanese wages:
Monthly earnings in Japanese manufacturing, regular workers, seasonally adjusted. Source: OECD, Main Economic Indicators.

Exchange rate:
Yen price of the dollar, monthly average. Source: International Monetary Fund, International Financial Statistics.

Japanese sectoral industrial production:
Industrial production by sector of manufacturing, available for the same nine sectors listed for the price series. Source: Economic Planning Agency, unpublished data.

Japanese (aggregate) industrial production:
Industrial production in Japanese manufacturing. Source: OECD, Main Economic Indicators.

U.S. industrial production:
Industrial production in U.S. manufacturing. Source: OECD, MEI.

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FOOTNOTES

1. Other recent studies of pricing to market and the related phenomena of currency pass-through include Feenstra (1987), Froot and Klemperer (1988), Giovannini (1988), Ohno (1988), and Schembri (1988).

2. The subscripts refer to the arguments of the function; C_1, for example, is marginal cost, or the derivative of total cost with respect to output, while C_{12} is the derivative of marginal cost with respect to the second argument, wages.

3. In the case of a Cobb-Douglas production function, for example, the short run marginal cost function is homogeneous of degree one in the prices of the variable factors, W_t and R_t.

4. The second order conditions require that $H > 0$.

5. Krugman (1987) and Feenstra (1987) also focus on the role of demand curve convexity in determining the influence of exchange rates on domestic prices, although they focus on the pass-through of foreign costs into export prices. Krugman points out that in the literature on trade policy under imperfect competition, the effects of tariffs is shown to depend on the convexity of the demand curve.

6. We cannot rule out other cases a priori. For example, markups would be positively related to prices if the demand curve were more convex than the loglinear case. And marginal costs may decline rather than increase with output. We focus on the more normal case described here because it is consistent with the empirical results below.

7. Note that as long as $M_1 \leq 0$, then $\delta \leq 0$.

8. These coefficients may be positive even if M_2 and M_3 are negative since the second terms in the expressions for α_{i3} and α_{i4} are positive.

9. If export prices expressed in yen vary more than domestic prices, this in itself is evidence of pricing to market and variable markups. If demand elasticities are constant, on the other hand, markups are constant and export prices in yen vary just as much as domestic prices of the same product (i.e., as much as marginal costs vary).

10. This component of raw materials, representing forty-eight percent of the total import price index, performed better than the price series for imported raw materials and fuels (representing sixty-one percent of the import index).

11. The trend equation is estimated over the period January 1973 to December 1986. Because Japanese growth appears to have slowed after the first oil shock, we estimated a separate trend for the period prior to July 1974 and a separate intercept term for the period through the end of 1974 when the economy reached its lowest point.

12. The Japanese wage in manufacturing is seasonally adjusted, since the unadjusted wage has a strong seasonal component corresponding to year-end bonuses.

13. The seasonal dummy variables are defined as $Vi = Si - S1$ for $i \neq 1$, and $V1 = S1$, where Si is a normal seasonal variable (with 1 in the ith month and 0 elsewhere). The coefficient of the V1 term provides an estimate of the constant independent of any seasonal effect.

14. As explained above, if export prices expressed <u>in yen</u> vary more than domestic prices, this in itself is evidence of pricing to market and of variable markups.

15. Cyclical movements in U.S. industrial production proved to be statistically insignificant in the equations.

16. Since a reduced form equation is being estimated, it is difficult to interpret the magnitude of the coefficients in terms of productivity growth rates. Even the relative magnitude of the trend terms across equations will depend on structural coefficients rather than just on the productivity growth rates.

17. The price terms are statistically insignificant regardless of the length of the lag or the degree of the polynomial being fitted.