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EXCHANGE RATE PASS-THROUGH AND INDUSTRY CHARACTERISTICS: THE CASE OF TAIWAN'S EXPORTS OF MIDSTREAM PETROCHEMICAL PRODUCTS

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ABSTRACT

Based on 1986-1992 survey data of 22 midstream petrochemical industries in Taiwan, the empirical results of the export price, the markup ratio and the price-cost margin equations in this study show that Taiwan's petrochemical firms absorb only a small portion of a given weighted exchange rate change in their export prices, markup ratios and price-cost margins. It implies that Taiwan's petrochemical firms have a weak pricing-to-market pattern. The empirical results may be explained by the volatility of profitability, high market concentration and small export/domestic production share. However, the impacts of the exchange rate change on the export price, markup ratio and price-cost margin have a tendency to increase during the period of 1987 to 1992. The tendency might be attributed to increasing competition of the petrochemical markets in the world, or Taiwanese firms' gradual realization of the importance of holding their world market shares in response to the exchange rate change.

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I. Introduction

In the 1980s there were many significant structural changes in Taiwan's economy. One of them was the drastic appreciation of New Taiwan dollars. It can be seen from table 1 that though the export price indexes had been decreasing along with the appreciation of NT dollars during this period, the magnitude of the export price indexes' decline did not match that of the NT dollar appreciation.[1] Furthermore, the trade imbalance kept growing. Does this imply that there exists an incomplete exchange rate "pass-through" in Taiwan's export price indexes, or do Taiwan's domestic firms have the "pricing-to-market" behavior?[2]

Most of the recent empirical studies show that firms in Newly Industrializing Countries tend to have "pricing-to-market" behavior in response to changes in real exchange rates [Hooper & Mann (1989), Athukorala (1991), and Liu (1994), ...etc.].[3] However, Marston (1990), Knetter (1993) and Athukorala & Menon (1994) find that different industries even in the same country may not have identical behaviors toward pricing-to-market. Therefore, if we want to investigate the exchange rate pass-through pattern, it is more appropriate to explain pricing-to-market on the basis of observable industry characteristics. Similarly, Krugman (1987), Dornbusch (1987), Feenstra (1987), Fisher (1989), Knetter (1989) and Shinjo (1993) also show that the elements of market structure are very important in determining the degree of exchange rate pass-through.

There does exist a few studies which investigate the exchange rate pass-through effects in Taiwan [Hooper & Mann (1989), Liu (1994) and Wu (1995)]. However, most of them are based on an aggregative level. As mentioned above, if we study the pass-through effect by examining the general aggregate price indexes, we might have misleading results due to the negligence of market structure elements. In order to avoid the aggregation problem, in this paper we use survey data on the exports of 22

Taiwanese petrochemical industries from 1986 to 1992 to investigate the exchange rate pass-through effect. Moreover, in addition to production cost and capacity utilization, special attention has been paid to the Herfindahl Index and price elasticities of demand in order to emphasize the importance of market structure and industry characteristics in the studies of the exchange rate pass-through effects.[4]

A number of important features should be noted when discussing the exchange rate pass-through effects of Taiwan's petrochemical industry. First, though it is a large-scale industry in Taiwan, it only exports a relatively small portion of its total output.[5] Secondly, it is a highly concentrated industry, i.e., it owns a relatively strong power of monopoly. Therefore, we expect this kind of industry to have a lower incentive to adjust its markup ratio in response to the changing of exchange rates except for the purpose of holding foreign market shares [Froot & Klemperer (1989)]. By studying these particular industries' exchange rate pass-through effects, one can not only examine whether all industries in Taiwan have manipulated the exchange rate for the purpose of gaining an unfair competitive advantage in the international market, but it also can provide us more information about industry-specific pricing behavior.

In addition to this section, the rest of this paper is organized as follows. Section 2 sets up the analytical framework for our empirical analysis of exchange rate pass-through and builds the empirical equations used in this study. Section 3 illustrates the characteristics of Taiwan's petrochemical industries and data description. Section 4 presents and analyzes the econometric estimates of exchange rate pass-through effects. The final section concludes the paper.

II. Analytical Framework

As mentioned by Hooper & Mann (1989), exchange rate pass-through can be broadly defined as the extent to which a change in the nominal exchange rate induces

a change in the import price. Since our analysis is focused on export price indexes, it is natural to define the exchange rate pass-through effect as the partial derivative of export price indexes with respect to the exchange rate minus one. In addition, following previous empirical researches [e.g. Hooper & Mann (1989), Marston (1990), Kim (1990), Athukorala (1991), Athukorala & Menon (1994)], we adopt a variant of markup models of price determination. In this kind of framework, we can discuss the strategic interaction between domestic and foreign firms operating through variations in the markup.

