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INTERNATIONAL COMPARISONS OF PRICING-TO-MARKET BEHAVIOR

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ABSTRACT

This paper measures the degree of price discrimination across export destinations that is associated with exchange rate changes using U.S., U.K., German and Japanese industry-level data. Given the industries sampled more price discrimination across destinations is observed in the U.K., German and Japanese data. For industries that match across source countries, however, behavior is very similar across source countries. Furthermore, destination-specific price adjustment on exports to the U.S. from Germany and Japan is similar to price adjustment observed on shipments to other destinations. Most variation in the data appears to be related to industry.

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I. Introduction

The optimal response of a firm's export price to changes in currency values depends on a variety of factors. These factors operate through two channels: (1) through the impact exchange rates have on marginal cost and (2) through the impact exchange rates have on markups of price over marginal cost. Destination-specific adjustment of markups in response to exchange rate changes have been referred to in the literature as "pricing-to-market" (henceforth PTM).[1] The nature of PTM emphasized in theoretical models is the following: sellers reduce markups to buyers whose currencies have depreciated against the seller, thereby stabilizing prices in the buyer's currency relative to a constant markup policy. I will refer to this specific variety of PTM as local currency price stability (LCPS).

Theoretically, PTM can arise for many reasons. For a monopolist that price discriminates across export destinations, PTM is a function of the convexity of demand schedules.[2] Demand schedules less convex than a constant elasticity schedule imply LCPS, whereas those more convex than a constant elasticity schedule will lead to the opposite relationship, i.e., markups increase as the buyer's currency depreciates. In general, it appears that the existence of competitors in any market will impose more discipline on firms in their pricing behavior. In other words, for a given form of the market demand schedule, adding competitors will increase the likelihood of observing LCPS. In dynamic models PTM can occur as a result of adjustment costs or intertemporal demand linkages.[3]

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[1] See Paul R. Krugman (1987).

[2] See Robert C. Feenstra (1989), Knetter (1991) or Richard C. Marston (1990).

[3] Kenneth A. Kasa (1990) formulates and estimates a dynamic model in which adjustment costs can generate short run pricing to market behavior.

PTM has been documented by casual and rigorous empiricism in a number of recent studies employing a variety of data sets.[4] Based on the movement in 4-digit industry U.S. import prices relative to a trade-weighted average of foreign production costs, Mann (1986) concluded that foreign profit margins are adjusted to mitigate the impact of exchange rate changes on dollar prices of U.S. imports. Somewhat surprisingly, U.S. exporters showed no tendency to adjust markups in response to exchange rate changes.[5] Knetter's (1989) study of export pricing in U.S. and German 7-digit industries documents strong evidence of LCPS on German exports to a variety of destinations. Once again, there is no evidence of LCPS for U.S. exports. Alberto Giovannini (1988) documents large deviations from the law of one price between export and domestic prices of narrowly defined Japanese manufactured goods–ball bearings, screws, and nuts and bolts. Marston (1990) finds impressive evidence of PTM in a wide range of 4-digit Japanese industries that export primarily to the U.S. Gagnon and Knetter (1991) estimate Japanese auto exporters offset approximately 70 percent of the effect of exchange rate changes on buyer's prices through markup adjustment. The comparable number for German auto exports varies by engine size: for small autos, about 40 percent of the effect of exchange rate changes are offset by destination-specific markup changes, whereas for large autos adjustment is minimal. They find no evidence of PTM for U.S. auto exports.

Taken as a whole, this growing literature supports several beliefs about PTM behavior. First, there is substantial industry-level evidence that Japanese and German exporters use destination-specific markup adjustment to stabilize local currency prices of exports, although for Japan most of the evidence is based on pricing to the U.S. Second, PTM appears to be non-

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[4] See the examples of grey markets mentioned in Krugman (1987) or the empirical studies of Catherine L. Mann (1986), Joseph E. Gagnon and Knetter (1991), Kasa (1990), Knetter (1989,1991), and Marston (1990).

[5] If anything, the data suggested markup adjustment on U.S. exports amplified the effect of exchange rate changes on prices measured in the buyer's currency.

existent for a number of U.S. export industries at various levels of aggregation. Third, the degree of stability of local currency prices appears to vary quite widely by industry even within a given exporting country.

This literature lacks an empirical framework capable of nesting competing explanations of PTM behavior. Short of a framework capable of nesting alternative models of PTM, a comprehensive study of PTM that examines similar industries across a range of export source and destination countries is the next best alternative. This paper attempts to bridge the gap in the existing literature by analyzing export price adjustment for a variety of U.S., U.K., German, and Japanese 7-digit industries. There is some overlap of the 7-digit industries across source countries, although exact matches are rare due to the idiosyncracies of industry classifications used by authorities in collecting the export data in the four source countries. The evaluation of industry, source, and destination market patterns of PTM would better establish the facts against which alternative theories can be judged.

The paper establishes three main empirical results. First is that German, Japanese and U.K. export industries exhibit more LCPS than the U.S. export industries included in this study. However, for those industries in which exact matches are possible across source countries, behavior is remarkably similar. Consequently, industry effects appear to be more important than source country effects in explaining the dispersion of PTM behavior across trading relationships.

