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ABSTRACT

This paper uses bilateral automobile export unit values from the United States, Germany and Japan to measure the importance of markup adjustment that is associated with exchange rate changes across export destination markets. Japanese auto export prices exhibit a high degree of markup adjustment that has the effect of stabilizing prices in units of the buyer's currency. There is weak evidence of this behavior in German auto exports and none for U.S. auto exports. Where it exists, markup adjustment is very persistent, not merely a short run phenomenon. The dynamic pattern of adjustment is consistent with invoicing in the exporter's currency, except for exports to the United States and Canada.

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With the extremely large fluctuations in currency values since the collapse of the Bretton Woods agreement, firms based in different countries have faced unprecedented shocks to their relative costs of production. In spite of this, it is widely observed that import prices (prices of foreign-produced goods in domestic currency) in the United States move very little compared to movements in exchange rates. While this observation is in principle consistent with two quite different models--integrated world markets in which the United States is a large country and segmented international markets with price discrimination--existing research strongly suggests that these observations are due to price discrimination.[1] Krugman (1987) has referred to such destination-specific markup adjustment, driven by exchange rate movements, as "pricing to market" (henceforth PTM).

Studies of PTM are of interest for several reasons. First, they contribute to our understanding of the relationship between exchange rate changes and inflation. Second, they reveal an important feature of the process of competition in traded goods markets. Finally, it is possible that studies of PTM can be used to gauge the impact of other disturbances, such as tariff changes, on import prices as argued by Feenstra (1989).

Existing empirical research has documented several stylized facts about PTM. Knetter (1989,1991), Ohno (1989), and Marston (1989) present evidence that Japanese and German exporters adjust markups of price over cost to stabilize the foreign currency prices of exports in a wide

1. See, for example, Knetter (1989) or Marston (1989).

range of industries. Mann (1986) and Knetter (1989) find no such tendency in U.S. export industries. If anything, markup adjustment appears to amplify fluctuations in the foreign currency price of exports. While this is suggestive that PTM behavior differs across source countries, none of these studies compares behavior in identical, detailed industries across source countries. Apart from papers by Kasa (1992) and Marston (1989) this research also has paid little attention to the dynamic behavior of markup adjustment.

This paper adds to the empirical literature on PTM by examining short-run and long-run markup adjustment across several exporting countries using panel data on disaggregated automobile exports. We focus on the automobile industry both because it is a very important industry and because we were able to obtain unit value data for exports to several destinations by Japan, Germany, and the United States over the entire floating exchange rate period. In addition, automobiles are often cited as an industry in which Japanese and German firms stabilize dollar prices in the U.S. market.[2] The data sets provide new information on the pattern of PTM since the unit value panels vary by source and destination country, allowing us to make a number of interesting comparisons of PTM behavior.

For each category of exports by each source country we study the long-run behavior of export prices to a cross section of destination markets. We control for the impact of cost changes on prices by including a full set of time dummies in estimation and by constraining cost

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2. Knetter (1989) and Marston (1989) present evidence on the extent of PTM by German and Japanese auto exporters, respectively, using different data sets and estimation techniques than those used in this paper.

and exchange rate changes to have symmetric effects on the foreign currency price of exports, as in Knetter (1991). We then estimate the short-run dynamics of export prices using an error-correction model based on the long-run results. While it is not possible to conduct formal hypothesis tests on the estimated long-run PTM behavior, there is strong evidence that long-run PTM is substantial in many cases. Comparison of the short-run and long-run behavior also provides evidence on the nature and importance of adjustment costs and currency contracts in international trade.

Our main findings concern the pattern of markup adjustment across source countries. We find that PTM is pervasive in Japanese auto exports, present for some destinations and categories of German auto exports, and virtually absent from U.S. auto exports. The results are robust to alternative specifications and generally are not sensitive to the sample period chosen. In particular, the evidence for PTM in Japanese auto exports to the United States is almost as strong before the imposition of voluntary export restraints as it is after their imposition. There is some evidence of a change in the PTM behavior of Japanese auto exports to Europe, however.

Our second main finding is that short-run PTM is typically less than long-run PTM, indicating that trade prices are sticky in the exporter's currency, although there are a few interesting exceptions. This finding is consistent with invoicing in the exporter's currency.

The plan of this paper is as follows. Section 1 presents the theoretical model of PTM and describes the data sets used in this study. Section 2 covers the estimation of long-run and short-run PTM behavior. Section 3 concludes the paper.

1. Model Specification and Data

This paper extends the model of export price adjustment in Knetter (1991) by incorporating features of dynamic adjustment that we motivate with quadratic adjustment costs. The basic equation derived in Knetter (1991) describes the optimal price response of an exporting monopolist to deviations in the marginal cost and the exchange rate from an initial equilibrium. If the initial equilibrium is taken to be an arbitrary constant for each variable, a natural regression relationship can be obtained by writing the equation in levels of the variables with an intercept term:

$$(1) \quad \ln p_{it} = \mu_i + (1-\beta_i) \ln MC_t - \beta_i \ln e_{it}$$

where p_{it} is the export price in period t for goods destined to market i, MC_t is marginal cost in period t, e_{it} is the bilateral exchange rate with destination i in period t, and μ_i and β_i are parameters. All variables are expressed in terms of the exporter's currency.

