PRICING TO PASS-THROUGH UNDER VOLATILE EXCHANGE RATE SCENARIO IN THE U.S. MANUFACTURING

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Abstract: A plethora of studies suggests the pricing decisions depend on product substitutability, costs, market structures, and the magnitude of exchange rate uncertainty in the international setting. Taking a departure from existing literature, this paper examines the average degree of exchange rate pass-through to the prices of export product under low to high exchange rate volatility. A panel data estimation method is performed using the annual U.S. export data to 69 export destinations across 111 four-digit Standard Industrial Classification (SIC) industries. An average zero or insignificant pass-through estimate for all industries in the high exchange-rate-fluctuation sub-sample confirms the hypothesis. In this period of high exchange risk, the possible high hedging engagements disconnect the relationship between exchange rate movements and export pricing.

Keywords: pass-through; foreign exchange volatility; international pricing

INTRODUCTION

Research on exchange rate pass-through is vital to understanding the relationship between exchange rates and prices, including import and export prices, and domestic inflation. The incomplete exchange rate pass-through can be explained by a market power, the imported inputs, the speed of price adjustment, the asymmetric response to exchange rate fluctuations, the choice of exchange rates and indices, price rigidity, multinational operations by related and non-related party trade, and the market segmentation by trade costs. Most research on the pricing behaviors under a theory of imperfect competition concludes that exchange rates are less than fully passed through in some markets and the market power plays an important role in local price destabilization (Dunn, 1970; Isard, 1977; Kravis and Lipsey, 1977; Richardson, 1978; Giovannini, 1988; Knetter, 1989; Feinberg, 1986, 1989 and 1996). In addition, the degree of pass-through is not only destination-specific but also sector-specific. It varies both within and across industries due to the differences in product differentiation and market structure (Caselli, 1996; Athukorala and Menon, 1994; Athukorala, 1991; Parsley, 1993; Menon, 1991). In general, the ability of adjusting

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the markup in favor of export agents or passing cost shock to consumers is based on the competitiveness of destination markets following the exchange rate changes.

The export pricing study of manufacturing between the U.S. and Japan indicates that the U.S. pass-through coefficients are close to but insignificantly different from one in general machinery, electrical machinery, and transportation equipment (Ohno, 1989). Japanese pass-through coefficients are less than 80% and significantly different from one. The declining in the degree of pass-through to the U.S. market in the 1980s is a result of a growing dependence on imports, changes in the structure of competition in the U.S. market and unfair practices by foreign firms (Parsley, 1993). The short-run estimate of the pass-through coefficient for Japanese aggregate exports is 18.4% in six industries. The pass-through behavior at the industry level is diverse as evident by (1) a zero pass-through for chemicals, electrical machinery and general machinery and (2) a 20.3% pass-through for metals and related product, a 26.3% pass-through for textiles and a 26% pass-through for transportation equipment.

The degree of pass-through is over-estimated, possibly due to exchange rate pass-through to imported input prices (Athukorala and Menon, 1994). The exchange rate and price relationships should be studied with reference to disaggregated data. The selected pass-through coefficient estimates for Japan are summarized along with the results of Ohno (1989) and Parsley (1993) in Table 1. The results from these three studies are all consistent in that high pass-through is found in the same industries. The industries in highly competitive markets such as chemicals, textiles and metal products are expected to show low pass-through coefficients. However, only Athukorala and Menon (1994) find a low pass-through for textiles. A possible explanation is that the degree of competition in these highly competitive markets is undermined by product differentiation among competitive products.

Analyzing quarterly data from the third quarter of 1981 to the second quarter of 1992, a pass-through is incomplete for most 40 products with significant differences across products in Australian imports of manufactures (Menon, 1996). The determinants of pass-through are decomposed into non-tariff barriers, product characteristics, foreign control and market structure. In general, the average pass-through for total manufactures is 75.19%, ranging from 18.48% to 104.5%.

