CHAPTER 4

EXCHANGE RATE PASS-THROUGH AND MARKET POWER

4.1 Introduction

Taiwan is well known for its miraculous economic development as well as glaring export performance. But it is less noticed that Taiwan has to import a variety of raw materials and semi-processed products each year due to its limited natural resources endowment. In Taiwan, there are more than 30 midstream petrochemical industries that refine the crude oil and natural gas before they are used as inputs for the downstream petrochemical industries. Most of the inputs of the midstream petrochemical industries are imported due to the fact that Taiwan is in serious short supply of both crude oil and natural gas. The high degree of import dependence of the midstream petrochemical products is clearly reflected in the trade deficit and import ratio shown in Table 4.1. However, Taiwan's downstream petrochemical industries have moved to China to seek cheaper labor and larger market demand in recent years. The international linkage between China and Taiwan significantly affects those midstream petrochemical industries which have remained in Taiwan, the first significant change is the trade surplus of midstream petrochemicals after 2000.

Under the pressure of the US government to reduce the trade imbalance with the USA, the Central Bank of China has floated the New Taiwan dollars (NT$) since 1986 and gradually given up its intervention in the foreign exchange market. However, as Tables 4.1 and 4.2 reveal, there is no indication that Taiwan's trade balance as a whole or in terms of the 21 midstream petrochemical industries has been significantly affected by the variations in the foreign exchange rate. In other words, the increase (decrease) in the value of NT$ does not lead to deterioration (improvement) of the trade imbalance. This is at direct variance with what predicted by the conventional trade theory, namely, floating exchange rate system would eliminate trade imbalance provided that the Marshall-Lerner condition is satisfied.[19] As a result, we have faced the celebrated "adjustment puzzle" in international economics. With a growing consensus that trade balance is not exclusively

[19] In a two-country model, the Marshall-Lerner condition requires that the sum of the elasticity of demand for imports of the two countries be greater than one.

determined by the exchange rate, however, most of the studies to date have shifted the focus from the “adjustment puzzle” to the relationship between the exchange rate and the prices of tradable goods.

The question of how exchange rate changes affect the price level is a popular question of research. Typically, this process is called exchange rate pass-through, referring to the degree to which exchange rate is passed through to price level changes. The degree of exchange rate pass-through, consequently, have important implications for the design of monetary policy to counteract the inflationary as well as trade implications of an exchange rate shock. There has been a large number of empirical studies on exchange rate pass-through. Most of these previous studies generally have found that pass-through is incomplete, implying that import prices are less volatile than exchange rates. Goldberg and Knetter (1997) present a review of the literature in this area and concluded that pass-through into US import prices was on the order of 50 percent, large variations around this estimate occur by industry. Antzoulatos and Yang (1996), Yang (1997) and Olivei (2002) all perform estimation of pass-through rates into import prices at the industry level and conclude that pass-through varies across industries. The existing evidence has been obtained by either focusing on a subset of narrowly defined industries, using data at the firm or product level (micro studies) or, more broadly, by looking at a cross-section of relatively aggregated industry statistics (industry studies).

Micro-oriented studies generally focus on pass-through from one country’s firms into another’s and concentrate on a particular product or industry. For example, Feenstra (1989) and Gron and Swenson (1996) examined the pass-through of movements of the yen into U.S. import prices for Japanese shipments of cars, trucks and motorcycles. Gil-Pareja (2003) and Goldberg and Verboven (2001) also focus on the degree of pass-through in the automobile industry by looking at detailed product imports from different countries. In other industries, Bernhofen and Xu (2000) examined the exchange rate pass-through into U.S. petrochemical imports from Germany and Japan and Blonigen and Haynes (2002) looks at Canadian exports of iron and steel into the United States.

The cross-industry studies focus on import prices for more than one industry at a time, often with more aggregated data than found in the micro-oriented studies. Yang

(1997), Pollard and Coughlin (2005) provide estimates of pass-through at broader industry classifications for imports in the manufacturing sector in the U.S. Similar evidence for five industry categories is presented for OECD countries in Campa and Goldberg (2005, 2006), Marazzi, Sheets, and Vigfusson (2005) and, for European Union 5 countries in Campa, Goldberg and Gonzalez Minguez (2005). Across the OECD countries, industry considerations, and particularly the sectoral composition of a country's imports, have been more important than macroeconomic volatility in explaining changes in exchange rate pass-through into aggregated import prices.