Several observations about this relationship provide insight. First, constant elasticity of demand in the destination market would imply that β equals zero. In this case export prices increase in proportion to changes in marginal cost and are invariant to exchange rate changes. Second, changes in marginal cost and the exchange rate have identical effects on price measured in the importer's currency. This property is independent of the shape of the demand schedule. Finally, the sign of β is dictated by the convexity of the exporter's perceived demand schedule. For demand schedules less convex than a constant elasticity schedule (which includes the case of linear demand) β is greater than zero. When $\beta>0$ the exporter adjusts the markup to offset some of the effect of exchange rate fluctuations on price measured in the importer's currency. In the extreme case that β equals one, the export price moves one for one with the exchange rate to completely offset any effect of the exchange rate on price in the importer's currency. The literature on PTM typically focuses on stabilization of the importer's price, which implicitly assumes that demand schedules are less convex than constant elasticity.

As a measure of export prices we use annual export unit values for selected 7-digit categories within the automobile industry.[3] There are three source countries: the United States, Japan, and Germany. The data are taken from government publications of the respective source countries and are typically collected by customs agents.[4] For each source country, we

3. The unit value series are the only export price measures that can be used in the multi-market framework since no other export price measures are available by destination. Furthermore, most of the problems associated with using unit values as a measure of price change are mitigated in cross-section applications. See Froot and Klemperer (1989) or Knetter (1989, 1991) for these arguments.

4. The U.S. data are from *U.S. Exports: Schedule B Commodity by Country*, Department of Commerce. The German data are from *Aussenhandel Reihe 2 Spezialhandel nach Waren und Landern*, Statistisches Bundesamt. The Japanese data are from *Japan Exports and Imports: Commodity by Country*, Japan Tariff Association.

have destination-specific f.o.b. values and quantities of exports to several major destinations. The destinations were chosen according to two criteria: first, that there be a significant volume of exports to each destination over the entire sample: and second, that there be as many common destinations across the three source countries as possible.

The exchange rates are annual average spot rates divided by the wholesale price index in each destination market.[5] The rationale for dividing by foreign price levels is to make the foreign demand curve a function of a real price. (The price faced by the importer is the export price, **p**, times the exchange rate, **e**.) During the sample periods we study there was tremendous variation in exchange rates, which ought to enable us to identify the extent of PTM very precisely.

Marginal costs are not observed directly and no attempt was made to proxy for them with observable series. Rather, the estimation strategy takes advantage of the cross-sectional nature of the available data on export prices. The marginal cost in each time period for each source country is simply estimated (up to a constant scale factor) by the common component in export prices across different destination markets. In other words, a dummy variable is created for each time period and a separate coefficient is estimated for each dummy variable. Coefficients on the time dummies are constrained to be identical across the different destination markets for a given source country. Since there are multiple destinations, the time effects do not exhaust

5. These data were obtained from *International Financial Statistics*, International Monetary Fund.

all degrees of freedom. The advantage of this approach is that it makes the minimum necessary assumptions. The only necessary assumption is that for a given exporter the marginal cost of exporting to different markets changes by the same proportion from period to period.

There are two drawbacks to this estimation strategy. First, it uses up more degrees of freedom than methods that use observable series to measure marginal cost. Second, any change in markup that is common across destination markets will be captured by the time effects, so that the time effects may measure more than just marginal cost movements.

2. Estimation and Results

We estimate pricing equations for three source countries: Japan, Germany, and the United States. There are several engine size categories in each source country. For each category in each source country, estimation proceeds by stacking equation (1) over all export destinations and replacing **MC**, which is not observed, with a set of time effects as follows:

$$
\begin{aligned}
(2)\quad \ln p_{1t} &= (1-\beta_1)\,\underset{\sim}{\theta}'\,\mathbf{D}_t - \beta_1 \ln e_{1t} + u_{1t} \qquad t = 1, \ldots, T \\
\ln p_{2t} &= \mu_2 + (1-\beta_2)\,\underset{\sim}{\theta}'\,\mathbf{D}_t - \beta_2 \ln e_{2t} + u_{2t} \\
&\;\;\vdots \\
\ln p_{Nt} &= \mu_N + (1-\beta_N)\,\underset{\sim}{\theta}'\,\mathbf{D}_t - \beta_N \ln e_{Nt} + u_{Nt}
\end{aligned}
$$

u_{it} is the residual error term in equation i during period t. $\tilde{\theta}$ is a T-vector of estimated coefficients that controls for effects that vary over time but are constant across destinations. In terms of the model of section 1, $\tilde{\theta}$ represents movements in marginal cost, but in a more general oligopoly model it may include changes in industry conduct. $\mathbf{D}_t$ is a T-vector equal to 1 in the t^{th} position and 0 elsewhere. $\tilde{\theta}$ and $\mathbf{D}_t$ are defined as follows:

$$\tilde{\theta}' = [\theta_1 \quad \theta_2 \quad \dots \quad \theta_T] \qquad \mathbf{D}'_1 = [1 \quad 0 \quad \dots \quad 0]$$

$$\mathbf{D}'_2 = [0 \quad 1 \quad \dots \quad 0]$$

$$\vdots$$

$$\mathbf{D}'_T = [0 \quad 0 \quad \dots \quad 1]$$

An intercept term, μ_i, was estimated for N-1 destinations to control for factors that are constant over time but differ by country.[6] This term should identify differences in the average quality of goods shipped to different markets as well as differences in the average markups to different markets that do not vary with exchange rates. The average level of the θ's thus incorporates the average quality and markup characteristics of the first destination market.