Under the assumption of imperfect competition, domestic firms more or less have a capability to control their prices of output and set the home-currency export prices (PEX) at a markup (MK) over the level of normal unit production cost (MC):

$$PEX = (1 + MK)\,MC \tag{1}$$

According to the existing literatures, there are many factors that may have impacts on the markup ratio, e.g., demand pressures in all markets combined, competitive pressures in foreign markets, maintaining foreign market share, and market structure. In this study, the demand pressures in all markets are proxied by the capacity utilization rate (CU). As the capacity utilization rate goes up, it implies that total demand in all markets is increasing. It is then easier for the domestic firms to raise domestic and export prices above marginal and average costs. The competitive pressures in the foreign markets are represented by the price elasticities of demand with respect to domestic firms in foreign markets (EL) and the weighted exchange rate (RX). The pricing theory tells us that other things being equal, the markup ratios are inversely related to elasticities of demand. Therefore, the higher the price elasticities of demand with respect to the domestic firms in the foreign markets, the less possible it is for the domestic firms to raise export prices above marginal costs. As for the exchange rate, it partially reflects the pressure of the foreign competitive price and partially reflects domestic firms' pricing strategy toward foreign market share [Mann

(1986), and Froot & Klemperer (1989)]. On the other hand, the market structure is captured by the domestic market concentration (H). It has been shown in oligopoly theory that the higher the level of domestic market concentration, the more likely it is that domestic firms will be able to raise domestic prices and, then, the export prices above marginal and average cost [Khalizadeh-Shirazi (1974)]. As a result, the markup ratio function can be expressed as follows:

$$MK = MK(\overset{(+)}{CU},\ \overset{(-)}{EL},\ \overset{(+)}{RX},\ \overset{(+)}{H}) \tag{2}$$

Substituting equation (2) into equation (1), the export price equation can be shown as:

$$pex_t^i = \alpha_0 + \alpha_1 rx_t^i + \alpha_2 mc_t^i + \alpha_3 CU_t^i + \alpha_4 H_t^i + \alpha_5 EL_t^i + \varepsilon_{1t} \tag{3}$$

$$0 \le \alpha_1 \le 1;\ \ \alpha_2,\ \alpha_3,\ \alpha_4 \ge 0;\ \ \alpha_5 \le 0;\ \ i = 1, \ldots, 22;$$

where lowercase letters represent logarithmic values of variables, and superscript i states the ith petrochemical product and subscript t states the time period.

Not all of the export prices of petrochemical products are based on FOB terms, some of them are based on C & F or CIF terms. When the distance between the home and destination countries increases, the transportation cost and the probability of an accident occurring during shipping will go up, and the domestic firms will tend to raise export prices. Therefore, we add a transportation cost variable (TC) to equation (3) to yield

$$pex_t^i = \alpha_0 + \alpha_1 rx_t^i + \alpha_2 mc_t^i + \alpha_3 CU_t^i + \alpha_4 H_t^i + \alpha_5 EL_t^i + \alpha_6 tc_t^i + \varepsilon_{2t} \tag{4}$$

$$0 \le \alpha_1 \le 1;\ \ \alpha_2,\ \alpha_3,\ \alpha_4,\ \alpha_6 \ge 0;\ \ \alpha_5 \le 0$$

The partial derivative of *pex* with respect to *rx*, α_1, measures the responsiveness of the domestic currency export price to a change in the weighted exchange rate. The pass-through coefficient or pricing to market coefficient (PTM) is then $\alpha_1 - 1$, which measures the effect of a changing exchange rate on the foreign currency price. At one

extreme, if the domestic firms are price takers, then $\alpha_1 = 1$, and exchange rate changes are reflected entirely in domestic currency prices through a markup adjustment leaving foreign currency prices unchanged while PTM will be zero. At the opposite extreme, where the domestic firms do have market or monopoly power in the foreign markets, changes in the exchange rate are passed through completely and the markup is left unchanged, i.e., $\alpha_1 = 0$ and $PTM = -1$. In between these two extremes, we have the case of incomplete pass-through or pricing to market, i.e., $-1 \le \alpha_1 - 1 \le 0$.

Rewriting equation (1) and substituting the related explanatory variables into the equation, we can get a variant of the empirical model of the markup ratio equation as follows:

$$MK_t^i = \beta_0 + \beta_1 rx_t^i + \beta_2 CU_t^i + \beta_3 H_t^i + \beta_4 tc_t^i + \beta_5 EL_t^i + \varepsilon_{3t} \qquad (5)$$

$$0 \le \beta_1 \le 1;\ \beta_2,\ \beta_3,\ \beta_4 \ge 0;\ \beta_5 \le 0;$$

where $MK = (PEX - MC)/MC$. Equation (5) can directly measure the effects of factors influencing a change in the markup ratio and its estimation results are supposed to be consistent with those in equation (4).

Furthermore, we can discuss the pricing behavior of the exporting firms through Price-Cost Margin (PCM). Assuming that the PCM function has the same explanatory variables as MK or pex, the PCM equation can be expressed as:

$$PCM_t^i = \gamma_0 + \gamma_1 rx_t^i + \gamma_2 CU_t^i + \gamma_3 H_t^i + \gamma_4 tc_t^i + \gamma_5 EL_t^i + \varepsilon_{4t} \qquad (6)$$

$$0 \le \gamma_1 \le 1;\ \gamma_2,\ \gamma_3,\ \gamma_4 \ge 0;\ \gamma_5 \le 0;$$

where $PCM = (PEX - MC)/PEX$. However, the effect of exchange rate fluctuation on PCM is not so clear as the above equations. Nevertheless, it has been shown in Appendix A that under some reasonable assumptions, the exchange rate still has a positive effect on PCM.

