CHAPTER 3

PROFITABILITY, CONCENTRATION AND OPENNESS

3.1 Introduction

Many papers investigate the relationship between a wide variety of trade openness measures and growth. Trade share, export share and import share in GDP are widely used in the literatures and are found to be positively correlated with growth.[13] The main issue is that those countries that are more open to the rest of the world have a greater ability to absorb technological advances generated in leading countries.

The problem is that the openness may be endogenous: as Helpman (1988), Bradford and Chakwin (1993), Rodrik (1995), and many others observe, countries whose income or growth are high may trade more. Therefore, some literatures use measures of countries' trade policies in place of (or as an instrument for) the trade share (openness).[14] However, countries trade policies are likely to be correlated with factors that are omitted from the equation and cannot be used to identify the impact of trade. Frankel and Romer (1999) propose an alternative instrument for trade, they consider geographic factors are not a consequence of income or government policy. As a result, the variation in trade that is due to geographic factors can serve as a natural experiment for identifying the effects of trade. The results of the experiment are consistent across the samples and specifications confirm that trade raise income. On the other hand, Rodriguez and Rodrik (2000) provide a critical analysis of the main contributions in the past decade and conclude that "the nature of the relationship between trade policy and economic growth remains very much an open question".

However, although the empirical studies of the income or growth - openness relationship have been studied extensively, much less attention has been given to the impacts of openness to trade on industry performance and market structure. Metin-Ozcan, Voyvoda and Yeldan (2000) use various manufacturing panel data to investigate the determinants of profit margins and real investments, they find that contrary to expectations, openness had very little impact, if any, on profit margins

[13] For example, Michaely (1977), Feder (1983), Kormendi and Meguire (1985), Fischer (1991, 1993), Dollar (1992), Edwards (1993), Harrison (1996), and Yankkaya (2003).

[14] See Fischer (1991,1993), Dollar (1992), Easterly (1993), Lee (1993), Sachs and Warner (1995), and Harrison (1996).

(mark-ups), and, within manufacturing, the trade-adjusting sectors reveal a positive relationship between the profit margins and openness. Profit margins are found to be positively and significantly related to concentration power and real wage cost increases. Real investments in the sector display positive relationship with profit margins and real wages, yet bear a statistically insignificant relationship with openness.

Although the empirical studies of the trade openness- growth have been growing rapidly, there are still some limitations on them. First, most of them make use of aggregate data in their analyses, and the aggregation process might conceal different effects among industries with different characteristics. Second, the theoretical foundation and simultaneous relationship between openness and performance have been neglected in most papers.

In this paper we intend to investigate the determinants of domestic firms' *PCM*, domestic concentration and the openness to trade as well as possible relationships among them for the midstream petrochemical industries in Taiwan. This paper will first set up an open-economy oligopoly model. Then, the possible relationships among domestic firms' *PCM*, domestic concentration and the openness to trade will be derived. Thereafter, based on the derived results and the existing literature, a simultaneous-equation system of domestic firms' *PCM*, domestic concentration and the openness to trade equations will be established. Finally, the simultaneous-equation system will be estimated by utilizing the disaggregated data of Taiwan's midstream petrochemical industry. [15]

In addition to the introduction, the remainder of this paper is organized as follows. An oligopoly model in the open-economy will be built in Section 2. The empirical model, data description and the interpretation of empirical results will be presented in Section 3. Section 4 concludes the paper.

3.2 The Model

3.2.1 Theoretical Model

According to the theoretical model built in chapter 2, and assuming there exist

[15] The data set of this paper is based on the Standard Industrial Classification 7-digit products.

non-zero conjectural variations, and manipulating the first-order conditions for profit maximization by the *i*th domestic firm mathematically (see Appendix 3A), we then have

$$PCM^{d} = \frac{1}{\varepsilon^{d}} \cdot (1+\phi - OP) \cdot \left\{(1-MR)\cdot\left[H^{d} \cdot (1-\alpha)+\alpha\right] + \beta \cdot MR\right\} \qquad (3\text{-}1)$$