Plots of the export unit values and price-level-adjusted exchange rates suggest that they are nonstationary, and our maintained hypothesis is that they are integrated processes of order

6. Because of the complete set of time dummies, the intercept term had to be dropped from one equation.

one, I(1).[7] When dealing with nonstationary variables it is important to consider the time series properties of the residuals in the estimating equation. There are essentially two alternate hypotheses: first, that the residuals are transitory and arise from adjustment lags, measurement error, or temporary shifts in the composition of exports; second, that the residuals are permanent and arise from lasting changes in consumer tastes, market structure, or the composition of exports. In practice we found it difficult to discriminate between these alternate hypotheses. The estimated first-order autoregressive coefficients of the residuals from equations (2) were typically between 0.7 and 0.8. However, given our short sample, we could never reject the hypothesis that the residuals had a unit root.

Our response to this dilemma was to estimate equations (2) both in levels and in first differences. The levels regression may be described as estimating a long-run cointegrating relationship between export unit values, the time effects, and the exchange rates. The differenced regression captures only short-run PTM behavior. Estimation was conducted using a Gauss-Newton procedure to minimize the total sum of squared residuals across all time periods and destination markets for a given exporting country and product category. This is equivalent to maximum likelihood under the assumptions that the residuals are normally distributed,

7. Standard Dickey-Fuller and augmented Dickey-Fuller tests were never able to reject a unit root in any of our series. A second unit root was rejected at the 5 percent level in about one-third of the export price and exchange rate series. Given the low power of these tests, we take the evidence as favorable to the hypothesis that all series are integrated of order one.

uncorrelated across equations and over time, and have equal variances across equations.[8] While serial correlation of the residuals is generally not significant for the regression in first differences, it is often significant for the levels regression. However, it is well-known that the estimated coefficients of cointegrating vectors (in this case, β) are strongly consistent even in the presence of serially-correlated errors, although the distributions of the estimators and their t-statistics are nonstandard.

Given that there was substantial evidence of dynamic behavior in the levels regression, we use the results of the levels regression to estimate an error-correction model of export prices. The error-correction model may provide information on the importance and nature of adjustment costs as well as the appropriateness of the presumed cointegrating relationship.

The general error-correction model considered in this paper is given by equation (3).[9]

$$(3) \quad \Delta \ln p_{it} = \alpha_i^0 + \alpha_i^1 \Delta \ln p_{it-1} - \alpha_i^2 \Delta \ln e_{it} + \left[1 - \alpha_i^2 - \alpha_i^3\right]\left[\hat{\theta}_t - \hat{\theta}_{t-1}\right] - \alpha_i^4 \hat{u}_{it-1} + \varepsilon_{it}$$

8. The presence of a complete set of time dummies precludes the estimation of an unrestricted covariance matrix of the residuals.

9. This equation can be derived under the assumption of quadratic adjustment costs to changing the volume of exports to each destination. A derivation of this result, based on Gagnon (1989) and Nickell (1985), is available from the authors upon request.

Equation (3) is regressed using $\hat{\theta}$ and $\hat{u}$ from the results of equations (2), where $\hat{\theta}$ is simply the estimated coefficient vector, $\tilde{\theta}$, converted into a time series.[10] Since $\hat{\theta}$ and $\hat{u}$ are fixed series in the second regression, a complete set of coefficients may be estimated for every destination market. However, to conserve degrees of freedom, we looked for parameters that could be constrained to zero for every source and destination. In the vast majority of cases, α^0 and α^1 were small and not significantly different from zero, so the results focus on the case in which α^0 and α^1 are constrained at zero. The second-stage residuals, ε, almost never exhibited any significant serial correlation.

The estimation results for automobile exports are in Tables 1-5. The estimation period is 1973-87 for Japanese and U.S. exports, and 1975-87 for German exports. Table 1 shows the estimates of β for equations (2) for Japanese exports of autos in three engine size categories--1 liter displacement or less, 1-2 liters, and 2 liters and over--to various destination markets. All but one of the estimates are positive, implying that markup adjustment associated with exchange rate changes has a stabilizing effect on the foreign currency price of exports.[11] The point estimate of .80 for Japanese exports of large cars to Canada implies that a 10 percent depreciation of the Canadian dollar against the yen (net of any change in the Canadian price

10. It is usually more efficient to estimate the error-correction model simultaneously with the cointegrating vector. (See Johansen (1988)). However, the presence of time effects in every period precludes estimation of equations (2) and (3) jointly.

11. The only exception is exports of small autos to the United States, which turns out to have a very noisy unit value series due to extremely low volumes in some years (e.g., four vehicles in 1975).

level) would elicit an 8 percent reduction in the markup of yen export prices over costs to Canadian importers. Assuming constant costs (and no common change in markups), the Canadian dollar price would rise by only 2 percent and the yen export prices faced by other buyers would remain unchanged provided their exchange rates had not changed.