A second important result is that destination-specific markup adjustment is very similar across destination markets. In over 80 percent of the industries studied, it is not possible to reject the null hypothesis that the degree of LCPS is identical across destination markets. While this does not necessarily imply all destinations are treated the same, it casts some doubt on the existence of systematic differences across destinations. It is almost never possible to reject the null hypothesis that destination-specific markup adjustment on exports to the United States, in particular, is the same as that to other destinations. To the extent behavior does differ, it tends to indicate that the United States experiences somewhat more local currency price stability.

Finally, it is shown that the hypothesis of identical export price adjustment behavior across all industries within a source country (assuming identical price adjustment behavior across destinations) can be rejected for the U.S. and the U.K., but not for Germany or Japan. Pooling over industries shows destination-specific export price adjustment offsets 48 percent of the impact of exchange rate changes on price in the buyer's currency for Japanese exports. For Germany and the U.K., the comparable number is 36 percent. For the U.S. it is zero.

II. The Empirical Model

The empirical framework adopted here follows that introduced in greater detail in Knetter (1989,1991). The motivation for the framework comes from a simple model of price discrimination by a monopolist selling to several export destinations. Price changes to any destination will consist of two components: (1) changes in marginal cost and (2) changes in the markup of price over marginal cost. The former effect will be common to all destinations, while the latter may have common and destination-specific components. Marginal cost and markups are assumed to be unobservable, but common movements in prices due to changes in marginal cost or common markup changes are accounted for by a including full set of time dummies in the model.[6] Destination-specific changes in markups will occur in response to changes that are unique to individual destination markets.

The crucial destination-specific explanatory variable will be changes in the exchange rate between the exporter's currency and the currency of the destination market. Other factors, such as changes in income in the destination market, may also play a role, although those effects would be

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[6] The interpretation of the time effects as capturing the behavior of marginal cost obviously requires more assumptions when the export sector consists of more than one firm. Although the conditions for exact aggregation are unlikely to hold, the model still controls for underlying changes in industry cost provided all firms costs move together.

of secondary importance due to the magnitude and variability of exchange rate changes across destinations relative to changes in income.

The general model of export price adjustment I propose to estimate for a 7-digit industry in a given source country can be written as follows:

$$(1)\quad \Delta p_{it} = \theta_t + \beta_i \Delta x_{it} + \varepsilon_{it}$$

where $i = 1,\ldots,N$ and $t = 1,\ldots,T$ index destination of exports and time respectively, p is the log of export price, x is the log of the destination-specific exchange rate (expressed as units of the buyer's currency per unit of the seller's divided by the destination market price level), and θ_t and β_i are (T+N) parameters to be estimated.[7] The error term, ε_{it}, is assumed to be independent and identically distributed with mean zero and variance σ^2_ε

The model given by (1) is an analysis of covariance model in which the intercept term is allowed to vary due to effects that are constant across individuals but vary over time (the θ's). The primary underlying factor that accounts for such movements is marginal cost of the exporters. It is also possible that some common movement in prices is due to changes in the markup over marginal cost that are common to all destination markets. The time effects will be treated as fixed. As

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[7] This model can be recast in logarithms of the variables, in which case a destination-specific constant should be added to each equation to reflect different levels of the markup over cost. (See Knetter (1989, 1991) for discussion of the microfoundations of such an equation.) Results for a model in logarithms are presented in a previous version of this paper. In estimation of that model I included lagged values of exchange rates and prices as regressors in order to alleviate the potential problems of non-stationarity of the data. The coefficient estimates are very similar to what is obtained by differencing the data. The findings of the paper are thus robust to these specification issues.

written in equation (1), the model allows for the slope coefficients to vary across destinations. In estimation I will test whether these coefficients can be constrained across destinations.

The statistical interpretation of the β's is straightforward. A value of zero implies that the markup to a particular destination is unresponsive to fluctuations in the value of the exporter's currency against the buyer's. Thus, changes in currency values would be fully passed through to the buyer (net of any common effects they have on prices to all destinations). Negative values of β imply that markup adjustment is associated with LCPS. For example, a value of -.5 implies that in response to a 10 percent appreciation (depreciation) of his currency, the exporter would reduce (increase) his markup by 5 percent. Assuming constant costs, the price paid in units of the buyer's currency would rise (fall) by only 5 percent. Positive values of β correspond to the case in which destination-specific changes in markups amplify the effect of destination-specific exchange rate changes on the price in units of the buyer's currency.

The economic interpretation of the β's depends on what one assumes about market structure. Obviously, PTM cannot occur in a frictionless, competitive model of trade. Export market segmentation is a necessary condition for the existence of price discrimination in general and PTM in particular. The underlying reasons for segmentation are not formally addressed in the theoretical models.[8] I assume that segmentation is possible and will now review the factors that dictate the pattern of PTM for various models.