where PCM^d is the weighted average of the domestic firms' *PCM*s in two countries, $\varepsilon^d \equiv -P^d / X^d \cdot \partial X^d / \partial P^d$ is the price elasticity of demand in the home country, $\phi \equiv X^m / X^T$ is the ratio between imports and domestic production, $OP \equiv (X^e + X^{m)} / X^T$ is openness to trade (Metin-Ozcan, Voyvoda and Yeldan, 2000) $MR \equiv X^m / X^d$ is import share, $H^d \equiv \sum_{i=1}^{n} (x_i^h / X^h)^2$ is the degree of domestic concentration, $\alpha \equiv \left(\partial \sum_{j \neq i} x_j^h / \partial x_i^h\right) \cdot \left(x_i^h / (X^h - x_i^h)\right)$ is conjectural elasticity among the domestic firms, $\beta \equiv \left(\partial X^m / \partial x_i^h\right) \cdot \left(x_i^h / X^m\right)$ is conjectural elasticity between a domestic firm and the foreign firms selling in the home country.

Similarly, manipulating the first-order conditions for profit maximization by the *k*th foreign firm mathematically (see Appendix 3B), we can obtain

$$\frac{1}{\varepsilon^{d}} = \frac{PCM^{m}}{MR \cdot H^{m}} \qquad (3\text{-}2)$$

where PCM^m is the foreign firms' *PCM* in the home country, $H^m \equiv \sum_{i=1}^{n^w} (x_k^m / X^m)^2$ is the degree of import concentration of foreign firms in the home country, substituting Equation (3-2) into Equation (3-1), we obtain

$$PCM^{d} = \frac{PCM^{m}}{MR \cdot H^{m}} \cdot (1+\phi - OP) \cdot \left\{(1-MR)\cdot\left[H^{d} \cdot (1-\alpha)+\alpha\right] + \beta \cdot MR\right\} \qquad (3\text{-}3)$$

By transforming, Equation (3-3) can be rewritten in the following forms

$$H^{d} = \left[\frac{PCM^{d} \cdot H^{m}}{PCM^{m} \cdot (1+\phi - OP)} - \beta\right] \frac{MR}{(1-MR)\cdot(1-\alpha)} - \frac{\alpha}{1-\alpha} \qquad (3\text{-}4)$$

Therefore, the problem of aggregation bias can be avoided.

and

$$OP = 1 + \phi - \frac{MR \cdot H^m \cdot PCM^d}{Z \cdot PCM^m} \tag{3-5}$$

where $A = H^d \cdot (1-\alpha) + \alpha$ and $Z = (1-MR) \cdot A + MR \cdot \beta$. Equations (3-3)-(3-5) indicate that PCM^d, H^d and OP depend on each other. That is, there might exist simultaneous relationships among the dependent variables of these three equations.

3.2.2 Comparative Static Analysis

PCM^d Equation

The impact of each independent variable on PCM^d can be derived by taking partial differentiations of Equation (3-3) with respect to H^d, MR, OP and H^m, respectively, as follows:[16]

The domestic concentration (H^d)[17]

$$\frac{\partial PCM^d}{\partial H^d} = \frac{(1+\phi-OP)\cdot(1-MR)\cdot(1-\alpha)\cdot PCM^m}{H^m \cdot MR} > 0$$

The larger the degree of domestic concentration is, the less competitive the domestic market becomes, and domestic firms will have stronger monopoly power to affect the market price of the home country and make more profit. Therefore, the relationship between H^d and PCM^d is expected to be positive.

The openness to trade (OP)

$$\frac{\partial PCM^d}{\partial OP} = -\frac{(1-MR)\cdot PCM^m \cdot Z}{H^m \cdot MR} < 0, \quad if\ \alpha > 0 \quad and \quad \beta > 0;$$

$$?, \quad otherwise$$

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[16] Since PCM^m, α and β will not be incorporated as explanatory variables in the empirical model due to some technical problems in estimating them, their comparative static analyses will be neglected in this paper. However, these comparative static results will be available upon request.

[17] It is assumed that $0 < PCM^m < 1$ when firms are maximizing profit. In addition, $(1+\phi-OP) = X^h / X^T > 0$, 1-$MR$>0 since $0 \le MR < 1$, $1/(n^W) \le H^m \le 1$ and $1-\alpha > 0$ since $-1 < \alpha < 1$.