The Durbin-Watson statistics associated with the first-stage regression provide some evidence that dynamic adjustment may be important, but they are not so low as to challenge our assumption that equations (2) capture a cointegrating relationship. Perhaps the most remarkable feature of Table 1 is the similarity of the estimated values of β across destinations and engine size categories. Thirteen of the fifteen coefficients lie between .79 and 1.03, indicating a very strong tendency to stabilize foreign currency prices.[12] The similarity of the coefficients casts doubt on the notion that Japanese exporters are somehow targeting the U.S. market more than other destinations, a claim often made by protectionist forces in the U.S. auto industry. The magnitude of the coefficients and the implied fluctuations in yen export prices suggest either very large profit margins for average levels of the exchange rate or that the exporters actually sell at prices below cost when the yen is strong. There is certainly no indication that yen export prices are inflexible.

Before analyzing the second-stage results for Japanese exports we turn to the first-stage estimates for German exports in Table 2. The estimated PTM in the long run is most pervasive in

12. Because the first-stage regression relates two nonstationary variables, the estimates of β are not normally distributed and we cannot perform standard t-tests.

the two smaller engine size categories. For exports of small cars to the United States and France, the estimated coefficients are .59 and .52, respectively. The implication is that a 20 percent depreciation of the dollar, all else constant, would elicit a 12 percent reduction in the Deutschemark (DM) price charged to U.S. buyers. The dollar price would rise by only 8 percent. The extent of pricing to market is less pronounced for other destinations. In the second category, estimated PTM is about 40 percent for France, Sweden, and the United Kingdom. It is 90 percent for Japan, and close to 0 percent for the United States and Canada.

For the largest auto category, the point estimates of the PTM coefficient imply that markup adjustment associated with exchange rate changes amplifies movements in the foreign currency price. For the United States, for example, the estimate of β implies that all else equal, a 20 percent depreciation of the dollar leads to a 3 percent increase in the DM price charged to U.S. buyers. Thus, the dollar price rises by 23 percent--even more than the depreciation itself would imply. For France and Sweden, the amplification effect is even larger.[13]

For U.S. auto exports, the long-run price adjustment pattern is much different in character. (See Table 3.) The correlation between destination-specific price movements and exchange rates is virtually zero for all destination markets. Export price adjustment appears as

13. This finding of "perverse" PTM is not necessarily implausible. It may be due to heterogeneity either within the category of auto exports or within the market of consumers. For example, when an exchange rate movement causes an exporter to raise prices, he may lose sales to his most price-elastic customers first, or, he may lose sales of cars that face the highest price elasticity of demand. In the case of "normal" PTM the price elasticity of demand increases with the price charged.

likely to increase the variability of price in the buyer's currency as to reduce it. Over half of the estimates lie between -.05 and .05. This stands in stark contrast to the German and Japanese auto exporters' behavior.[14]

We were concerned about the possibility of structural change in these relationships, particularly due to the imposition of voluntary export restraints (VERs) on Japanese auto exports to Canada and the United States in 1981.[15] Due to the nonstationarity of the data, we could not run a standard Chow test. However, we did estimate equations (2) for Japanese auto exports over two subsamples, 1973-80 and 1981-87. The results are presented in Table 4. Binding quantity restraints would be associated with a stable price in the destination market, and hence, a high degree of observed PTM. For the United States and Canada, which imposed VERs on Japanese autos at this time, there appears to have been a substantial degree of PTM before the VERs, and the

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14. Low estimates of PTM could be due to transfer pricing. If automakers ship their cars to a foreign subsidiary at a constant price and the foreign subsidiary stabilizes the price paid by independent dealers in foreign currency, PTM behavior would be occurring, but would not be identified by the export unit value data. (Later in the paper we show that retail price behavior is consistent with our findings on export unit values.)

We spoke to executives at General Motors, Daimler-Benz, and Volkswagen. General Motors stated that its domestic exports are shipped directly to independent dealers in foreign countries, except for shipments to Canada, so that transfer pricing is not a problem. Daimler-Benz and Volkswagen both claimed that their American subsidiaries were expected to be profitable and bargained over price with the parent company in light of market conditions. BMW refused to provide information on its pricing policies.

15. The Japanese auto industry has agreed to an informal restriction that limits the Japanese share of the U.K. auto market to 11 percent. This restriction was in place throughout the sample, although we do not know whether it was binding. There has been a binding restriction on Japanese auto exports to Australia throughout the sample. An informal rate of growth restriction was also in place in Germany (for more information, see Cohen (1983)). We are not aware of any other restrictions on Japanese auto exports to the remaining destinations in our sample, and there were no restrictions on U.S. and German auto exports to any of our destinations except Australia.

estimated increase in PTM after 1980 is modest. The large increases in estimated PTM to the United Kingdom and Germany are puzzling, however, because market share restrictions for the United Kingdom were fixed throughout the sample and the restrictions on exports to Germany were weaker than those for Canada and the United States. There was no substantial evidence of structural change in markup adjustment by U.S. and German exporters over this sample. Further evidence of the constancy of the relationship in equation (2) is obtained from the error-correction regressions which are discussed later.