If the exporter is a monopolist, the value of β is determined by the convexity of the demand schedule in the destination market. The class of demand schedules having constant elasticity with respect to price imply a value of β equal to zero. β is negative provided demand is less convex than a constant elasticity demand schedule. When the export sector consists of multiple firms that compete with firms located in other countries (the typical case), the interpretation of β is more

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[8] Among the possible reasons why prices are not equalized across buyers in different markets are: incomplete information, transportation costs, trade barriers and health and safety regulations that create sometimes subtle product differentiation.

complicated. Generally speaking, it would be the weighted average over exporting firms of the response of price to changes in exchange rates.[9]

The economic interpretations of β discussed above involve equilibrium responses in the absence of intertemporal demand and supply linkages. If exporters face quadratic costs of adjusting the flow of product to a destination market, then quantity adjustment may take place over a period of time. If quantities were literally fixed in the short run, then one would expect to observe complete LCPS–i.e., a β of minus one. As quantity adjustment occurs, local currency prices change and the value of β would adjust toward zero. Even with annual frequency data, part of the contemporaneous response of destination-specific prices to exchange rate changes may reflect adjustment costs.[10]

No attempt is made to distinguish temporary from permanent exchange rate changes for estimation purposes. There is no widely accepted method by which to make such distinctions. Furthermore, the empirical literature on exchange rate determination has yet to offer models that

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[9] For given preferences, a variety of models of imperfect competition predict that more competitors will increase the tendency to observe stability in local currency prices. For example, it is easy to show in the context of Rudiger W. Dornbusch's (1987) model of exchange rate pass-through under Cournot oligopoly that prices in the importer's currency exhibit more stability for a given change in the exchange rate the larger the number of foreign firms faced by the exporting country. Consequently, LCPS is positively associated with the degree of competition in at least some models.

[10] In a previous draft of this paper, lagged values of the change in exchange rates were introduced into the model in an attempt to distinguish the importance of adjustment costs. The coefficients were almost never significant and did not alter the main results in any way. There was no obvious pattern to the lagged coefficients across industries or countries.

outperform a simple random walk in forecasting future realizations.[11] That literature supports the assumption that exchange rate changes are permanent and reduces concern that measured PTM is an artifact of omitted variables that are correlated with exchange rates. Exchange rate changes are treated as exogeneous to the export industries, which seems natural since the data are at the 7-digit industry level. Given that there are over 10,000 7-digit industries, it is difficult to imagine that simultaneity bias is a serious problem.[12]

III. Data

The data used in this study are based on the annual value and quantity of exports to selected destination countries for a number of 7-digit industries in four source countries: the United States, the United Kingdom, Japan, and Germany. The sample period is 1973-1987 for U.S. and Japanese exports, 1974-1987 for most British exports, and 1975-1987 for German exports.[13] For each source country-industry pair, data on exports to a number of relatively large (in terms of sales) export destinations are collected. Eligible destination markets are those that have currencies

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[11] See Richard Meese and Kenneth S. Rogoff's (1983) original paper or the more recent survey by Meese (1990). In a dynamic model that attempts to measure the impact of temporary exchange rate changes on export pricing, Kenneth A. Froot and Paul D. Klemperer (1989) find little evidence to suggest that this is an important phenomenon.

[12] The only scenario under which such bias might be important is if the underlying shocks driving exchange rates were strongly correlated across industries within a country. However, if this were true, it would almost certainly imply that other macroeconomic variables (such as output or consumption) would then be highly correlated with exchange rates, which we do not observe. For a more thorough discussion of this issue in the present context, see Knetter (1989).

[13] The only important exceptions are U.S. exports of photographic film and switches, which are for the period 1978-87. Changes in product categories precluded a longer sample.

that fluctuate in value against the exporter's currency, to the extent possible. The aim in choosing large export destinations is to improve the accuracy of the unit values (the value of exports divided by the quantity) as a measure of price and to minimize the number of periods in which price is not observed because of a lack of shipments. These criteria for data collection imply that sampling over destinations is not random. As a result, caution should be taken in drawing inferences about other trading relationships.

The industries were selected with several factors in mind. One aim was to provide variation in terms the types of products: durables, non-durables, intermediate goods, etc. Another was to try to choose some products that are important export industries in the source countries being studied. Most important, however, was the attempt to select industries that exported from more than one of the source countries in the sample. This task was difficult due to the lack of harmonization of the industry classification codes across source countries. The data set includes a number of chemical products for each source country, although exact matches are rare. Automobiles are exported by all four of the source countries, but the classification by engine size is different for each country.

The data are available at higher frequencies in some cases. In the United States and Germany, they are available monthly. The choice of annual frequency reflects primarily the need to economize on data collection effort.[14] Previous work (Giovannini (1988), Kasa (1990) and Marston (1990)) has addressed the dynamics of price responses with monthly data. That will not be the focus of this work. There is also a trade-off between frequency and the length of the sample period. The lower frequency information was collected over the entire floating exchange rate period in most cases. Another reason lower frequencies may actually be preferred in constructing

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[14] All of the data used in the study were handcopied from government publications of the respective source countries. This creates a trade-off between higher frequency information and more source country and industry variation. The latter seemed to be of greater interest and importance.

unit values is that erratic variation in shipments at high frequencies could increase the amount of noise in the unit value series. This is particularly likely in cases where there is heterogeneity in the product category.