III. Data Descriptions and Features of Taiwan Petrochemical Industries

The data used in this study are based on the annual survey data of 22 midstream petrochemical industries in Taiwan for the period of 1986 to 1992. Though there are more than thirty different products in the midstream petrochemical industry, data on some of these products are not complete. Therefore, we only choose 22 of them in our study. Moreover, data for some related explanatory variables are missing before 1986, we have to limit our sampling period to start from 1986. The detailed information about the 22 petrochemical products, computations of Herfindahl index, price elasticities, weighted exchange rate and weighted transportation cost, and related data sources are enclosed in Appendix B and table B.1.

Before we begin our empirical analysis, it is worth describing the features of Taiwan petrochemical industries. In table 2, we have shown some characteristics of those 22 petrochemical industries. First, from the last column we can see that 10 out of 22 industries' Herfindahl indexes were one during the period, i.e., they have strong monopoly power in the domestic market. Secondly, from columns 4, 5 and 6 we can find that only 5 of 22 industries' average export/domestic production ratios are higher than 30 percent during the period. However, most industries' export/domestic production ratios had been increasing during the period. This implies that the foreign countries' market shares have become more and more important for Taiwan's petrochemical industries. Thirdly, in the early stage of the petrochemical industries' development, their focus was on the domestic market and not until the mid-1980s did they start to export their products. Moreover, most of the export destination countries are small countries in which their domestic firms usually produce a small amount of the related petrochemical products. It can be seen from table 3 that only a few products' export destination countries are developed countries.

IV. Estimation Results

Since each of equation (4), (5) and (6) in section II has different economic implications, in this section we will estimate the above mentioned equations and to examine whether the empirical results are consistent or not. Table 4 reports empirical results of the export price (pex), markup ratio (MK) and price-cost margin (PCM) equations for Taiwan's petrochemical industries. Since all we have is 7 years of annual survey data for 22 petrochemical industries, we adopt the pooling regression procedure to estimate the three equations. The explanatory variables consist of unit production cost (mc), weighted exchange rate (rx), capacity utilization rate (CU), Herfindahl Index (H), demand elasticity (EL) and transportation cost (tc). The production cost, weighted exchange rate and transportation cost are in logarithmic form. Because not all variables have significant estimates, we report several variants of estimates. In addition to the coefficient for each variable, the table also reports the adjusted R^2 and root mean square error.

The estimation results of the export prices' equations show that, except for demand elasticity, all the explanatory variables have the right signs as expected. Among them, unit production cost, weighted exchange rate, capacity utilization rate and transportation cost are significantly different from zero at the 10 or 5 percent level of significance, while the market concentration and demand elasticity are insignificantly different from zero. Though the effect of the exchange rate on export prices is significantly different from zero, the magnitude is rather small and is around 0.07. This implies that on average, Taiwanese petrochemical firms absorb only about 7 percent of a given exchange rate change in their export prices, i.e., the exchange rate pass-through effect is as high as 93 percent. It is contrary to the general perception that most exporters in developing countries have pricing to market behaviors.

For the markup ratio function, the regression results are shown in the middle part of table 4. It can be seen that the results are very similar to those in the export price equations. The weighted exchange rate, capacity utilization rate, transportation cost and market concentration rate all have significant positive effects on the markup ratio. Though demand price elasticity has the right sign, it is insignificantly different from zero. Since the markup ratio is not expressed in logarithmic form, we cannot interpret the coefficient of the weighted exchange rate as an elasticity. However, we can approximate it through dividing the coefficient by the sample mean of MK. In this way, we can get the elasticity of the markup ratio with respect to the weighted exchange rate as around 0.19.[6] The results of the price cost margin equation are shown in the bottom of table 4. They are also very similar to those in the export price and markup ratio equations. The computed elasticity of PCM with respect to the weighted exchange rate is also around 0.19, which is very close to the findings of MK equations.[7] Moreover, by referring to equation (A.12) in the Appendix A, the positive sign of the coefficient of the exchange rate in the PCM equation implies that firms in Taiwanese petrochemical industries and export destination countries are in the competitive situation.

The empirical results of the export price, MK and PCM equations all show that the impact of the exchange rate on the export price is relatively small, in the range from 7% to 19%. These results are quite different from economists' general impression. Actually, from some existing empirical studies, exporters in developing countries such as Korea and Taiwan do have pricing-to-market behavior [Athukorala (1991), Liu (1994)]. However, why do the exporting firms of petrochemical products in Taiwan enjoy more than an 80% pass-through effect? The possible reasons are stated as follows. First, it is a general feature in the petrochemical industry that the volatility of profitability is very large. Therefore, firms are unwilling to change their markup while the exchange rate fluctuates. Second, from table 2 it has been shown

that the petrochemical industries in Taiwan are highly concentrated. They own a strong monopoly power and have a large domestic market share. Moreover, as we have shown in section 3, the export/domestic production share is relatively small. They do not rely on the foreign market to maintain production efficiency. Third, most of the markets to which Taiwan's petrochemical products being exported are small-scale markets in which there do not existt domestic firms or their domestic firms usually produce a small amount of the related products. Therefore, Taiwanese petrochemical firms can have a strong position toward those countries. This can also be justified by all the estimated coefficients of demand elasticity in the variant equations being insignificantly different from zero.