Figures 1 and 2 provide convincing evidence of the differences in PTM for Japanese exports of autos and U.S. exports of autos. The evidence also shows that the measured export unit values behave quite sensibly given the inflation and exchange rate movements of this period. Figure 1 plots the log of the unit values of Japanese exports of autos between 1 and 2 liters to the United States (us price) and Germany (wg price), the estimated time effects (theta) from the regression of equations (2), and the U.S.-German real exchange rate (real $/DM). All series are normalized by subtracting their sample means. The time effects behave much as expected, with their change over time approximating an average of the price changes. The evidence of PTM is quite clear during the 1980s in this figure. The unit value of shipments to the United States rises much more rapidly than it does to Germany during dollar appreciation. When the DM strengthens against the dollar from 1985 onward, German unit values rise abruptly and U.S. unit values fall. The correlation between the U.S.-German export price differential and the U.S.-

German real exchange rate is obviously very strong, which is precisely what estimated values of β near unity would imply.

Figure 2 is the corresponding evidence for unit values of U.S. shipments of autos under 6 cylinders to Canada and the United Kingdom (cn price and uk price). The unit value series grow together quite closely, leaving little scope for PTM. The time effects (theta) follow the price movements closely. The best chances of identifying PTM are during the pound appreciation from 1976 to 1980 and during the pound depreciation thereafter. In spite of real exchange rate movements comparable in magnitude to the movements in the U.S.-German real exchange rate in Figure 1, Figure 2 shows that the U.K.-Canadian export price differential is not at all correlated with the U.K.-Canadian real exchange rate.

We next consider the error-correction results for each of the exporters. Three coefficients are reported for each category of autos. The first gives the short-run response of price to exchange rate changes. Comparing it with the long-run response reveals whether price adjustment is greater in the short run or the long run. The second coefficient estimates the difference in the short run between the effect of changes in the exchange rate and the effect of changes in the estimated time effects. Recall that the theory in the first section of the paper shows that these effects should be symmetric in the long run, provided that the time effects are a good measure of marginal cost. The final coefficient measures the response of the export unit value to a deviation from its long-run equilibrium value in the previous period. The estimate gives the fraction of last period's error that is corrected this period.

According to Table 1 the high degree of long-run PTM estimated for Japanese exports appears to occur largely or entirely in the first year of any exchange rate movement, especially for exports to the United States and Canada. For some European countries, however, short-run PTM (α^2) is estimated to be about half of long-run PTM (β). The estimated short-run response to changes in marginal cost ($1-\alpha^2-\alpha^3$) does not appear to deviate significantly from the symmetric response ($1-\alpha^2$) that our long-run theory predicts. The primary exceptions are exports of small cars to three European countries that also exhibited lower short-run than long-run PTM. Finally, most of the error-correction coefficients (α^4) are significant, indicating that roughly half of any disequilibrium is corrected after just one year. The estimated error-correction coefficients thus lend some support to the hypothesis of a stable long-run relationship in equations (2) and argue against any significant break in PTM behavior, although an exact statistical test is not possible.

Table 2 gives the parameter estimates for German automobile exports. For exports to Japan, the United Kingdom, France, and Sweden it appears that there is much less evidence of PTM in the short run than in the long run. For Canada and the United States, the opposite seems to hold--export prices seem to overreact in the short run. This would be consistent with invoicing in the buyer's currency for sales to the United States and Canada and invoicing in DM otherwise.[16] Symmetry of the short-run responses to exchange rates and marginal costs appears to be rejected

16. Invoicing in the buyer's currency would force the DM price to move one-for-one with an exchange rate change in the short run.

in most cases. Departures from symmetric responses are of an unusual character. Short-run PTM appears to be more vigorous with respect to changes in marginal cost than with respect to exchange rate changes. (That is, the sign of α^3 is typically the same as the sign of α^2.) The error-correction coefficients all have the expected sign, the magnitudes look plausible, and the standard errors are small.

For the United States (Table 3), the evidence of short-run PTM is minimal. This result is not surprising given the very low estimates of long-run PTM. Adjustment to the steady state appears rapid, with error-correction coefficients clustered around 1.

As a further check on the robustness of our results, we estimated equations (2) in first differences. PTM estimates from these first-differenced regressions are presented in Table 5.[17] Estimates of β for Japanese exports in Table 5 are nearly as large and consistent across destination markets as in Table 1. Only two estimates of β are lower than 0.4, and these are not significantly different from 1.0 The estimates of β for German exports in Table 5 mimic those obtained from the levels regression, except for exports to Japan which have β near zero for all categories. The pattern of moderate PTM for small and medium cars and no PTM for large cars is quite strong. U.S. β's in Table 5 are all insignificantly different from zero except for exports

17. Intercept terms were rarely significant in these regressions, so they were omitted from all equations.

to Canada, which now have a moderate estimate of PTM.[18] For all three auto exporters, estimates of β which are negative in the levels regression are insignificantly different from zero in the first difference regression. Overall, we were struck by the close correspondence between our estimates of β from equations (2) in levels and in first differences. We take this result as powerful evidence that the model developed in this paper can explain the bulk of the variability of export unit values, and that the error variance is small relative to the variances of export unit values and exchange rates.