Table 1 Review of Selected Pass-Through Coefficient Estimations (%) – Japan Manufacturing Industry Exports

Industry	*Ohno (1989)*	*Parsley (1993)*	*Athukorala and Menon (1994)*
Samples	*1977:4-1987:3 Quarterly*	*1980-1988 Annual*	*1980:1-1992:1 Quarterly*
Chemicals	0.0	0.0	42.1
Electrical Machinery	77.0	0.0	45.5
Textiles		16.3	4.3
Transportation Equipment	78.0	26.0	53.3
General Machinery	77.0	0.0	42.3
Metal Products	74.0	20.3	4.8
Aggregate	76.5	18.4	66.9

The pass-through estimates for selected similar industries (car parts and accessories 84.73%, passenger motor cars 69.46%, motorcycles and bicycles 58.56%, trucks and busses 55.34%) do not suggest conventional thought. Car parts and accessories should show a lower pass-through than passenger motor cars because of higher competition.

The mixed results may be attributed to the product sectors i.e. primary product sectors (more competitive industries) and manufacturing sectors (less competitive industries). Normally, the pass-through coefficients on average should be lower in primary product than manufacturing sectors. However, in the Denmark case, the primary product pass-through coefficient of 45% is higher than that of 38% in manufacturing sectors (Rahman, 1998). The German case has many high pass-through coefficient estimates in primary product sectors.

Moreover, these empirical findings may be biased without taking into account a user or non user of hedging and the impact of exchange rate volatility. When the firms apply financial or operational hedging against exchange risk to protect their trade contract values, the connection between exchange rates and prices of traded goods may be weakened. A crucial feature of this study is to introduce and control hedging by using exchange rate volatility to improve the understanding of the exchange rate and price relationship.

HYPOTHESIS AND ECONOMETRIC METHODOLOGY

Hypothesis

A firm facing high exchange rate volatility is more likely to hedge its trade returns in a forward market or by other means. Thus, the export pricing under contract is less likely to be changed by exchange rate fluctuation. As a result, a pass-through would be incomplete and low. On the other hand, a firm in a low exchange rate fluctuation environment will be less likely to hedge its trade returns. The degree of pass-through would not be distorted in this case. Another integral part to the degree of pass-through is that a producer with a high market power could pass the exchange rate shock to consumer price (a high pass-through) if selling to a low volatile exchange rate destination. If selling to a highly volatile exchange rate destination, this producer would hedge the trade returns. Therefore, the pass-through would be low or zero (a low pass-through). For a given export product in the mixture of high and low exchange rate fluctuations, the average exchange rate pass-through estimate would be lower than normally expected. Based on the issues and discussion raised above, the following hypothesis is generated for verification of the relationship between exchange rate and export prices:

- *The average degree of exchange rate pass-through to the prices of any given export product would be lower than expected due to the differences in exchange rate volatilities and possible hedging activities, ceteris paribus.*

Consequently, the empirical export pricing model is specified as:

- $$p_{ict} = \beta_0 + \beta_1 e_{c,\,t-1} + \beta_2 p^f_{ct} + \beta_3 gdp^f_{ct} + \beta_4 pc_{i,\,t-1} + \beta_5 pg_t + \varepsilon_{ict}.$$

where all variables are in natural log and in lower case italic; the subscripts i is the 4-digit SIC industry; c is export destination country; t is time; p_{ict} is export value in exporter's currency such as the U.S. dollar pricing by 4-digit SIC and by country destination over time; $e_{c,\,t-1}$ is the one-year-lagged bilateral nominal exchange rate for source country (the U.S.) against

each destination; p_{ct}^{f} is the price of foreign destination competing goods in destination currency; gdp_{ct}^{f} is foreign destination GDP in destination currency as a demand shifter; $pc_{t,\,t-1}$ is the one-year-lagged U.S. producer price index including unit labor, raw material and energy costs by 4-digit SIC over time; pg_t is the U.S. productivity growth over time and ε_{ict} is a disturbance term. The partial derivatives are:

- $(\partial p_{ict} / \partial e_{c,\,t-1}) = \beta_1 < 0;$
  $(\partial p_{ict} / \partial p_{ct}^{f}) = \beta_2 > 0;$
  $(\partial p_{ict} / \partial gdp_{ct}^{f}) = \beta_3 > 0;$
  $(\partial p_{ict} / \partial pc_{i,\,t-1}) = \beta_4 > 0;$
  $(\partial p_{ict} / \partial pg_t) = \beta_5 < 0.$

Methodology

The cross section and time series data are adopted to test the hypothesis. Due to a relatively short sample period of annual data (1974-1996), the cointegration analysis for a long run pass-through relationship is not exercised. Breusch and Pagan Lagrangian multiplier tests for random effects are performed. With a high value of χ^2 statistic and at 0% significant level, all tests reject the null hypothesis assuming that the variance of the cross section (the SIC industry) is zero. This means the individual differences from cross-sectional industries have contributed to the various levels of a constant term. Therefore, only the balanced panel fixed effect regression methodology is used to test the export pricing model.