It can be noted from table 1 that the NT/US$ exchange rate has been stabilizing since 1989. It is interesting whether the exchange rate pass-through effect of Taiwan's petrochemical industries has structure changes or not [Kim (1990)]. However, our data period is too short to analyze the time-varying property of exchange rate pass-through parameters. Nevertheless, we can discuss the issue by dividing our sample period into two separate periods, and present our estimation results in table 5 and table 6, respectively. Comparing the exchange rate parameters between these two tables, we find that when the coefficients are significant, the exchange rate parameters in the second period are all almost twice as much as those in the first period. The exchange rate elasticity of MK or PCM in the first period was around 13%, and in the second period it was about 30%.[8] In table 7 we also present the rolling estimation for every four years of each equation. It can be seen from the table that exchange rate elasticities of the estimated parameters do have the tendency to increase through time. By referring to equation (A-12) in the Appendix A, it implies that when the elasticity of collusion(β) is negative and the absolute value of β is increasing, the impact of exchange rate change on PCM will be positive and increasing. That is, Taiwan's petrochemical export firms have been more and more pricing to market in recent years.

This implication may be justified by the fact that while petrochemical firms in most countries have continued expanding their capacities since 1986, the degree of competition in the world petrochemical markets has become increasing. In addition, Taiwanese petrochemical firms have not been so well protected as before in holding their market shares in the domestic markets since the government lifted all restrictions on the import of petrochemical products and lowered the related import tariffs in 1986. They gradually realize that a proper pricing behavior in response to exchange rate changes is very important for them to penetrate the world market, to reach minimum efficient scale and to attain production efficiency. On the other hand, the increasing degree of pricing-to-market may also be explained by acquiring the modern management and marketing knowledge of entrepreneurs in Taiwan's petrochemical industries. Therefore, they are increasingly aware of the importance of holding world market share in order to maintain a long-run business [Froot & Klemperer (1989)].[9]

V. Conclusion

In the existing literatures, there is a general perception that Newly Industrializing Countries like Korea and Taiwan have little control over prices at which they sell and therefore exchange rate changes may not have significant impacts on their foreign currency-denominated export prices in international markets. In this paper we investigate a special industry, petrochemicals, which has a high monopoly power and faces weak competition in export destination countries, to demonstrate that not all industries in Taiwan's export sectors have a strong pricing-to-market pattern. The empirical results show that Taiwanese petrochemical export firms absorb only about 7 percent of a given weighted exchange rate change in their export prices, and a 19 percent impact of a one percent exchange rate change on the markup ratio or price-cost margin. It implies that Taiwan's petrochemical industries have had a weak

pricing-to-market pattern during the period of 1987 to 1992. The empirical results may be explained by the large volatility of profitability, high market concentration, and small export/domestic production share. These empirical results further support the argument, pointed by Knetter (1993), that the range of parameter estimates across industries within each source country is very wide and there exist little differences in behavior within common industries of different source countries. We also show that though influences of the exchange rate on export prices, MK or PCM are relatively low in Taiwan's petrochemical industries, the impacts have a tendency to increase over time. This might be attributed to increasing competition in the world market and/or the realization of the importance of world market shares for Taiwanese petrochemical export firms. Finally, our results are very preliminary due to the short sampling period and insufficient data of foreign countries. If we could have prices of petrochemical products in every export destination countries, we would have more reasonable proxies for demand pressures. In addition, more rigorous analyses on the causes for structural change of pricing-to-market and the cyclical behavior of pass-through effects are worth of future research.

Table 1. Main Economic Indicators for Taiwan External Sectors

Variable \ Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Export Price Index	103.93	111.68	113.01	112.85	113.15	112.43	108.44	102.06	100.29	97.40	99.64	100.00	96.39	100.94	103.60	110.07
Import Price Index	116.03	126.00	124.20	122.72	122.02	120.07	109.46	101.93	101.03	98.09	100.39	100.00	95.27	99.33	103.85	113.23
Exchange Rate (NT/US$)	36.00	36.84	39.12	40.07	39.60	39.83	37.84	31.74	28.59	26.41	26.89	26.81	25.16	26.39	26.46	26.48
Exports of goods and services (US$ Million)	21758	24998	24347	27809	33270	33674	43836	58456	66694	73959	74896	85062	92038	98477	106305	127437
Imports of goods and services (US$ Million)	22251	24015	21847	23281	26643	25101	28900	40768	53743	62777	66914	76929	87592	94274	101730	121441
Trade Surplus (US$ Million)	-493	983	2500	4528	6628	8574	14937	17689	13221	11183	7981	8132	4445	4204	4576	5996
GDP Growth Rate	7.30	6.16	3.55	8.45	10.60	4.95	11.64	12.74	7.84	8.23	5.39	7.55	6.76	6.32	6.54	6.06

Sources: "National Income", Directorate-General of Budget, Accounting and Statistics, Executive Yuan, Republic of China.

Table 2. Important Characteristics for Twenty-two Midstream Petrochemical Industries (Average for the period 1987~1992)