Most of the empirical studies on exchange rate pass-through using different empirical methodologies have focused on the industrialized countries, in particular the United States and Japan. Menon (1995) surveyed 48 studies on the exchange rate pass-through. He found that most of the research in this area is done on U.S and Japan data. Goldberg and Knetter (1997) noted that in the 1980s research on exchange rate pass-through was dominated by the analysis of pass-through for the U.S. However, a few studies on exchange rate pass-through have been done for developing countries (see Dowling and Rana, 1985; Alba and Papell, 1998; Anaya, 2000; Garcia and Restrepo, 2001; Goldfajn and Werlang, 2000; Frankel, Parsley, and Wei, 2005).

The first aim of our paper is to contribute to the empirical analysis of exchange rate pass-through into domestic prices in developing countries. The second goal of our paper is to investigate the effect of market power on exchange rate pass-through. This paper uses an industry-specific econometric model of exchange rate pass-through that distinguishes itself from other papers in the literature. In contrast to other structural models, which have almost exclusively focused on product-differentiated industries, we investigate exchange rate pass-through in the context of a homogeneous product oligopoly. Since oligopolistic pricing, in the case of identical products and a given demand structure, is a function of cost and firm conduct, we are able to obtain a transparent link between firm conduct and market power.

Our data allows us to test for non-competitive conduct of the US and Japanese midstream petrochemical firms exporting into Taiwan, consequently, the role of imperfect competition to account for the lack of pass-through in the midstream petrochemical industry. An important feature of this paper is its use of a product-specific data set for 21 traded midstream petrochemicals for Taiwan, the US

and Japan during 1986 to 2002. From 1986 to 2002, the US and Japan had been the biggest 2 importers in Taiwan midstream petrochemical industries, over 40% of imports coming from these two countries (see Table 4.3). It's the reason why we choose to analyze the exporting behaviors of the US and Japanese firms in Taiwan.

Our empirical estimates indicate that the US and Japanese firms exercised (statistically) 'significant' market power in Taiwan's midstream petrochemical market during our sample period. However, their market power played an insignificant role in explaining the domestic price adjustment to exchange rate movements.

The paper is organized as follows. Section 2 contains a general model of oligopoly. Section 3 describes the empirical specification and the data. The empirical results are then presented and discussed. Concluding remarks are contained in Section 4.

4.2 Theoretical Model

Following Bernhofen and Xu (2000), we consider an oligopolistic market of a homogeneous product in domestic country;[20] there are n^w foreign firms competing with domestic firms in the domestic market. Since our focus is on how exogenous changes in the exchange rate affect the equilibrium price in the domestic market. In particular, we are interested in the elasticity of the home equilibrium price with respect to the exchange rate. Since the channel through which the exchange rate affects the equilibrium price is the foreign marginal cost in terms of domestic currency, it is sufficient to restrict our attention to the foreign firms' profit function (Bernhofen & Xu, 2000). Let the inverse market demand function of the homogeneous product in domestic country be

$$P^d = P^d(X^d)$$

where P^d is the price of the good in domestic currency units, X^d is the total market supply. $X^d \equiv X^h + \sum_{k=1}^{n^w} x_k^m$, X^h denotes the supply by all domestic firms and x_k^m is the market supply by a foreign firm *k*. Therefore, the *k*th foreign firm's profit function in terms of the home country's currency can be expressed as:

[20] Although Taiwan's midstream petrochemical industries operate in either oligopolistic or monopolistic markets, we construct a general model for simplicity which is applicable to other kinds of market structure.

$$\pi_k^m = P^d \cdot x_k^m - ex \cdot \left(C_k^w + f^w + t^h\right) \cdot x_k^m - ex \cdot F^w, \quad (k = 1,..., n^w) \tag{4-1}$$

where π represents profit, *ex* is the exchange rate,[21] the marginal cost for the *k*th foreign firm is constant at C_k^w, *k*=1,2,…, n^w, in terms of the foreign country's currency. t^h stands for the specific tariff rate imposed by the home country and f^w is the unit transportation cost for foreign firms to export, and the F^w are fixed costs for foreign firms in terms of the foreign country's currency. The first-order condition that characterizes profit-maximizing behavior of a foreign firm is then given by:

$$P^d = ex \cdot \left(C_k^w + f^w + t^h\right) - \left(\partial P^d / \partial X^d\right) \cdot X_k^m \cdot \theta_k^m, \quad (k = 1,..., n^w) \tag{4-2}$$

where $\theta_k^m = \partial X^d / \partial x_k^m$ is the conjectural variation on how a foreign firm's supply affects the total industry supply in the domestic country. Eq. (4-2) has the standard interpretation of marginal revenue being equal to marginal cost, both measured in domestic currency. The conduct parameter θ_k^m can be viewed as a measure of the degree of market power that a foreign firm *k* holds in the industry.