One of the important findings of this paper is that Japanese exporters use markup adjustment more than German exporters in order to smooth foreign currency prices of exports. Because our evidence is based on the behavior of export unit values, we are sensitive to two possible criticisms. First, markup adjustment on German autos may occur at the level of U.S. subsidiaries, so that PTM is observed at the retail, but not export, price level. Second, there is some chance that even our relatively disaggregated data provides an inadequate measure of price changes. Unit value changes reflect both quality and price changes. If destination-specific quality change is correlated with destination-specific exchange rate changes, we may get false indications of PTM.

To address these concerns we examined the behavior of dollar retail prices of specific models of Japanese and German exports to the United States over periods when the yen and DM

18. U.S. exports of large cars to Italy and Australia were dropped from the first difference regression because several outliers in the data had a large effect on the estimated β's and their standard deviations. These outliers occurred in years in which there were few U.S. cars exported to Australia and Italy.

depreciated dramatically against the dollar.[19] If our findings apply at the retail level, we would expect to observe real dollar prices of German autos falling more than real dollar prices of Japanese autos over the respective periods. Table 6 indicates that our findings on markup adjustment apply at the retail level as well. German real import prices fell much more than Japanese real import prices. The table also substantiates another of our qualitative findings--that PTM is more pronounced in German exports of small autos than large autos.

3. Conclusion

This paper has attempted to provide different perspectives on markup adjustment for automobile exports in response to exchange rate fluctuations. We have attempted to distinguish long-run behavior from short-run disequilibrium dynamics and we have made comparisons across source and destination countries. We have provided evidence that price differentials across destination markets for the same category of automobile are often related to exchange rate movements and that these differentials can persist for many years. These long-run differentials cannot be explained by invoicing practices. The short-run dynamics appear reasonable. The source of short-run disequilibrium seems to involve price rigidity in the exporter's currency and not in the importer's currency. The primary exceptions to this pattern are exports to Canada and

19. The criteria for selecting models was to minimize the amount of change in product characteristics. We also emphasize behavior of large German cars, since that is where the asymmetry in behavior is greatest. The sample periods are 1978-83 for Japanese imports and 1980-85 for German imports. These periods had changes of roughly equal magnitudes in real exchange rates against the dollar for both Germany and Japan.

the United States, which may be invoiced in dollars. This result is consistent with the findings of Magee (1974).

This paper documents stark differences in the extent of PTM across source countries even within similar categories of automobile exports sold in the same destination markets. The size of the destination market does not seem to be an important determinant of PTM behavior. One explanation of the differences in source country behavior is that they reflect differences in the intensity of competition across product categories and national markets. Japanese automobile exports tend to be in the low-priced end of the auto market for most of our sample, unlike U.S. and many German exports. Bresnahan (1981) finds that competition is more vigorous for inexpensive autos. Thus, the scope for variation in local currency prices of Japanese exports may be limited by the difficulty of rapidly adjusting export quantities. Meanwhile, if there are few close substitutes for the specialty items exported by U.S. and certain German producers, we might expect more fluctuations in local-currency prices and less measured PTM for these categories, since quantities would be less sensitive to price changes.

An alternative explanation for the high estimates of Japanese PTM is that Japanese automobile exporters have faced formal or informal quantitative restrictions on their exports to several of the destination markets we study. We presented evidence that estimated PTM for Japanese exports to the United States and Canada increased modestly after the imposition of VERs in 1981, but there was still a high degree of estimated PTM before VERs were in place.

Yet another potential explanation for differences in PTM behavior across source countries is that PTM is an essential strategy for firms that do not have production facilities in their destination markets. U.S. automakers tend to serve foreign markets primarily out of foreign production. Their domestic exports are largely specialty items that are not intended to capture significant market shares abroad. The Japanese had very limited foreign production over our sample. In order to maintain market share of their most popular models and keep their distribution networks intact, the Japanese had to stabilize foreign currency prices. This hypothesis cannot explain German exporters' behavior, however.

A final possibility which we hope to explore in further industry-level research is that Japanese and German firms find it more costly than U.S. firms to adjust the level of labor input, and hence output, in response to shocks. Institutional features of labor markets in these countries lend some credibility to this hypothesis. Furthermore, recent popular press accounts tend to confirm the reluctance of Japanese automakers to adjust labor input even in their U.S. production facilities.[20] This difference in labor adjustment costs would lead naturally to stabilization of foreign currency prices of auto exports by the Japanese, whereas U.S. firms may have more volatile prices and quantities in foreign markets. Again, this hypothesis does not explain the pricing strategy behind exports of large German cars.

20. *The Wall Street Journal* (March 5, 1991, p. A4) reported that Japanese auto makers were allowing inventories to swell at their U.S. plants, whereas U.S. firms were choosing to layoff workers in response to an industry sales slump.