When the interactive relationship among domestic firms as well as that between domestic and foreign firms are both collusive ($\alpha > 0$, $\beta > 0$), domestic firms will have stronger monopoly power to affect the market price and make more profit in the home country. Under this condition, the rising openness to trade may indicate that domestic firms face more competition pressure from foreign firms, as a result, the relationship between *OP* and PCM^d is expected to be negative. Under other conditions, the relationship between *OP* and PCM^d is hard to determine.

The import share (*MR*)

$$\frac{\partial PCM^d}{\partial MR} = -\frac{(1+\phi - OP)\cdot PCM^m \cdot A}{H^m \cdot MR^2} < 0, \quad if \;\; \alpha > 0;$$

$$?, \quad otherwise$$

While domestic firms are in a situation of collusion ($\alpha > 0$), the rising *MR* may make domestic firms feel more competitive pressure. As a result, domestic firms will have weaker incentives to raise price. It will make PCM^d become lower. Therefore, the impact of *MR* on PCM^d is expected to be negative. However, under other conditions, the relationship between *MR* and PCM^d is ambiguous.

The import concentration (H^m)

$$\frac{\partial PCM^d}{\partial H^m} = -\frac{(1+\phi - OP)\cdot PCM^m \cdot Z}{(H^m)^2 \cdot MR} < 0, \quad if\; \alpha > 0 \quad and \quad \beta > 0;$$

$$?, \quad otherwise$$

when $\alpha > 0$ and $\beta > 0$, the rising H^m may indicate that foreign firms have more power in negotiating with domestic firms about market share. Consequently, PCM^d will go down while H^m goes up. Therefore, the impact of H^m on PCM^d is expected to be negative. Similarly, the relationship between H^m and PCM^d is hard to determine under other conditions.

In addition, PCM^m can be further decomposed. Then, after mathematical manipulation, the negative impact of *cd* and positive impacts of t^h , f^w and *ex* on PCM^d can be presented; $cd=(CD/P^d)$, $CD \equiv \left[\overline{C}^h - ex\cdot(\overline{C}^w + f^w + t^h)\right]$ is the cost differential between domestic and foreign firms (see Appendix 2). The higher the cost differential between domestic and foreign firms, the more competition pressure domestic firms feel from foreign firms, then domestic firms will have weaker monopoly power to affect the market price in the home country and make less profits. The larger the specific tariff rate imposed by the home country, transportation cost per unit of foreign firms or the exchange rate is, the higher barriers for foreign firms to enter domestic market. Therefore, the less competition pressure domestic firms feel from foreign firms, domestic firms will have stronger power to affect the market price in the home country and make more profits. As a result, the relationships between tariff rate, transportation cost as well as exchange rate and PCM^d are all positive.

Based on the above results of comparative static analysis, the relationships between PCM^d and all independent variables can be summarized as:

$$PCM^d = f(\underset{(+)}{H^d}, \underset{(?)}{OP}, \underset{(?)}{MR}, \underset{(?)}{H^m}, \underset{(-)}{cd}, \underset{(+)}{t^h}, \underset{(+)}{f^w}, \underset{(+)}{ex}) \tag{3-6}$$

where the notation under each independent variable indicates its expected sign.

H^d Equation

Similarly, by taking partial differentiations of Equation (3-4) with respect to PCM^d, MR, OP and H^m, respectively, the impact of each independent variable on H^d can be derived as follows:

The domestic firms' PCM (PCM^d)

$$\frac{\partial H^d}{\partial PCM^d} = \frac{H^m \cdot MR}{(1-MR)\cdot(1+\phi-OP)\cdot(1-\alpha)\cdot PCM^m} > 0$$

When the PCM^d becomes larger, domestic firms will be more capable of raising their market shares and, then, H^d will go up. Consequently, the relationship between PCM^d and H^d is expected to be positive.

The openness to trade (OP)

$$\frac{\partial H^d}{\partial OP} = \frac{H^m \cdot MR \cdot PCM^d}{(1-MR)\cdot((1+\phi-OP))^2\cdot(1-\alpha)\cdot PCM^m} > 0$$

When *OP* goes up, domestic firms will face more competition in both home and foreign markets. As a result, it will force inefficient domestic firms to exit, decrease the number of domestic firms and, then, raise H^d. Therefore, the impact of *OP* on H^d is expected to be positive.