The exchange rate series used as an independent variable is expressed in units of the buyer's currency per unit of the exporter's and is based on the annual average nominal exchange rate published in *International Financial Statistics*. The nominal rate is adjusted by dividing by the wholesale price index in the destination market. The rationale for this adjustment is that the optimal export price should be neutral with respect to changes in the nominal rate that correspond to inflation in the destination market. The wholesale price indices are annual averages taken from *International Financial Statistics*. The specific industries selected and the data sources for the unit value data are listed in the data appendix.

IV. Estimation and Results

For each source country-industry pair, the regression equations for each destination are estimated jointly, imposing the cross-equation restrictions. The errors are assumed to be independent and identically distributed. Errors must be assumed to be uncorrelated across equations, since the presence of a full set of time dummies in the model precludes estimating an unrestricted covariance matrix.

Tables 1-4 present the estimated values of β for each source country-industry pair when it is constrained to be the same across destinations.[15] The percentage of point estimates by industry for each source country that imply LCPS is as follows: Germany 89 percent, Japan 79 percent, U.K. 67 percent, and U.S. 45 percent. This evidence is suggestive of important differences in behavior that are related to source country. Approximately half of the German β's are statistically

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[15] The point estimates and standard errors of the unconstrained betas are presented in a working paper version of this paper.

significant at conventional levels. The number of statistically significant coefficients is lower for the other source countries. The unit value series are sufficiently noisy that pooled estimates of β are not terribly precise. Nonetheless, the broad patterns across countries are unmistakeable.

The F-statistics presented in these tables indicate that the null hypothesis of identical values of β across destinations is rejected by the data at the 5 percent level in only eight of the 52 source-industry pairs. Whether one interprets this as evidence that behavior is indeed identical across export destinations depends on prior beliefs. A prior belief of common β's would be validated by the data. Thus, there is weak evidence that PTM behavior does not depend critically on destination market.

There is also substantial variation in the estimated values of β by industry. The results for German export price adjustment in Table 1 show that LCPS is pervasive in chemical products, which include aluminum oxide, synthetic dyes, special dyes, titanium oxide pigments, titanium dioxide, aluminum hydroxide, vitamin A, and vitamin C.[16] Surprisingly little evidence of PTM can be found in German exports of large automobiles, whereas the data indicate LCPS is present in price adjustment on exports of small autos.[17] Of the three alcoholic beverage categories, beer and

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[16] For those who might be skeptical of the possibility of common currency price differentials in chemical products across countries, independent evidence is abundant in trade publications, such as *Chemical Marketing Reporter*. Exchange rate movements are frequently mentioned in conjunction with price differentials between North American and European markets in products such as Vitamin C.

[17] The seemingly puzzling results for large autos deserve some comment, since Krugman's (1987) original work on PTM was motivated in part by common currency price differentials on European luxury cars in the mid 1980's. It is possible that PTM does not exist within export markets, but does exist between export markets as a whole and the domestic market. This might be true if all export prices were based on U.S. market conditions. This may be a reasonable strategy in light of the fact that about 70 percent of German exports of large autos go to the U.S., with no other

sparkling wine both show evidence of LCPS, while there is no evidence of PTM in white wine. Finally, LCPS characterizes price adjustment in exports of fan belts, steel containers and steel rails. The surprising finding is that pricing to market is an important phenomenon in relatively homogeneous chemical product categories, rather than being confined to differentiated durable goods.[18] As noted earlier, these results are robust to estimation in log levels rather than first differences. Only the β for white wine changes sign, and it is near zero anyway.

There is strong evidence of pricing to market in Japanese and British auto exports, but not for the U.S. PTM is evident in photographic film exports for all three of these countries. Chemical and related products from Japan and the U.K. show evidence of PTM, but U.S. exports in those broad categories do not. Puzzling, but consistent with previous research, is the frequency of positive estimates of β for U.S. export industries.

Tables 5 and 6 offer a more precise test of whether the United States is statistically different as an export destination for German and Japanese exports, respectively. For each industry in each source country a common β is estimated for all destinations (β_{all}) and the U.S. equation includes an additional coefficient γ which measures the amount by which the U.S. price response to exchange rate changes differs from the common β.

In the German export price equations the estimate of γ is negative in 11 of the 18 industries. One generalization that seems appropriate is that the U.S. experiences more LCPS in autos and

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market receiving more than about 3 percent of total exports. Alternatively, one might also conclude that German automakers have more market power in large autos and as a consequence are better able to pass on exchange rate changes to buyers more easily than they can in small autos, where they may face greater competition. This argument is advanced in Gagnon and Knetter (1991). In any event, experience since 1987 certainly conforms to the findings for large autos: relative prices of German luxury cars have risen dramatically in the U.S. market and market shares have tumbled.