The scatter plot of exchange rates over the sample period (1974-1996) shows a mixture of high and low exchange-rate-fluctuation destinations. The exchange rates in the first sub-sample (1974-1990) are not as volatile as in the second sub-sample (1990-1996). The financial markets might not be fully developed in the first sub-sample period for exporters to hedge their trade values. According to the hypothesis, the highly exchange-rate-volatile period may yield low pass-through estimations while the less-volatile period may level off the pass-through estimations that reflect the competition and the factors other than the hedging engagements. Hence, the entire sample and two sub-sample periods are tested using pooled time series and cross sections or a panel data estimation method.

ANALYSIS OF EMPIRICAL RESULTS

The sample is somewhat limited due to data availability and compatibility considerations. The unit of observation is the export price of a U.S. industry in a given year to an export destination because the individual firm data are unavailable. In additional, the linked export pricing dataset is constrained by some key variables such as the values of U.S. domestic shipment and U.S. factor productivity. These are only available in the 1972 SIC manufacturing product industries. The dataset is also restricted by the launch of a floating exchange regime from 1971 to 1973 for most countries and the 1997 Asian financial crisis. Thus, the best available annual U.S. export data to 69 export destinations across 111 four-digit Standard Industrial Classification (SIC) industries during 1974 and 1996 are collected. This data set allows the bilateral nominal exchange rates to be used in this pass-through study. A balanced panel and bilateral export dataset contains 81,374 observations.

The F statistics in Table 2 are statistically significant at less than 1% level for all three models with different sample periods: 1974-1996, 1974-1990 and 1990-1996. The testing indicates that all three regression models properly include and control the variables which determine the export

Table 2 The Export Pricing Model Estimations with Fixed Effect (All Variables Are in Natural Logarithm)

Variables	*(1)* *Aggregate (1974-1996)*	*(2)* *Low Volatility (1974-1990)*	*(3)* *High Volatility (1990-1996)*
CONSTANT	0.0015 (0.802)	0.0054 (0.445)	0.0032 (0.852)
EXCHANGERATE	-0.0178 (0.466)	-0.0578 (0.083) *	0.0560 (0.150)
FOREIGNPRICE	0.1070 (0.005) ***	0.1489 (0.001) ***	0.0717 (0.500)
FOREIGNDEMAND	-0.1052 (0.018) **	-0.0823 (0.075) *	-0.7710 (0.009) ***
PRODCOST	0.1314 (0.000) ***	0.0984 (0.003) ***	0.6678 (0.000) ***
PRODUCTIVITYGROWTH	-0.2905 (0.000) ***	-0.2715 (0.000) ***	-0.4647 (0.000) ***
Observations	81,374	60,146	24,766
R-Squared (within)	0.0008	0.0008	0.0023
	F(5,77831) = 12.49 (0.000) ***	F(5,56603) = 8.88 (0.000) ***	F(5,21223) = 9.94 (0.000) ***
Breusch and Pagan LM Test for Random Effects	χ^2 = 1,309.73 (0.000) ***	χ^2 = 1,311.63 (0.000) ***	χ^2 = 1,163.56 (0.000) ***

Note:

a. EXCHANGERATE and PRODCOST are both one-year-lagged.

b. *, **, and *** are the significant levels at 10%, 5%, and 1% respectively.

c. The number in parenthesis is the probability value (p-value).

pricing. The estimation results of the average manufacturing industry-level pass-through coefficients are consistent with the hypothesis. Column 1 shows that the coefficient estimate of EXCHANGERATE (b_1) or the average pass-through elasticity estimation across all industries from the entire sample (1974-1996) is zero or statistically insignificant. Note that the average pass-through elasticity estimation is marginally significant at 10 % level in the low exchange-rate-fluctuation sample (Column 2) while insignificant in the high exchange-rate-fluctuation sample (Column 3). The aggregation issue of combining the two sub-samples may explain the neutralized results in the aggregate export pricing model pass-through estimation (Column 1).