The import share (*MR*)

$$\frac{\partial H^d}{\partial MR} = \frac{H^m \cdot PCM^d - \beta \cdot (1+\phi - OP) \cdot PCM^m}{(1-MR)^2 \cdot (1+\phi - OP)\cdot(1-\alpha)\cdot PCM^m} > 0, \quad if \;\; \beta < 0;$$

$$?, \quad otherwise$$

While domestic firms are in a situation of competition ($\beta < 0$), if *MR* goes up, domestic firms will feel more pressure from foreign firms and have stronger desire to improve their efficiency via merger. Then, H^d will go up. Therefore, the impact of *MR* on H^d is expected to be positive. However, under other conditions, the relationship between *MR* and H^d is hard to determine.

The import concentration (H^m)

$$\frac{\partial H^d}{\partial H^m} = \frac{MR \cdot PCM^d}{(1-MR)\cdot(1+\phi - OP)\cdot(1-\alpha)\cdot PCM^m} > 0$$

When the degree of H^m goes up, competition pressure on domestic firms by foreign firms will rise. Domestic firms have to improve their efficiency in order to survive. Similarly, it will force inefficient domestic firms to exit, decrease the number of domestic firms and, then, raise H^d. Therefore, the impact of H^m on H^d is expected to be positive.

Dependent upon the above results of comparative static analyses, the relationships between H^d and all independent variables can be summarized as follows:

$$H^d = f(\underset{(+)}{PCM^d}, \underset{(+)}{OP}, \underset{(?)}{MR}, \underset{(+)}{H^m}) \tag{3-7}$$

OP Equation

Similarly, by taking partial differentiations of Equation (3-5) with respect to PCM^d, H^d, MR and H^m, respectively, the impact of each independent variable on

OP can be derived as follows:

The domestic firms' *PCM* (PCM^d)

$$\frac{\partial OP}{\partial PCM^d} = -\frac{H^m \cdot MR}{PCM^m \cdot Z} < 0\,, \quad if \;\; \alpha > 0 \;\; and \;\; \beta > 0\,;$$

$$?, \quad otherwise$$

While the interactive relationships among domestic firms as well as that between domestic and foreign firms are both collusive, if PCM^d goes up, domestic firms will not only have weaker desire to export but also have strong power to deter import competition. This, in turn, leads to a smaller *OP*. Therefore, the impact of PCM^d on *OP* is expected to be negative. However, under other conditions, the relationship between PCM^d and *OP* is ambiguous.

The domestic concentration (H^d)

$$\frac{\partial OP}{\partial H^d} = \frac{H^m \cdot MR \cdot PCM^d \cdot (1-MR) \cdot (1-\alpha)}{PCM^m \cdot Z^2} > 0$$

When H^d rises, domestic firms will have stronger monopoly power to raise price through decreasing their sales in the home country. Then, the export will increase. This will, in turn, lead to a larger *OP*. Therefore, the impact of H^d on *OP* is expected to be positive.

The import share (*MR*)

$$\frac{\partial OP}{\partial MR} = -\frac{H^m \cdot PCM^d \cdot A}{PCM^m \cdot Z^2} < 0\,, if \;\; \alpha > 0\,;$$

$$?, \; otherwise$$

While domestic firms are in a situation of collusion ($\alpha > 0$), if *MR* goes up, it may indicate that foreign firms are more competitive and aggressive than domestic firms, in both home and foreign countries. As a consequence, domestic firms' exports will fall significantly because of the comparative disadvantage in the foreign market. Therefore, the impact of *MR* on *OP* is expected to be negative. Similarly, under other conditions, the relationship between *MR* and *OP* is ambiguous.

The import concentration (H^m)

$$\frac{\partial OP}{\partial H^m} = -\frac{MR \cdot PCM^d}{PCM^m \cdot Z} < 0 \text{, } if \quad \alpha > 0 \quad \text{and} \quad \beta > 0 \text{;}$$

$$?, \; otherwise$$

While the interactive relationship among domestic firms as well as that between domestic and foreign firms are both collusive, if H^m goes up, it will be easier to maintain the collusive relationship among domestic firms and, then, home market will be more attractive than foreign market because of profit incentive. As a result, domestic firms may decide to lower export. This will, in turn, lead to a lower *OP*. Therefore, the impact of H^m on *OP* is expected to be negative. Similarly, under other conditions, the relationship between H^m and *OP* is ambiguous.