[18] This contrasts sharply with Krugman's (1987) finding with more aggregated data that PTM is confined to machinery and transport equipment and is absent in chemicals and basic manufactures.

alcoholic beverages, but not in chemical products. One explanation for this might be that the United States is a particularly large buyer in autos and alcoholic beverages relative to other destinations. The only estimates of γ significantly different from zero are four negative values (two autos categories, beer and sparkling wine). In only one case (autos 1.6-2 liters engine size) does the F-test actually reject the null hypothesis of a common β at the 5 percent level. This in part reflects the low power of these tests due to the noise in the unit value series. The standard errors of the coefficient estimates are too large relative to their magnitudes to reject equality even when the point estimates themselves are quite different. The evidence of greater LCPS in German exports of autos and alcoholic beverages suggests that the U.S. may be a more competitive destination market in these industries.

In the Japanese export price equations the estimate of γ is negative in 8 of the 14 industries. In only one case, golf balls, does the F-test reject the null hypothesis of a common β. The only significant values of γ are negative–golf balls and autos between 1.1 and 2 liters engine size. In general, the evidence for greater local currency price stability on exports to the United States seems markedly weaker in the case of Japanese, as opposed to German, exports. This is surprising considering that Japanese firms are perhaps more reliant on the U.S. market than German firms and are also frequently cited as failing to pass-through yen appreciations in order to maintain market share. It is worth noting, however, that once again the cases in which there is substantially more PTM to the U.S. are industries in which the U.S. buys a large share of total exports.

Arguably the most interesting comparisons involve those industries for which more than one source country is included in the data sample. Since the character of PTM seems to vary a great deal by industry, the source country patterns may be a consequence of the particular export industries chosen for each country. Such comparisons have not been made in previous work due to lack of appropriate data.

In automobiles, for example, the U.S. does much less LCPS than Japan or the U.K., and somewhat less than Germany in small autos. Most U.S. sales abroad are acheived by production in the market of final sale via multinational operations. Thus, the few autos that are exported tend to be specialty items that are not expected to gain significant shares in the foreign markets. As a result, little attention may be paid to pricing exports. It seems likely that LCPS achieves for foreign producers what foreign production achieves for U.S. producers. As a result, these findings should not be construed as indicating U.S. firms behave differently than other firms faced with the same environment. Gagnon and Knetter (1991) interpret the differences in automobile price adjustment as reflecting varying degrees of competition in different segments of the auto market. Japanese auto exports tend to be in smaller engine size categories (especially for the sample period used here) and face more competition than U.S. and German exports. Therefore, local currency price stability may be essential to long term survival.

For a number of industries in which direct comparisons across source countries are possible, the export price adjustment equations were estimated simultaneously and F-tests for common values of β across source countries were conducted.[19] In each case, the estimated value of β is constrained to be the same across all destinations for a given source country.[20] The results of this exercise are presented in Table 7. The table reports the estimated value of β for each source country individually as well as the estimate obtained by pooling the data for all source countries and estimating a new common value of β. The F-tests reveal that the null hypothesis that export price adjustment behavior is identical across source countries within a given industry cannot be rejected at the 5 percent level for any of the industries considered. Although the power of the test may be weak, the point estimates of the response of price to exchange rate changes are remarkably

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[19] Such tests were not conducted in autos or switches. In autos the engine size classifications are different for each source country. In switches, the U.S. data sample was too short (1978-1987) to make for a very powerful test. The United States was also dropped from the tests in photographic film export price adjustment, again because of the short sample.

[20] The only industry considered in which imposing this constraint does some harm to the data are U.K. exports of synthetic dyes, where the constraint was overwhelmingly rejected.

close in most cases. This is confirmed by the fact that the F-test statistic is below 0.1 in magnitude in four of the seven industries.

Exports of photographic film are included in the data samples for Japan, the United States, and the United Kingdom. The point estimates of β in the regressions that constrain the coefficients to be the same across destinations (found in Tables 5-8) are -.477 for the United Kingdom, -.519 for the United States, and -.940 for Japan. While these numbers do suggest LCPS is more pronounced for Japanese exporters, the behavior is not qualitatively different. In aluminum foil, the point estimates of β for Japan and the United States are -1.38 and -1.15, respectively. Two paper products are included in the sample, photographic paper exports by Japan and photocopier paper exports by the U.S. The estimates of β are -.611 for Japan and -.914 for the U.S. In this case, the U.S. exporters engage in a higher degree of LCPS, although these are not identical products. There is no evidence of PTM in U.S. or U.K. exports of whiskey, with both estimated coefficients very close to zero. In all four of these industries, the F-statistics were very small, indicating that the null hypothesis of identical behavior was never close to being rejected.

There are several chemical products in which comparisons are possible. The German data show no evidence of PTM in aluminum oxide exports. The U.S. data reveal a positive point estimate, implying that markups increase to destinations whose currencies have depreciated against the dollar. In both cases, the standard errors of the estimated coefficients are quite large, reflecting extremely large standard deviations of the mean changes in the unit values for this product. As a result, the F-statistic is not significant at conventional levels. For synthetic dyes, the point estimates of β for German and British exports are remarkably close and show strong tendencies for LCPS–the values being -.575 for Germany and -.616 for the U.K. Exports of titanium dioxide are included in the U.S., Japanese and German data samples. Both Germany and Japan exhibit LCPS, with the estimate for Japan exceeding one in magnitude. The point estimate for the U.S. is positive. It appears, however, that the U.S. estimate is driven by outliers in the export unit values on shipments to Germany. The standard deviation of the mean price change on shipments to Germany is about three times the magnitude of the same statistic for the other destinations. When

Germany is dropped as a destination, the point estimate of β for U.S. exports of titanium dioxide is -.57 with a standard error of .23. This is virtually indistinguishable from the estimated behavior of German exporters. Even with Germany included as a destination, the null hypothesis of identical behavior is not rejected.