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Table 1. Japanese Export Unit Values

Destination	β	D-W	α^2	α^3	α^4
			0-1 liter		
United States	-1.66	1.21	-1.67*	-0.17	0.89*
	(2.04)		(0.11)	(0.10)	(0.38)
United Kingdom	0.95	1.45	0.43*	0.77*	0.47*
	(0.12)		(0.08)	(0.08)	(0.10)
Germany	1.03	0.57	0.45*	0.63*	0.24
	(0.13)		(0.14)	(0.10)	(0.16)
Switzerland	0.98	0.76	0.44*	0.64*	0.30
	(0.12)		(0.16)	(0.13)	(0.19)
Australia	0.35	1.22	0.27	0.69	0.88*
	(0.46)		(0.53)	(0.44)	(0.39)
			1-2 liter		
Canada	0.79	0.95	0.76*	0.09	0.33
	(0.12)		(0.08)	(0.11)	(0.17)
United States	0.79	1.20	0.69*	0.20	0.28
	(0.12)		(0.10)	(0.14)	(0.19)
United Kingdom	0.82	0.82	0.46*	0.41	0.41*
	(0.11)		(0.17)	(0.22)	(0.17)
Germany	0.83	0.99	0.63*	0.22	0.60*
	(0.09)		(0.13)	(0.17)	(0.18)
Sweden	0.82	1.33	1.06*	-0.36*	0.62*
	(0.09)		(0.12)	(0.17)	(0.24)
			2+ liter		
Canada	0.80	0.68	0.94*	-0.12	0.35*
	(0.23)		(0.06)	(0.09)	(0.17)
United States	0.81	1.25	0.88*	-0.05	0.65*
	(0.23)		(0.06)	(0.07)	(0.23)
United Kingdom	0.91	1.32	0.40	0.53	0.47*
	(0.12)		(0.29)	(0.40)	(0.13)
Germany	1.03	1.16	0.85*	0.08	0.64*
	(0.11)		(0.19)	(0.23)	(0.30)
Norway	0.98	0.88	1.00*	-0.25	0.29
	(0.16)		(0.17)	(0.22)	(0.20)

Table 2. German Export Unit Values

Destination	β	D-W	α^2	α^3	α^4
			1.5-2 liter		
Canada	0.24 (0.26)	0.24	0.44 (0.23)	-0.01 (0.91)	0.55 (0.30)
United States	0.59 (0.18)	0.31	0.72* (.11)	0.27 (.48)	0.24 (.16)
Japan	-0.64 (0.53)	2.17	-0.66* (0.07)	-0.40* (0.18)	1.08* (0.15)
United Kingdom	0.05 (0.26)	0.83	-0.24 (0.37)	-0.02 (0.60)	0.71* (0.22)
France	0.52 (0.11)	0.85	0.06 (0.22)	0.79* (0.23)	0.27 (0.19)
Sweden	0.31 (0.16)	0.41	0.11 (0.12)	0.65* (0.21)	0.38* (0.10)
			2-3 liter		
Canada	-0.08 (0.26)	1.13	-0.01 (0.14)	-0.63* (0.19)	0.47 (0.30)
United States	0.12 (0.19)	0.98	0.21* (0.05)	0.17 (0.13)	0.76* (0.09)
Japan	0.90 (0.21)	0.96	0.01 (0.18)	0.85* (0.31)	0.23 (0.15)
United Kingdom	0.37 (0.22)	0.60	0.06 (0.15)	0.55* (0.14)	0.74* (0.14)
France	0.45 (0.11)	1.25	0.13 (0.24)	0.75* (0.23)	0.62 (0.32)
Sweden	0.44 (0.13)	0.83	0.08 (0.21)	0.35 (0.39)	0.23 (0.31)
			3+ liter		
Canada	-0.20 (0.14)	1.14	-0.31 (0.11)	0.56* (0.18)	0.72* (0.31)
United States	-0.15 (0.19)	0.99	-0.13 (0.23)	0.63* (0.15)	0.64 (0.44)
Japan	-0.09 (0.35)	0.78	-0.06 (0.23)	0.54* (0.18)	0.46* (0.23)
United Kingdom	0.00 (0.14)	1.32	-0.25* (0.12)	0.49* (0.18)	0.46* (0.17)
France	-0.79 (0.21)	1.21	-0.84* (0.28)	-0.50* (0.16)	0.71* (0.19)
Sweden	-0.68 (0.21)	1.13	-0.50 (0.29)	-0.94* (0.25)	0.66* (0.20)

Table 3. U.S. Export Unit Values

Destination	β	D-W	α^2	α^3	α^4
			1-6 cylinders		
Canada	-0.04	0.72	0.25*	0.37	-0.05
	(0.16)		(0.09)	(0.12)	(0.13)
Japan	0.05	1.39	0.05*	0.34*	0.98*
	(0.16)		(0.12)	(0.15)	(0.23)
Germany	-0.03	1.70	-0.19	0.15	0.99*
	(0.10)		(0.10)	(0.08)	(0.24)
United Kingdom	0.16	2.60	0.18	0.03	1.60*
	(0.14)		(0.12)	(0.31)	(0.22)
Sweden	0.10	2.64	-0.03	-0.49	1.31*
	(0.16)		(0.16)	(0.45)	(0.26)
			7+ cylinders		
Canada	0.11	1.27	0.24*	0.48*	0.42*
	(0.17)		(0.10)	(0.18)	(0.15)
Japan	-0.02	1.62	-0.12	0.44*	1.05*
	(0.29)		(0.17)	(0.20)	(0.25)
Germany	0.00	2.21	0.07	0.44	1.26*
	(0.19)		(0.23)	(0.28)	(0.27)
United Kingdom	-0.21	2.29	-0.23	-0.27	1.25*
	(0.35)		(0.32)	(0.45)	(0.24)
Sweden	0.00	1.53	0.08	0.60	0.96*
	(0.17)		(0.21)	(0.43)	(0.34)
Italy	0.02	1.94	-0.30	-1.71*	1.04*
	(0.37)		(0.69)	(0.55)	(0.16)
Australia	0.24	2.19	-0.06	0.43	1.11*
	(0.14)		(0.99)	(0.84)	(0.29)