In addition, *OP* also can be rewritten. Then, after mathematical manipulation, we can get the negative impact of *cd* on *OP* (see Appendix 3B).

$$\frac{\partial OP}{\partial cd} = -\frac{(\varepsilon^d)^2 \cdot PCM^d}{(H^m \cdot MR - \varepsilon^d \cdot cd)^2} < 0$$

The larger the domestic firms' production cost is over the foreign firms, the less competitive domestic firms become in the foreign country. Then, domestic firms' exports will decline and the *OP* will go down. Therefore, the impact of *cd* on *OP* is expected to be negative.

Again, the relationships between *OP* and all independent variables can be summarized as follows:

$$OP = f(\underset{(?)}{PCM^d}, \underset{(+)}{H^d}, \underset{(?)}{MR}, \underset{(?)}{H^m}, \underset{(-)}{cd}) \qquad (3\text{-}8)$$

3.3 Empirical Model

Based on the theoretical model and comparative static analysis, we could build our empirical simultaneous model as follows:

$$PCM^d = f(\underset{(+)}{H^d}, \underset{(?)}{OP}, \underset{(?)}{MR}, \underset{(?)}{H^m}, \underset{(-)}{cd}, \underset{(+)}{t^h}, \underset{(+)}{f^w}, \underset{(+)}{ex})$$

$$H^{d} = f(\underset{(+)}{PCM^{d}}, \underset{(+)}{OP}, \underset{(?)}{MR}, \underset{(+)}{H^{m}})$$

$$OP = f(\underset{(?)}{PCM^{d}}, \underset{(+)}{H^{d}}, \underset{(?)}{MR}, \underset{(?)}{H^{m}}, \underset{(-)}{cd})$$

However, in order to make sure that each equation of the simultaneous system above be identified, three more independent (exogenous) variables (country concentration of exports (H^{ce}), market size (MS) and capacity utilization (E)) are added to the system by referring to Carlton and Perloff (1994), Chou (1986), Wang (1997) and Bhattacharya (2002).

$$\frac{\partial PCM^{d}}{\partial H^{ce}} < 0$$

According to Carlton and Perloff (1994), the buyer concentration can lead to lower price when buyers are larger and more powerful, their concentration can offset the power of sellers. Therefore, taking the importance of buyer concentration on sellers' performance into account, we add country concentration of exports to the PCM^{d} equation, and its expected sign is negative.

$$\frac{\partial H^{d}}{\partial MS} < 0$$

According to Chou (1986) and Wang (1997), when the domestic market size grows, H^{d} will decline if there is free entry. Bhattacharya (2002) claims that the larger the value is of market size, the lower the level of concentration will be. Therefore, the relationship between market size and H^{d} is expected to be negative.

$$\frac{\partial H^{d}}{\partial E} > 0$$

According to Wang (1997), capacity utilization represents the economies of scale. The rising ratio of capacity utilization implies that domestic firms are approaching the minimum efficient scale. Therefore, the production efficiency will deter new firms from entry. Consequently, H^{d} will go up. Therefore, the relationship between capacity utilization and H^{d} is expected to be positive.

Finally, the empirical model in this paper can be established as:

$$PCM^d = f(\underset{(+)}{H^d}, \underset{(?)}{OP}, \underset{(?)}{MR}, \underset{(?)}{H^m}, \underset{(-)}{cd}, \underset{(+)}{t^h}, \underset{(+)}{f^w}, \underset{(-)}{H^{ce}}, \underset{(+)}{ex}) \tag{3-9}$$

$$H^d = f(\underset{(+)}{PCM^d}, \underset{(+)}{OP}, \underset{(?)}{MR}, \underset{(+)}{H^m}, \underset{(-)}{MS}, \underset{(+)}{E}) \tag{3-10}$$

$$OP = f(\underset{(?)}{PCM^d}, \underset{(+)}{H^d}, \underset{(?)}{MR}, \underset{(?)}{H^m}, \underset{(-)}{cd}) \tag{3-11}$$

3.4 Data Description and Empirical Results

3.4.1 Data Description and Estimation Procedure

The data set used in this paper consists of 21 midstream petrochemical industries. Since the data of H^d on some midstream petrochemical products are unavailable before 1989 and after 1997, the period covered by this paper spans from 1989 to 1997, during which annual data are available for all midstream petrochemical industries under examination. The detailed description of these midstream petrochemical products is presented in Appendix 2C. Although the number of dependent and independent variables in the simultaneous-equation system is only 11, the total number of variables needed for creating these 11 variables is much more than that. Therefore, the data set is a little bit complicated, coming from 6 different sources. Formulas used to calculate the relevant variables and data sources are given in Table 2.1.