For those industries in which more than one source country is included in the sample, the general finding seems to be that behavior is not very different across source countries. This finding stands in sharp contrast to the conclusion one might reach without accounting for industry. Indeed, one of the stylized facts of previous work is that U.S. exporters exhibit far less evidence of LCPS than their counterparts in Japan or Germany. To the extent that fact is true in the aggregate, it could well reflect the mix of export industries rather than genuine differences in behavior in the same industries.

Table 8 provides summary evidence on behavioral differences in the aggregate. It reports the estimated values of β obtained when it is constrained to be identical across all industries for each source country and the F-statistic for the restriction on the data. For U.S. industries, the estimated common value of β is virtually zero, although the restriction that all industries have identical export price response to exchange rate changes is rejected. For Germany, the United Kingdom and Japan, the estimate of β is statistically significant and the restriction is not rejected by the data for Germany and Japan. The industry-wide numbers indicate that German and U.K. exporters use destination-specific adjustments of the markup to offset about 36 percent of the impact of exchange rate changes on price paid in units of the buyer's currency. The comparable number for Japan is 48 percent.

V. Conclusion

The methods and data used in this analysis permit new insights by expanding the dimensionality across which variations in pricing to market can be considered. In particular, the framework allows for comparisons across source countries, destination countries, and industries.

At a minimum this paper has documented that common currency price differentials exist and are sensitive to exchange rate changes for a large number of very detailed products. More importantly, this paper has established several interesting new facts about the pattern of pricing to market behavior that can be used to guide further theorizing about this phenomenon.

First, substantial doubt has been cast on the importance of destination market in determining the extent of local currency price stability. The destination where one might have expected the most pronounced tendency by foreign exporters to stabilize prices, the United States, does not appear to receive markedly different treatment based on the results in Tables 5 and 6. There is only weak evidence to suggest that German exporters use destination-specific markup adjustment to offset the effect of exchange rate changes on dollar prices paid by U.S. importers. Japanese exporters appear to treat the U.S. like any other export market.[21] The lack of an important U.S. destination effect casts doubt on the empirical importance of explanations of PTM that rely on features of the exchange rate process (e.g., distinctions between temporary and permanent or large versus small changes). Large, perhaps unsustainable, swings in the dollar may have piqued interest in PTM, but are not responsible for its existence.

Second, comparisons of source country behavior within common industries indicate remarkably little evidence of differences in behavior. This is contrary to the impression generated by previous work on markup adjustment by Mann (1986), Knetter (1989) and Kenichi Ohno (1989). Formal F-tests never reject identical price adjustment within industries, although the power of these tests is admittedly weak. Nonetheless, the parameter estimates themselves are quite similar across source countries within an industry.

Finally, it appears that industry is the critical dimension upon which future research should focus in explaining pricing to market behavior. When the data are pooled across industries for

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[21] This is certainly a fact policymakers should bear in mind when considering whether the (lack of) pass-through of exchange rate changes on Japanese imports is something that ought to be interpreted as *prima facia* evidence of unfair trading practice.

each source country it is possible to reject identical behavior across industries for the U.S. and the U.K., although not for Germany and Japan. The range of parameter estimates across industries within each source country is very wide. The parameter estimates obtained when pooling across industries reveal very similar behavior for the British, German and Japanese exporters–ranging from 36 percent to 48 percent of the effect of destination-specific exchange rate changes being offset by destination-specific markup adjustment. The point estimate for the United States is literally zero. To the extent United States behavior appears different in the aggregate, it may be due to the pattern of industry specialization, rather than behavioral differences by firms in the same industry.

The pervasive evidence of PTM presented in this paper confirms the importance of departures from static, competitive models in international trade and industrial organization. Without providing any direct tests of alternative models, the empirical framework used here has assembled an important set of facts against which various theories might be judged. The fact that industry appears to be the main source of variation in the pattern of PTM suggests that future research should attempt to explain PTM on the basis of observable industry characteristics.

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Table 1. German Exports - Constrained Estimates of β from Equation (1)

Industry	β	F-Statistic
Autos over 3L.	0.048 (.11)	1.175
Autos 2.1 - 3L.	0.083 (.23)	1.492
Autos 1.6 - 2L.	-0.356 (.25)	2.257
Aluminum Oxide	-0.029 (.98)	0.523
Autos 1.1 - 1.5L.	-0.542 (.30)	1.684
Beer	-0.435 (.16)	2.708*
Synthetic Dyes	-0.575 (.10)	1.679
Titanium Oxide Pigments	-0.809 (.25)	0.331
Preparations for Syn Dye	-0.188 (.33)	0.260
Titanium Dioxide	-0.645 (.30)	0.235
Aluminum Hydroxide	-0.724 (.42)	0.979
Vitamin A	-0.488 (.44)	0.265
Vitamin C	-0.249 (.07)	0.059
White Wine	-0.021 (.14)	3.925*
Sparkling Wine	-0.610 (.29)	0.840
Fan Belts	-0.432 (.23)	0.248
Steel Containers	-0.359 (.23)	0.770
Steel Rails	-0.774 (.98)	0.302

* : reject constraint at 5% level.