Characteristics / Industries	PRO	EX	EX/PRO % (87-89)	EX/PRO % (90-92)	EX/PRO % (87-92)	CU %	H
ABS	373437.50	229783.70	53.28	65.44	59.36	66.08	0.60
AN	134428.50	2876.50	3.57	6.62	2.10	97.55	1.00
BR	41687.17	21742.67	59.80	45.35	52.58	104.05	1.00
CPL	104830.17	896.67	0.36	1.34	0.85	103.13	1.00
DOP	191212.33	7144.33	3.86	3.71	3.78	61.88	0.55
EG	189398.00	9407.67	6.66	2.84	4.75	73.97	0.52
HDPE	162913.17	50362.00	26.18	36.67	31.42	79.28	0.54
LDPE	197460.50	38800.67	10.90	28.40	19.65	81.73	0.50
ME	11338.50	2537.00	25.19	19.62	22.40	97.32	1.00
ML	26331.83	3620.50	9.13	54.66	27.34	23.98	1.00
MMA	27465.83	2575.50	0.82	18.22	9.52	69.95	1.00
PA	66728.17	1575.33	63.16	1.58	2.37	91.92	1.00
PP	224162.33	13228.33	2.57	9.01	5.79	80.00	0.51
PPG	20938.33	3138.17	8.45	21.56	15.01	81.98	1.00
PS	336417.00	119572.50	22.88	40.98	31.93	70.52	0.34
PTA	780547.17	13199.67	0.00	2.10	1.05	87.17	0.90
PVA	40798.67	30578.83	79.13	71.69	75.41	82.25	1.00
PVC	888982.67	29244.83	1.21	5.01	3.11	80.23	0.78
SBR	140195.50	21627.83	10.94	28.57	19.76	56.97	0.88
SM	333008.83	15600.33	8.32	1.37	4.85	85.52	0.51
VAM	78779.00	4953.67	7.15	5.48	6.32	78.93	1.00
VCM	661603.67	0.00	0.00	0.00	0.00	75.47	0.91

Note: For the detailed description of the 22 petrochemical industries, please see Table B.1 in Appendix B.

PRO: Domestic Production; EX: Exports; CU: Capacity Utilization Rate; H: Herfindahl Index.

Table 3. Major Export Destination Countries of Taiwan Petrochemical Products in 1992 (%)

Product	ABS		AN		BR		CPL		DOP		EG	
c	Hong Kong	78.01	Indonesia	98.82	Hong Kong	22.38	Hong Kong	83.88	Hong Kong	58.80	Hong Kong	56.51
o	Malaysia	3.52	Hong Kong	0.94	Japan	13.62	Thailand	16.12	Vietnam	12.28	Singapore	18.71
u	U. S. A.	3.22	Bahrain	0.24	Malaysia	10.03			Australia	9.84	Philippines	8.67
n	Japan	1.58			Thailand	7.89			Korea	8.55	Malaysia	6.67
t	Thailand	1.25			Philippines	7.82			Philippines	3.66	South Africa	2.89
r	Netherlands	1.16			Germany	7.76			Thailand	1.93	Indonesia	2.65
i	Belgium	1.14			United Kingdo	6.33			Libya	1.60	Australia	1.97
e	United Kingdo	1.03			Korea	3.90			Indonesia	1.57	New Zealand	1.16
s	Philippines	0.86			Australia	3.13			Japan	0.52	Japan	0.72
	Singapore	0.86			U. S. A.	2.86			U. S. A.	0.52	Sri Lanka	0.04

Product	HDPE		LDPE		ME		ML		MMA		PA	
c	Hong Kong	87.18	Hong Kong	69.36	Japan	69.52	Hong Kong	96.14	Thailand	25.50	Hong Kong	27.51
o	Malaysia	4.35	Thailand	6.72	Indonesia	18.75	Pakistan	3.69	Philippines	14.83	Korea	27.51
u	Thailand	3.09	Japan	5.85	Malaysia	8.84	Malaysia	0.06	Hong Kong	13.44	Indonesia	23.21
n	Japan	2.81	Australia	5.11	Thailand	1.54	Macao	0.06	South Africa	9.02	Japan	9.08
t	Philippines	0.94	Malaysia	3.12	U. S. A.	0.35	Korea	0.03	Korea	7.78	Singapore	7.95
r	Jordan	0.91	Philippines	2.49	Israel	0.35	Vietnam	0.03	Australia	7.66	Philippines	1.93
i	Indonesia	0.73	Singapore	2.41	Iran	0.31			Japan	6.27	Australia	1.83
e			India	1.82	Singapore	0.28			New Zealand	5.19	South Africa	0.97
s			Indonesia	1.33	Belgium	0.06			Indonesia	4.97		
			Vietnam	0.80					Malaysia	3.04		

Table 3. (continued)

Product	PP		PPG		PS		PTA		PVA	
c	Hong Kong	59.04	Hong Kong	86.68	Hong Kong	85.02	Thailand	78.02	U. S. A.	55.84
o	Indonesia	25.40	Singapore	7.63	Japan	3.30	Indonesia	9.07	Germany	12.61
u	Thailand	6.75	Thailand	2.90	Thailand	2.59	Hong Kong	8.12	Indonesia	7.05
n	Malaysia	5.07	Australia	1.18	Malaysia	2.06	Singapore	1.62	Thailand	3.86
t	Italy	1.20	Indonesia	0.69	Korea	1.48	Philippines	1.35	Malaysia	3.82
r	South Africa	0.31	Pakistan	0.42	Singapore	0.99	Iceland	0.68	Mexico	2.45
i	Philippines	0.30	Malaysia	0.40	South Africa	0.77	Pakistan	0.68	Singapore	1.99
e	Vietnam	0.28	India	0.10	Philippines	0.66	Japan	0.32	Korea	1.86
s	Venezuela	0.28			India	0.61	Australia	0.11	Pakistan	1.85
	U. S. A.	0.26			Vietnam	0.54	Spain	0.03	Hong Kong	1.19