Summing up the firms' first-order conditions given in Eq. (4-2), we obtain:

$$P^d = ex \cdot \left(\overline{C}^w + f^w + t^h\right) - \left(\partial P^d / \partial X^d\right) \cdot X^m \cdot \theta^m \tag{4-3}$$

$X^m \equiv \sum_{k=1}^{n^w} x_k^m$ represent the total supply by all the foreign firms in the domestic country, $\overline{C}^w \equiv \left(\sum_{k=1}^{n^w} C_k^w \cdot x_k^m / X^m\right)$ represent the weighted average of the foreign firms' marginal costs, $\theta^m \equiv \left(\sum_{k=1}^{n^w} \theta_k^m \cdot x_k^m / X^m\right)$ is a weighted sum of the foreign firms' conduct parameters, θ_k^m. Eq. (4-3) relates the market price P^d to the average foreign marginal cost $\overline{C}^w$, transportation cost f^w, tariff arte t^h and an industry conduct parameter θ^m.

We can rewrite Eq. (4-3) to obtain an empirical estimable pricing equation at the industry level:

[21] *ex* is expressed in terms of domestic currency units per foreign currency unit.

$$P^d = ex \cdot \left(\overline{C}^w + f^w + t^h \right) - \left(\partial P^d / \partial X^d \right) \cdot X^m \cdot \theta^m$$

$$= ex \cdot C^{w*} - \left[\frac{\partial P^d}{\partial X^d} \cdot \frac{X^d}{P^d} \cdot \frac{X^m}{X^d} \cdot P^d \cdot \theta^m \right]$$

$$= ex \cdot C^{w*} + \frac{1}{\varepsilon^d} \cdot s^m \cdot P^d \cdot \theta^m$$

Then we can obtain:

$$P^d \left(1 - \frac{1}{\varepsilon^d} \cdot s^m \cdot \theta^m \right) = ex \cdot C^{w*} \tag{4-4}$$

where $\varepsilon^d \equiv -P^d / X^d \cdot \partial X^d / \partial P^d$ is the price elasticity of demand in the domestic country, $s^m = X^m / X^d$ is the foreign firms' market share in the domestic market. C^{w*} is the average foreign marginal production cost plus transportation and tariff cost (actual average foreign marginal cost). Eq. (4-4) relates the home equilibrium price P^d to exchange rate ex, actual average foreign marginal cost C^{w*}, foreign market share s^m, inverse price elasticity of demand and the foreign industry conduct parameter θ^m. If no firm has any market power, i.e. $\theta^m = 0$, the market price will be equal to this marginal cost value. For given values of ε^d and s^m, a higher value of the industry conduct parameter θ^m implies a higher mark-up of price over the actual average marginal cost in the industry.

Taking natural logarithms on both sides of Eq. (4-4), we obtain:

$$\log P^d + \log\left(1 - \frac{1}{\varepsilon^d} \cdot s^m \cdot \theta^m \right) = \log ex + \log C^{w*} \tag{4-5}$$

Defining $\beta_s = \frac{\theta^m}{\varepsilon^d}$ and applying the Taylor series expansion of the logarithm,

Eq. (4-5) can be rewritten as:

$$\log P^d = \log ex + \log C^{w*} + \beta_s \cdot s^m + \sum_{j=2}^{j=\infty} \beta_s^j s^{mj} \tag{4-6}$$

Provided that $\beta_s \cdot s^m$ is sufficiently small, the last term on the right-hand side of Eq. (4-6) becomes negligible and the Taylor series formulation of $\log\left(1-\beta_s \cdot s^m\right)$ can approximated by it's liner term, which yields:

$$\log P^d = \log ex + \log C^{w*} + \beta_s \cdot s^m \tag{4-7}$$

The composite parameter β_s is our measure of market power in this paper. It consists of the main determinants of market power in a static environment-demand elasticity and non-competitive conduct. For a given positive inverse demand elasticity, a higher value of θ^m implies a greater degree of market power. The parameter β_s is treated as unobservable and will be estimated. Its two components, $\frac{1}{\varepsilon^d}$ and θ^m are unobservable and will not be separately identified when β_s is estimated.