A zero pass-through in 1974-1996 means that the average export prices in the U.S. dollar for all industries are unresponsive to the exchange rate movements to 69 U.S. trade destinations. Assuming a zero markup adjustment, when the U.S. dollar appreciates by 100%, the destination currency price of the U.S. exports may increase by 100%. However, if the importers of the U.S. exports adjust the markup downward to prevent losing a market share, the destination currency price of the U.S. exports may increase by less than 100%. This export pricing model does not predict the exchange rate pass-through to the destination currency pricing of the U.S. exports. In the low exchange-rate-volatility sub-sample 1974-1990, there was on average -5.78% pass-through after one year at 10% significant level. This finding reveals that a 100% appreciation of the U.S. dollar against a foreign currency would reduce the U.S. dollar export price by 5.78%. During the low exchange-rate-volatility period and in turn, the low hedging activity period, this estimated 5.78% pass-through emanates from the exporter's market power due to the product differentiation and market structure. However, the degree of pass-

through is relatively low comparing to the existing findings.

The estimated low pass-through may be due in part to the export product mixes rather than the market power alone. The degree of the exchange rate pass-through would depend usually on the product differentiation and the destination market structure. A half of the industries in this study have little differences in unit export prices across different markets over time while the other half has large differences. Given the arbitrage opportunities and assuming the export products are identical for each U.S. industry, there would have been similar prices among foreign destination markets. The differential prices in different destinations may come from export product mixes rather than purely different pass-through by the industry of identical product. Therefore, the ability of U.S. firms to pass the exchange rate changes to export prices is more limited. This helps explain the low average pass-through elasticity estimates over the entire sample period. In the U.S. industries, the markup adjustment is unlikely to increase the movements in the foreign currency price of exports (Mann, 1986). Though, exporters may adjust their markups in order to stabilize the market price. At any rate, more pass-through is observed on trade directions from the U.S. to foreign destinations rather than from foreign countries to the U.S. (Knetter, 1989; Ohno, 1989; Marston, 1990).

Other control variables are all significant with the correct signs except the foreign demand variable (foreign GDP). The estimates confirm that the higher the foreign competitor's prices and the higher the cost of production, the higher the U.S. dollar unit export prices in all sample periods. Furthermore, the productivity growth reduces the export prices in all samples. However, the foreign demand actually reduces prices, which is not economically intuitive.

CONCLUSIONS

An average zero or insignificant pass-through estimate for all industries in the highly exchange-rate-fluctuation sub-sample of 1990-1996 confirms the theoretical prediction. The possible high hedging engagements in this period of high exchange risk disconnected the relationship between exchange rate movements and export pricing. Any willingness to pass changes in exchange rates to export price has been eliminated by possibly hedging on export contract values. This important finding points out that the resulting zero pass-through estimation might be explained in the existing literature to have the lack of the ability rather than the willingness to pass the cost shocks to prices instead of other factors such as hedging possibility. The exporters trading with highly exchange-rate-fluctuation foreign destinations usually face a larger exchange risk and therefore would be more likely to protect their trade contract values by involving in some hedging activities, thus a low pass-through should result. Consequently, the exporters trading with a low exchange-rate-fluctuation environment facing a low exchange risk would be less likely to invest in hedging on the trade contract values. Further research may be specifically directed at tariff pass-through to import prices presented by Feenstra (1989) in a more nuanced study of the exchange rate pass-through. More and better data can be gathered to calibrate the model, especially to characterize the outside U.S. economy.

BIOGRAPHY

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Senior Scholar, a 2003 Fulbright Senior Specialists in Thailand and a 2007 Fulbright Senior Specialists in Kazakshstan. He holds a M.S. from Indiana State University, and a M.A. and Ph.D. from University of Cincinnati. He earned two professional designations: Certified Financial Planner (1991) and Chartered Financial Consultant (1992). His recent articles appear in selected refereed journals such as Journal of the Asia Pacific Economy, Journal of Transnational Management, International Journal of Entrepreneurship, Journal of International Business Research and Managerial Finance.

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