Product	PVC		SBR		SM		VAM		VCM	
c	Hong Kong	32.50	Hong Kong	46.86	Hong Kong	59.62	Hong Kong	49.28	Hong Kong	100.00
o	Thailand	30.81	Korea	21.15	Indonesia	11.89	Nigeria	18.97		
u	Philippines	22.34	Indonesia	14.43	Malaysia	11.31	Indonesia	13.09		
n	Japan	4.80	Philippines	10.58	Australia	4.99	Sri Lanka	11.76		
t	Singapore	3.30	Thailand	2.82	United Arab Emirate	4.11	Thailand	5.31		
r	Malaysia	3.06	Pakistan	2.82	Igypt	4.11	New Zealand	0.76		
i	Indonesia	1.90	Mexico	0.80	Pakistan	2.06	India	0.38		
e	Vietnam	0.68	Singapore	0.53	Thailand	0.73	Malaysia	0.38		
s	South Africa	0.19	India	0.00	Nigeria	0.44	Japan	0.08		
	U. S. A.	0.15			Saudi Arabia	0.44				

Table 4. Estimates of Export Price, Markup Ratio and Price-Cost Margin, 1986~1992

Dep.Var. \ Ind.Var.	constant	mc	rx	CU	tc	H	EL	$\bar{R}^{2}$ [b]	RMSE [c]
pex	4.293 (-1.470)[a]	0.341 (1.357)	0.073 (2.008)**	0.835 (1.997)*	0.196 (1.632)	0.0006 (1.411)	0.0002 (0.155)	0.094	0.297
pex	3.008 (1.261)	0.481 (2.379)**	0.077 (2.357)**	1.118 (3.563)***	0.156 (1.454)	0.0006 (1.503)		0.279	0.287
pex	2.972 (1.672)*	0.512 (3.336)***	0.054 (2.070)**	0.897 (3.167)***	0.170 (1.819)*			0.280	0.284
MK	-4.260 (-3.447)***		0.156 (3.072)***	2.183 (3.854)***	0.373 (2.188)**	0.001 (1.706)*	-0.0004 (-0.272)	0.425	0.431
MK	-4.217 (-3.402)***		0.138 (2.913)***	2.137 (4.731)***	0.334 (2.224)**	0.001 (1.779)*		0.448	0.417
PCM	-2.270 (-2.594)***		0.067 (2.027)**	0.751 (2.031)**	0.219 (1.972)*	0.0005 (1.131)	-0.0004 (-0.428)	0.196	0.281
PCM	-2.064 (-2.619)		0.063 (2.095)**	0.796 (2.771)***	0.190 (1.993)**	0.0005 (1.239)		0.233	0.265

[a] The figures in parentheses below the coefficients are t-statistics, with significance levels denoted as: * = 10%, ** = 5%, *** = 1%.

[b] Adjusted R^2

[c] Root of Mean Square Error

Table 5. Estimates of Export Price, Markup Ratio and Price-Cost Margin 1986~1989

Dep.Var. \ Ind.Var.	constant	mc	rx	CU	tc	H	EL	$\bar{R}^{2}$ [b]	RMSE [c]
pex	-3.004 (-0.715)[a]	1.183 (3.283)***	0.071 (2.321)**	2.120 (3.368)***	-0.038 (-0.270)	0.0005 (1.799)*	-0.0008 (-0.565)	0.576	0.178
pex	-2.021 (-0.598)	1.082 (3.784)***	0.065 (2.318)**	1.496 (4.040)***	0.033 (0.309)	0.0005 (1.730)		0.639	0.178
pex	3.756 (1.986)*	0.639 (4.097)***	0.033 (1.326)	1.247 (3.939)***	-0.108 (-1.145)			0.553	0.192
MK	-1.895 (-1.665)		0.108 (2.642)**	3.502 (3.959)***	-0.094 (-0.551)	0.0009 (2.105)*	-0.0009 (-0.520)	0.605	0.251
MK	-2.076 (-1.923)*		0.102 (2.668)**	2.742 (5.503)***	0.016 (0.125)	0.0009 (2.136)**		0.659	0.248
PCM	-0.454 (-0.752)		0.044 (2.024)*	1.331 (2.833)**	-0.058 (-0.634)	0.0003 (1.439)	-0.0003 (-0.287)	0.387	0.133
PCM	-0.594 (-1.031)		0.043 (2.085)*	0.838 (3.152)***	0.015 (0.228)	0.0003 (1.385)		0.382	0.132

[a] The figures in parentheses below the coefficients are t-statistics, with significance levels denoted as: * = 10%, ** = 5%, *** = 1%.