we are interested in the elasticity of the home equilibrium price with respect to the exchange rate, the elasticity of exchange rate pass-through : $\varphi = \left(ex / P^d\right)\left(\partial P^d / \partial ex\right)$. It cab be derived from Eq. (4-7) as follows:[22]

$$\phi = 1 + \beta_s (\partial s^m / \partial \log ex) \tag{4-8}$$

Since an increase in the exchange rate increases the costs of all foreign firms,[23] it will reduce the foreign market share in the domestic market, i.e. $\partial s^m / \partial \log ex < 0$.[24] Therefore, if exists any market power, i.e. $\beta_s > 0$, the exchange rate pass-through will

[22] Based on the assumption that exchange rate changes have no effect on local currency values of marginal costs, i.e. $\partial \log C^{w*} / \partial \log ex = 0$.

[23] An increase in ex will increase the cost of foreign firms $ex \cdot C^{w*}$.

[24] It is a characteristic of oligopolistic competition.

be less than 1, if the market is perfectly competitive, i.e. $\beta_s = 0$, there will be complete pass-through, $\phi = 1$. The higher the degree of market power, i.e. the larger the value of β_s, the less pass-through will occur.

4.3 Empirical Model and Results

4.3.1 Specification

In contrast to other chemical products, midstream petrochemical products are intermediate goods and homogeneous in each industry (Bernhofen and Xu, 2000), besides, midstream petrochemical industries have production functions with fixed proportions, and their marginal costs are constant when the input prices are given. Therefore, midstream petrochemical industries fit perfectly to our theoretical model.

According to Eq. (4-7), empirical model in this paper can be established as

$$\log P_{it}^{d} = \beta_0 + \beta_e \log ex_t + \beta_c \log C_{it}^{w*} + \beta_s \cdot s_{it}^{m} + \varepsilon_{it} \tag{4-9}$$

where P_{it}^{d} refers to the Taiwan domestic price of midstream petrochemical product *i* at time *t*, ex_t is the bilateral exchange rate at time *t*, C_{it}^{w*} is the actual average foreign marginal cost for product *i* at time *t*, s_{it}^{m} is the foreign market share in Taiwan in product *i* at time *t*, and ε_{it} denotes the product- and time-specific disturbance term. On the other hand, we will take into account the 'exact' formulation given in Eq.(4-6).

In this paper, we intend to investigate the exchange rate pass-through of the US and Japan in Taiwan market, then, we estimate Eq (4-9) separately for the US and Japan.

There are several assumptions we need to address, first, that composite parameter β_s is not affected by exchange rate changes and that it is the same for all products in the sample. Since $\beta_s (= \theta^m / \varepsilon^d)$ consists of two components, we are assuming that the price elasticities of demand and the average industry conduct do not very across products.[25] Another assumption is with regard to the foreign market share, s^m, being specified as exogenous to price. In the context of a time series to a single

[25] See Bernhofen and Xu (2000).

product, price and market share are determined simultaneously. However in the context of a cross-section, the endogeneity bias is less severe since market share might be determined by product-specific exogenous factors.[26]

4.3.2 Data Description

Our data set consists of 21 midstream petrochemical products for which we have annual data for the sample period 1986-2002.

The price data are product-specific unit values, the exchange rate are the means of the spot exchange rate monthly. The marginal cost in our pass-through Eq. (9) might cause concerns. Product-specific cost data of foreign firms is not available, therefore, they are proxied by product- and country-specific import unit value for this study.

The foreign import share in Taiwan is the shares of imports from foreign countries in the total sales in the Taiwan market. Since all of our products are homogeneous, we are able to use quantity measures of imports and Taiwan sales.

Market prices are obtained from *Industrial Production Statistics Monthly*, published by Department of Statistics, Ministry of Economic Affairs. Quantity measures of foreign countries imports and import unit value were obtain from *Monthly Statistics of Exports and Imports*, published by Department of Statistics, Ministry of Finance. Bilateral exchange rates are from *Financial Statistics*.

4.3.3 Empirical Results

We estimated Eq. (4-9) by pooling the available time-series and cross-sectional observations, using ordinary least square estimator. As a result of the missing values, the sample sizes for US and Japan are 345 and 355 observations respectively.