Table 4. Japanese Export Unit Values
Split Sample Estimates of β

Destination	1-2 liter		2+ liter	
	73-80	81-87	73-80	81-87
Canada	0.58	0.86	0.66	0.69
United States	0.53	0.85	0.48	0.67
United Kingdom	0.19	0.86	-0.28	0.76
Germany	0.02	0.89	0.18	0.75
Norway			0.67	0.60
Sweden	0.44	0.85		

Table 5. Estimates of β in First Differences

	Japanese Export Unit Values			German Export Unit Values			U.S. Export Unit Values	
Destination	0-1 l[3]	1-2 l[3]	2+ l[3]	1.5-2 l[3]	2-3 l[3]	3+ l[3]	0-6 cyl	6+ cyl
Canada		0.62* (0.07)	0.73* (0.16)	0.16 (0.32)	-0.30 (0.54)	-0.10 (0.08)	0.43* (0.19)	0.40* (0.15)
United States	-1.62 (1.86)	0.63* (0.08)	0.71* (0.18)	0.67* (0.15)	0.15 (0.20)	0.10 (0.12)		
Japan				-0.28 (0.34)	0.18 (0.27)	0.19 (0.23)	0.29 (0.24)	-0.29 (0.45)
United Kingdom	0.75* (0.27)	0.42* (0.15)	0.47 (0.36)	0.58* (0.28)	0.56* (0.18)	-0.32 (0.19)	0.28 (0.25)	-1.18 (0.67)
Germany	0.90* (0.17)	0.48* (0.15)	0.79* (0.19)				0.13 (0.26)	-0.43 (0.31)
France				0.32 (0.20)	0.53* (0.19)	-1.28 (0.81)		
Sweden		0.49* (0.12)		0.31* (0.09)	0.05 (0.32)	-0.90 (0.73)	-0.06 (0.46)	0.24 (0.35)
Norway			0.58 (0.31)					
Switzerland	0.88* (0.16)							
Australia	-0.59 (0.88)							

Table 6. Retail Price Changes During Dollar Appreciations: Japanese and German Exports to the U.S. Market

Model	Real Dollar Appreciation	Real Retail Price Change in U.S. Market
Honda Civic 2-Dr. Sedan	39%	-7%
Datsun 200SX 2-Dr.	39	-10
Toyota Cressida 4-Dr.	39	6
BMW 320i 2-Dr. Sedan	42	-8
BMW 733i 4-Dr. Sedan	42	-17
Mercedes 300TD Sta. Wgn.	42	-39

Note: The real dollar appreciation measures the movement of the U.S. producer price index relative to the Japanese and German producer price indices converted into dollars by the nominal exchange rate. The real retail price change measures the movement of the dollar retail price of specific auto models relative to the retail unit value of all domestically-produced cars.

Sources: *Statistical Abstract of the United States* and *Ward's Automotive Handbook*.

Figure 1. Unit value of exports of Japanese 1-2 L. autos

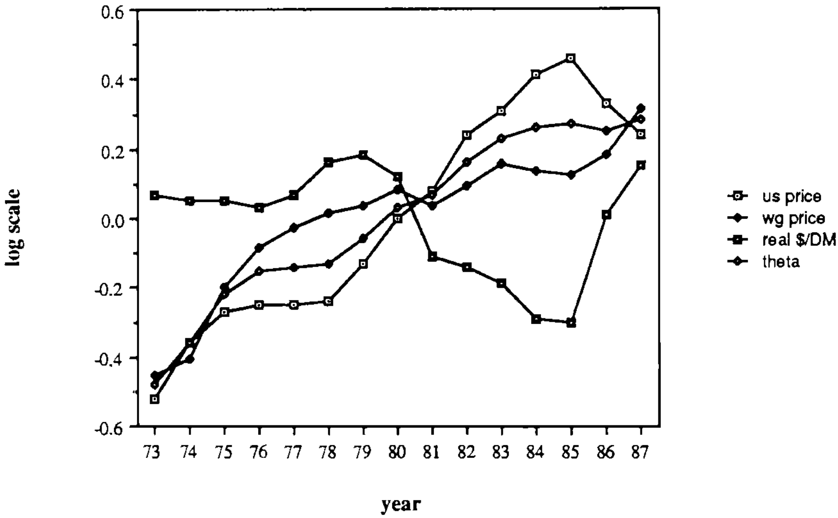

Figure 2. Unit values of exports of U.S. autos under 6 cyl