[b] Adjusted R^2

[c] Root of Mean Square Error

Table 6. Estimates of Export Price, Markup Ratio and Price-Cost Margin 1990~1992

Ind.Var. / Dep.Var.	constant	mc	rx	CU	tc	H	EL	$\bar{R}^{2}$ [b]	RMSE [c]
pex	7.903 (2.218)** [a]	-0.170 (-0.556)	0.054 (0.848)	0.251 (0.500)	0.406 (2.307)**	0.0032 (0.675)	0.0005 (0.421)	0.121	0.294
pex	5.149 (1.764)*	0.164 (0.672)	0.106 (1.943)*	0.588 (1.306)	0.344 (2.174)**	-0.0021 (-0.751)		0.257	0.298
pex	4.314 (1.839)*	0.205 (0.961)	0.116 (2.517)**	0.726 (1.971)*	0.355 (2.783)***			0.349	0.280
MK	-7.149 (-2.461)**		0.211 (1.901)*	1.872 (2.193)**	0.712 (2.219)**	0.0012 (0.139)	0.0007 (0.284)	0.375	0.539
MK	-6.074 (-2.805)***		0.167 (1.793)*	1.551 (2.038)*	0.644 (2.417)**	-0.0004 (-0.081)		0.385	0.510
PCM	-3.200 (-1.638)		0.095 (1.269)	0.543 (0.946)	0.375 (1.738)*	- 0.0019 (-0.340)	-0.0003 (-0.215)	0.131	0.362
PCM	-3.023 (-2.149)**		0.089 (1.472)	0.470 (0.950)	0.365 (2.108)**	-0.0021 (-0.672)		0.211	0.332

[a] The figures in parentheses below the coefficients are t-statistics, with significance levels denoted as: * = 10%, ** = 5%, *** = 1%.

[b] Adjusted R^2

[c] Root of Mean Square Error

Table 7. Estimated Exchange Rate Elasticities for Different Periods[a]

Dep.Var.	1987~1989	1988~1990	1989~1991	1990~1992
pex	0.065	0.066	0.074	0.106
MK	0.102 (0.133)[b]	0.114 (0.152)	0.122 (0.179)	0.167 (0.237)
PCM	0.043 (0.120)	0.048 (0.137)	0.054 (0.172)	0.089 (0.290)

[a]Since the estimates of demand elasticity in all equations are insignificantly different from zeroes, in this table we present regression results which contain mc, rx, CU, tc and H as explanatory variables.

[b]The figures in parentheses below the coefficients are elasticities.

NOTES

1. It can be seen from table 1 that the average NT/US$ exchange rate had been decreasing from 36.84 in 1981 to 26.41 in 1989, which is over a 38.31 percent appreciation. However, during the same period the export price indexes dropped from 111.68 to 97.40, only decreasing 12.79 percent.
2. Incomplete exchange rate pass-through is often mentioned as one of the main reasons for sluggish adjustment in the trade imbalance among countries.
3. For the case of Japan and other countries, please see Athulorala & Menon (1994), Froot & Klemperer (1989), Knetter (1993), Marston (1990), Menon (1995), Ohno (1989), etc.
4. Herfindahl Index is a measure of market concentration or fewness, and is equal to the sum of squares of the market shares of the firms in the market.
5. It can be seen from table 2 that there were 12 out of 22 industries whose average export/domestic production share was less that 10 percent during the period 1986 to 1992.
6. The sample mean of markup ratio during the period 1987 to 1992 is 0.737.
7. The sample mean of price cost margin for the sampling period is 0.333.
8. The sample means of MK and PCM for first period are 0.769, 0.359, and 0.706, 0.307 for second period, respectively.
9. Since 1985, accompanied by the recovery of the world economy, petrochemical industries world wide have vigorously expanded their production capacity, which increases the degree of competition among world petrochemical exporters.

Appendix A. Derivation of the Impact of the Exchange Rate on PCM

Following Cowling & Waterson (1976), Brander & Krugman (1983) and Dei (1990), we envisage two open economies, home and foreign countries. Assume that there is a monopolist producing a homogeneous product with the same cost condition, respectively, in both countries. Suppose that marginal costs are constant at c for both monopolists, and the inverse market demand functions in both countries are as follows:

$$P^d = P^d(X^h + X^m),\ P^{d\prime} < 0 \tag{A-1}$$

$$P^w = P^w(X^e + X^f),\ X^w = X^e + X^f,\ P^{w\prime} < 0; \tag{A-2}$$

where P^d and P^w represent prices at home and in the foreign countries, respectively; X^h and X^e, quantities produced by the domestic firm and sold at home and in the foreign countries, respectively; X^m and X^f, quantities produced by the foreign firm and sold at home and in the foreign countries, respectively; X^w, total quantity demanded in the foreign country. Let $P^e = r \cdot P^w$, where P^e represents the home-currency export price and r is the exchange rate. Then, the domestic firm's and the foreign firm's profits can be formulated as follows:

$$\pi^d = (P^d - C)X^h + (P^e - C)X^e - F^d \tag{A-3}$$

$$\pi^w = (rP^w - C)X^f + (P^d - C)X^m - F^w; \tag{A-4}$$

where π^d and π^w represent the domestic firm's and the foreign firm's profits, respectively; F^d and F^w, the domestic firm's and the foreign firm's fixed costs, respectively.

Assuming profit-maximizing behavior and Cournot zero conjectural variation, the first-order conditions for a maximum can be derived as follows:

$$\frac{\partial \pi^d}{\partial X^e} = P^e + rX^e P^{w\prime} - C = 0 \tag{A-5}$$

$$\frac{\partial \pi^{w}}{\partial X^{f}} = rP^{w} + rX^{f} P^{w\prime} - C = 0 \qquad \text{(A-6)}$$

Taking total differentiation of equations (A-5) and (A-6), and rearranging and manipulating them yields

$$\begin{bmatrix} 2rP^{w\prime} & rP^{w\prime} \\ rP^{w\prime} & 2rP^{w\prime} \end{bmatrix} \begin{bmatrix} dX^{e} \\ dX^{f} \end{bmatrix} = \begin{bmatrix} -(P^{w} + P^{w\prime} X^{e})dr + dC \\ -(P^{w} + P^{w\prime} X^{f})dr + dC \end{bmatrix} \qquad \text{(A-7)}$$