Note: standard errors in parentheses.

Table 2. Japanese Exports - Constrained Estimates of β from Equation (1)

Industry	β	F-Statistic
Color Film	-0.940 (.28)	1.500
Photo Paper	-0.611 (.37)	0.599
Aluminum Foil	-1.38 (.81)	0.794
Fish Hooks	0.854 (.60)	1.678
Tires	-0.167 (.57)	0.332
Autos 1.1 - 2L	-0.615 (.10)	3.375*
Autos 1L or less	-0.182 (.24)	1.282
Autos over 2L	-0.689 (.22)	2.589*
Inner Tubes	-2.26 (1.18)	2.938*
Imitation Pearls	-0.484 (.37)	2.637
Portland Cement	-0.570 (.64)	1.601
Titanium Dioxide	-1.53 (.64)	0.251
Selenium	0.545 (.62)	0.157
Golf Balls	1.42 (1.16)	10.57*

* : reject constraint at 5% level.

Note: standard errors in parentheses.

Table 3. U.S. Exports - Constrained Estimates of β from Equation (1)

Industry	β (se)	F-Statistic
Autos over 6 cyl	0.004 (.35)	0.368
Autos 6 cyl or less	-0.192 (.19)	0.369
Aluminum Oxide	1.45 (.65)	1.339
Cigarettes	0.032 (.14)	0.554
Paper	-0.914 (.48)	0.311
Aluminum Foil	-1.15 (.85)	1.591
Bourbon	0.052 (.35)	0.147
Yellow Corn	-0.069(.09)	0.944
Titanium Dioxide	0.725 (.92)	0.695
Switches	1.73 (.61)	0.647
Film	-0.519 (.59)	2.015

* : reject constraint at 5% level.

Note: standard errors in parentheses.

Table 4. U.K. Exports - Constrained Estimates of β from Equation (1)

Industry	β	F-Statistic
Automobiles	-0.829 (.63)	0.665
Tractors	-0.146 (.22)	0.137
Whiskey	0.040 (.08)	0.655
Switches	0.052 (.15)	0.966
Books	0.005 (.16)	0.348
Film	-0.477 (.30)	1.583
Fabric	-0.017 (.12)	0.486
Synthetic Dye	-0.616 (.14)	11.04*
Tools	-1.47 (.52)	0.315

* : reject constraint at 5% level.

Note: standard errors in parentheses.

Table 5. German Exports: Estimates of a Separate U.S. Response Coefficient

Industry	β_{all}	γ_{us}	F-Statistic
Autos or 3L	0.12 (0.12)	-0.17 (0.10)	0.775
Autos 2.1 - 3L	0.23 (0.28)	-0.33 (0.16)	3.124
Autos 1.6 - 2L	-0.12 (0.26)	-0.53 (0.14)	8.417*
Aluminum Oxide	0.26 (1.29)	-0.66 (0.92)	0.307
Autos 1.1 - 1.5L	-0.10 (0.30)	-0.62 (0.46)	2.717
Beer	-0.34 (0.19)	-0.22 (0.08)	1.687
Synthetic Dyes	-0.62 (0.13)	0.10 (0.11)	0.592
Titanium Oxide Pigment	-0.91 (0.32)	0.15 (0.18)	0.335
Special Dyes	-0.36 (0.25)	0.39 (0.30)	0.538
Titanium Dioxide	-0.78 (0.47)	0.19 (0.56)	0.261
Alum. Hydroxide	-0.17 (0.64)	-0.77 (0.46)	1.974
Vitamin A	-0.39 (0.50)	-0.22 (0.49)	0.100
Vitamin C	-0.24 (0.06)	-0.03 (0.12)	0.030
White Wine	-0.06 (0.13)	0.07 (0.09)	0.264
Sparkling Wine	-0.31 (0.36)	-0.58 (0.28)	1.171
Fan Belts	-0.59 (0.22)	0.17 (0.20)	0.400
Steel Containers	-0.36 (0.29)	0.01 (0.23)	0.000
Steel Rails	-0.51 (1.50)	-0.26 (0.66)	0.083

*reject constraint at the 5% level

Note: Standard errors in parentheses.