The regression results are reported in Table 4.4, Overall all, the data seems to fit the model reasonably well. In the case of Japan, the explanatory variables explain 14% of the variation in the dependant variable, in the case of the US, the explanatory variables explain 34% of the variation in the dependant variable. All the explanatory variables have the expected signs and are statistically significant. In particular, for

[26] Examples could be differences in product-specific local demand, product-specific first mover advantage, etc. (Bernhofen & Xu ,2000).

both Japan and the US imports, the estimated market power β_s, are positive and highly significant at the 1% level. This indicates that, controlling for product-specific cost changes and overall exchange rate changes, a 'larger presence' of Japan and US firms in the Taiwan market leads to an increase in the average price of midstream petrochemicals in Taiwan. However, our data seems to suggest that other causes of incomplete pass-through were important for Japan and US imports.

Observing the differences between Japanese and the US import behavior, in the case of Japanese imports, the estimate for β_e (0.13) is significantly below 1. For instance, a 1% depreciation of the NT dollar would bring about 0.13% increase in the average price of midstream petrochemicals, after controlling for market power. In other words, our data seems to suggest that other causes of incomplete pass-through were important for Japanese imports. In the case of the US imports, the estimate for β_e (0.34) is higher than its counterpart in the Japan regressions, but still significantly below 1, this suggests that factors other than market power also inhibited pass-through in the case of the US.

In addition, the estimate of β_c in the Japan regression (0.13) is lower than its counterpart in the US regression (0.52), indicating that cost increases for Japanese firms have a lower effect on equilibrium price. That could be explained by the desire of Japanese manufacturing firms to build up their shares in Taiwan during the period. The estimate of β_s in the Japan regression (1.63) is larger than its counterpart in the US regression (0.58), indicating that the Japanese firms in Taiwan have more market power than US firms. According to Eq. (4-8), this result also implies that elasticity of exchange rate pass-through of Japanese firms is smaller than the US firms'.

Since Eq.(4-9) is based on the linear approximation given in Eq.(4-7), we also run OLS estimates which included additional terms of the Taylor series expansion up to the fourth power of the market share variable. The estimation results are contained in Table 4.5. Comparing the estimates in Table 4.4 with the ones in Table 4.5, we can see a remarkable increase in β_s for both Japan and the US. VIF test suggests a relatively high degree of multicollinearity between marker share variable and its higher powers. However, since the β_s remains positive and statistically significant, these estimates seem consistent with our previous findings.

Observing the empirical results of Bernhofen and Xu (2000), they find that the estimated market power parameters are positive, highly significant and similar in magnitude for German and Japanese importers in US market (0.155 for Germany and 0.141 for Japan). Although, our empirical results also show that US and Japanese importers exercise market power in Taiwan market, however, their magnitude of market power are quite different (0.58 for US and 1.63 for Japan). In addition, Bernhofen and Xu find that, in the case of German imports, the estimate for β_e is fairly close to 1. In other words, their data do not seem to suggest that other causes of incomplete pass-through were important for German imports. For the Japanese data, however, the estimate of β_e is significantly below 1. This suggests that factors other than market power also inhibited pass-through in the case of Japan. Our findings suggest that factors other than market power also inhibited pass-through in the both cases of the US and Japan (the estimates of β_e are both significantly below 1). We also notice that cost increases for Japanese firms have a lower effect on equilibrium prices in our and Bernhofen and Xu's findings. That could be explained by the desire of Japanese manufacturing firms to build up their shares during the period.

4.4 Conclusions

We use a simple model of a homogeneous-product oligopoly to investigate the effect of market power on exchange rate pass-through and observe the differences between Japanese and US firms in Taiwan midstream petrochemical industries. In the context of this model, the industry equilibrium price is explained by the average of firms' marginal costs and average industry conduct. This paper has used a micro-data set on the petrochemical industry to test the hypothesis that incomplete exchange rate pass-through is due to imperfectly competitive conduct by foreign firms. An unusual feature of the data is that it provides detailed- and internationally comparable-information on market prices and average marginal production costs for a cross-section of 21 homogeneous petrochemical products over a time period (1986–2002) characterized by large exchange rate fluctuations. A unique aspect of our study is that the data is compatible with the behavioral assumptions of the underlying theoretical model.

In sum, we have found that firms from the two largest importing nations of midstream petrochemicals in Taiwan, the US and Japan, have exercised market power

in Taiwan market during our sample period. However, our data seems to suggest that other causes of incomplete pass-through were important for Japan and US imports. Observing the differences between Japanese and the US import behavior, cost increases for Japanese firms have a lower effect than US firms on equilibrium price, that could be explained by the desire of Japanese manufacturing firms to build up their shares in Taiwan during the period. In addition, the result indicates that the Japanese firms in Taiwan have more market power than US firms. According to theory model, this result also implies that elasticity of exchange rate pass-through of Japanese firms is smaller than the US firms'.