Assuming that the costs of production remain constant (i.e., $dC = 0$), we can obtain by the Cramer's Rule

$$\frac{\partial X^{e}}{\partial r} = \frac{rP^{w\prime}\left[P^{w\prime}(X^{f} - 2X^{e}) - P^{w}\right]}{3(rP^{w\prime})^{2}}$$

$$> 0 \quad , \quad if\ X^{f} > 2X^{e}; \qquad \text{(A-8)}$$

$$? \quad , \quad otherwise.$$

$$\frac{\partial X^{f}}{\partial r} = \frac{rP^{w\prime}\left[P^{w\prime}(X^{e} - 2X^{f}) - P^{w}\right]}{3(rP^{w\prime})^{2}}$$

$$> 0 \quad , \quad if\ X^{e} > 2X^{f}; \qquad \text{(A-9)}$$

$$< 0 \quad , \quad if\ X^{f} > 2X^{e};$$

$$? \quad , \quad otherwise,$$

where the absolute value of $-3X^{e}P^{w\prime}$ is assumed to be greater than that of P^{w}.

In order to allow possible collusion between the domestic and foreign firms, we relax the assumption that the domestic firm expects no response to its output change from the foreign firm. Therefore, equation (A-5) becomes

$$rX^{e}P^{w\prime}(1 + \frac{\partial X^{f}}{\partial X^{e}}) + rP^{w} - C = 0 \qquad \text{(A-10)}$$

By rearranging and manipulating equation (A-10), we can obtain

$$PCM \equiv \frac{P^{e} - C}{P^{e}} = (1 + \frac{X^{f}}{X^{e}}\beta)\frac{1}{\varepsilon^{p}_{w,h}}; \qquad \text{(A-11)}$$

where PCM represents the exporting price cost margin of the domestic firm; β, the elasticity of collusion between the domestic and the foreign firms; $\varepsilon^{p}_{w,h}$, the domestic

firm's price elasticity of demand in the foreign country. Finally, by taking partial differentiation of equation (A-11) with respect to r and referring to equations (A-8) and (A-9), we can obtain

$$\frac{\partial PCM}{\partial r} = \frac{\beta}{\varepsilon^{p}_{w,h}} \cdot \frac{X^{e}\dfrac{\partial X^{f}}{\partial r} - X^{f}\dfrac{\partial X^{e}}{\partial r}}{(X^{e})^{2}}$$

$$> 0 \quad , \quad if\ \beta < 0\ and\ X^{f} > 2X^{e}; \qquad \text{(A-12)}$$

$$< 0 \quad , \quad if\ \beta > 0\ and\ X^{f} > 2X^{e},$$

where $\beta = 1$ stands for perfect collusion, $\beta = -1$ is perfect competition, $0 < \beta < 1$ is imperfect collusion, and $-1 < \beta < 0$ is imperfect competition [Clarke & Davies (1982), Cubbin (1983)].

Appendix B. Computation of Related Variables and Data Sources

1. Computation of Related Variables

MK: *markup ratio* = $(PEX - MC) / MC$

PCM: *price-cost margin* = $(PEX - MC) / PEX$

H: *Herfindahl index* = $\sum_{i=1}^{22}\left[(PRO_i - EX_i) / \sum_{j=1}^{22}(PRO_j - EX_j)\right]^2$

el: *exports demand price elasticity* = $(\frac{EX_t - EX_{t-1}}{EX_{t-1}}) / (\frac{PEX_t - PEX_{t-1}}{PEX_{t-1}})$

RX: *weighted exchange rate* = $\sum_{i=1}^{n} \frac{EX_i}{\sum_{j=1}^{n} EX_j} RX_i$

TC: *Weighted transportation cost* = $\sum_{i=1}^{n} \frac{EX_i}{\sum_{j=1}^{n} EX_j} VD_i$

2. Data sources for each variable are indicated by (A)~(E) below:

CU: capacity utilization rate (A)

EX: export quantity (B)

MC: unit production cost (C)

PEX: export price (A)

PRO: domestic production quantity (A)

RX: exchange rate (D)

VD: voyage distance (E)

(A): Taiwan Petrochemical Industry Union

(B): Monthly Statistics of Exports and Imports, Taiwan Area, R.O.C.

(C): Commodity-Price Monthly in Taiwan Area of R.O.C.

(D): International Financial Statistics

(E): Ministry of Communication, Executive Yuan, Taiwan, R.O.C.

Table B.1 Description of 22 Midstream Petrochemical Products

Abbreviation	Description
ABS	ABS Resin
AN	Acrylonitrile
BR	Butadiene Rubber
CPL	Caprolactam
DOP	Dioctyl Phthalate
EG	Ethylene Glycol
HDPE	High Density Polyethylene
LDPE	Low Density Polyethylene
ME	Melamine
ML	Methanol
MMA	Methyl Methacrylate Acid
PA	Phthalic Anlydride
PP	Polypropylene
PPG	Polypropylene Glycol
PS	Polystyrene
PTA	Terephthalic Acid
PVA	Polyvinyl Alcohol
PVC	Polyvinyl Chloride
SBR	Styrene-Butadiene Rubber
SM	Styrene
VAM	Vinyl Acetate
VCM	Vinyl Chloride

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