Table 6. German Exports: Estimates of a Separate U.S. Response Coefficient

Industry	β_{all}	γ_{us}	F-Statistic
Film	-0.923 (0.31)	-0.105 (0.22)	0.148
Photo Paper	-0.507 (0.32)	-0.616 (0.62)	0.412
Alum Foil	-1.38 (0.84)	0.027 (0.98)	0.001
Fish Hooks	0.850 (0.60)	0.069 (0.39)	0.015
Tires	-0.215 (0.58)	0.194 (0.41)	0.040
Autos 1.1-2L	-0.561 (0.10)	-0.164 (0.07)	3.094
Autos 1L or less	-0.401 (0.26)	0.581 (0.34)	2.022
Autos over 2L	-0.674 (0.24)	-0.044 (0.13)	0.088
Inner Tubes	-2.21 (1.23)	-0.201 (0.29)	0.046
Imitation Pearls	-0.431 (0.48)	-0.149 (0.51)	0.100
Portland Cement	-0.585 (0.66)	0.975 (0.66)	1.201
Titanium Dioxide	-1.53 (0.75)	0.024 (0.99)	0.001
Selenium	0.607 (0.71)	-0.178 (0.39)	0.096
Golf Balls	2.55 (0.99)	-1.79 (0.60)	8.878*

*reject constraint at the 5% level.

Note: Standard errors in parentheses.

Table 7. Source Country Comparisons of Constrained

Estimates of β for Common Industries

Industry	U.S.	Japan	Germ	U.K.	Pooled	F-Statistic
Alum Ox	1.45 (0.65)		-0.029 (0.98)		0.754 (0.43)	1.769
Syn Dyes			-0.575 (0.10)	-0.616 (0.14)	-0.601 (0.07)	0.082
Titan Diox	0.725(0.92)	-1.53 (0.64)	-0.645 (0.30)		-0.169 (0.58)	2.706
Paper	-0.914(0.48)	-0.611 (0.37)			-0.767 (0.35)	0.096
Alum Fl	-1.15(0.85)	-1.38 (0.81)			-1.27 (0.55)	0.043
Bourbon	0.052(0.35)			0.040 (0.08)	0.042 (0.12)	0.002
Film		-0.940 (0.28)		-0.477 (0.30)	-0.603 (0.12)	0.248

None of the F-Statistics are significant at the 5% level.

Note: Standard errors in parentheses.

Table 8. Source Country Estimates of β Constrained Across Destinations and Industries

	β	F-Statistic
United States	-0.009 (.128)	3.127* (8,648)
Germany	-0.361 (.148)	0.457 (17,834)
Japan	-0.477 (.185)	1.149 (13,742)
United Kingdom	-0.370 (.138)	4.271* (8,524)

* reject constraint at 5% level

Note: Standard errors and degrees of freedom in parentheses.

DATA APPENDIX

The export unit value data used in this study are based on customs declarations in the respective countries of export. The values reported are FAS (free alongside ship) which measures the transactions value at the port of export and is exclusive of transportation and tariff wedges. U.S. data are published by the Commerce Department under the title of *Schedule E: U.S. Exports*. German data are published by Statisticsches Bundesamt under the title *Aussenhandel nach Waren und Laendern, Fachserie 7, Reihe 2*. Japanese data are published by the Japan Tariff Association under the title *Japan Exports and Imports*. British data are published by the Central Statistical Office in *Annual Statement of the Overseas Trade of the United Kingdom*. The specific product categories of exports for country and their classification codes are listed below.

German Export Data

Code	Product
2203900	beer in containers under 10 liters
2205090	sparkling wine other than champagne
2205160	white wine below 13% alcohol in containers under 2 liters
2820110	aluminum oxide
2820150	aluminum hydroxide
2825000	titanium dioxide
2938210	vitamin A
2938500	vitamin C
3205100	synthetic dyes
3205200	synthetic dyes prepared according to regulation 32
3207400	titanium oxide pigment
4010300	fan belts of soft rubber
7316140	steel rails over 20 kg/m.

7320420	steel containers
8702216	autos from 1 - 1.5 liter engine size
8702232	autos from 1.6 - 2 liter engine size
8702234	autos from 2.1 - 3 liter engine size
8702250	autos over 3 liter engine size

U.S. Export Data

0440045	yellow corn not donated for charity or relief
1124120	bourbon whiskey in containers holding one gallon or less
1222000	cigarettes
5256060	titanium dioxide
5253960	aluminum oxide
6842720	aluminum foil, whether or not embossed, under .006 in. thick
7721018	snap-action switches
7810010	autos with piston-type engines, 6 cylinders or less
7810020	autos with piston type engines, over 6 cylinders
8822710	paper, silver halide type designed for continuous tone reproduction
8822645	still photo film in cartridges or rolls for retail sale, not exposed

Japanese Export Data

2825000	titanium dioxide
9706051	golf balls
3702092	photographic film in rolls, unexposed
3703010	color photographic paper, not developed
7604000	aluminum foil of a thickness not exceeding 0.2 mm
2804220	selenium
8702191	autos with engine size 1 liter or less

8702192	autos with engine size 1.1 - 2 liters
8702193	autos with engine size over 2 liters
4011620	inner tubes for bicycles, of rubber
7019010	imitation pearls of glass
2523010	portland cement
9707020	fishing hooks
4011420	pneumatic tires for bicycles, of rubber

U.K. Export Data

112.41	whiskey
7721	electrical switchgear, switchboards and control panels
781	automobiles
882.22	film in rolls, sensitized, unexposed
531.1	synthetic dyestuffs
654.21	fabric woven, containing 85% or more by weight of carded wool
695.41	interchangeable tools for hand or machine tools
892.11	books, booklets, brochures, pamphlets, and leaflets
722.4	wheeled tractors