In order to have better estimates, we estimate three different models of equations (3-9) to (3-11). Since the relationships among PCM^d, H^d and OP are simultaneous, there might exist a simultaneous bias should the OLS method be applied to estimate the system of Equations (3-9)-(3-11). To avoid the above problem, a simultaneous regression method will be used to estimate the simultaneous-equation system. Because the rank condition of the simultaneous-equation system is satisfied, and by order condition Equation (3-9) is exactly identified in model (1) and over-identified in model (2) and model (3), Equation (3-10) is exactly identified in model (3) and over-identified in model (1) and model (2), Equation (3-11) is over-identified in all three models, therefore, 3SLS will be chosen to estimate the system.

3.4.2 Empirical Results

Table 3.1 reports the 3SLS estimation results for three different models of equations (3-9)-(3-11). Model (1) is the exact simultaneous model of equations (3-9)-(3-11), then we delete four statistically insignificant variables from Eq. (3-9) in model (2). In model (3), one more statistically insignificant variable has been deleted from Eq. (3-9). We will focus our attention on model (3).

The regression results of PCM^d equation show that there exist a positive relationship between H^d and PCM^d at 1% significant level. That is, domestic firms in the midstream petrochemical industries with higher H^d have stronger market power to affect the market price of the home country and make more profit. Consequently, PCM^d in the midstream petrochemical industry with higher H^d is higher than that with lower H^d. The coefficient of *OP* is negative and significant at 1% level, implying that the rising openness to trade will increase the competition pressures in both home and foreign markets, then, domestic firms' profitability will decline. This result also implies that the interactive relationship among domestic firms as well as that between domestic and foreign firms might both be collusive. The coefficients of H^m are negative and significant at 1% level, implying that when the foreign firms' negotiation power become stronger, domestic firms' profitability will decline. More importantly, based on the comparative static analysis of the PCM^d equation, this result implies that the interactive relationship among domestic firms as well as that between domestic and foreign firms might both be collusive. Finally, the coefficient of f^w is statistically insignificant.

Each of the estimated coefficients of H^d equation is statistically significant. The regression results of H^d equation show that there exist a positive relationship between PCM^d and H^d at 10% significant level. It indicates that along with the rising PCM^d, domestic firms will have stronger power to expand market share and, then, H^d will go up. There exists a positive relationship between *OP* and H^d at 5% significant level, indicating the rising openness to trade will increase the competition pressures in both home and foreign markets and force inefficient domestic firms to exit, decrease the number of domestic firms. Then, H^d will go up. In addition, the coefficients of *MR* and H^m are both positive and significant at 1%

level, implying that when *MR* and/ or H^m go up, domestic firms will have stronger desire to improve their efficiency via merger, or the stronger monopoly power by foreign firms in the import market of the home country will force inefficient domestic firms out of business. The coefficient of *MS* is significantly negative at 1% level with an expected sign,[18] indicating that H^d will fall along with the rising number of domestic firms due to the rising domestic market size. Finally, as expected, there exists a positive relationship between *E* and H^d at 1% significant level. It indicates that the rising capacity utilization will deter new firms from entry and force the H^d to go up.

The regression results of *OP* equation show that the coefficient of PCM^d is significantly negative at 1% level, indicating that rising PCM^d will make domestic firms have strong power to deter competition., and openness to trade will decline, and this result also implies that the interactive relationship among domestic firms as well as that between domestic and foreign firms might be collusive based on the comparative static analysis of the *OP* equation. As expected, there exists a positive relationship between H^d and *OP* at 5% significant level. The coefficient of H^m is significantly negative, implying that the interactive relationship among domestic firms as well as that between domestic and foreign firms might be collusive. In addition, *MR* has a positive impact on *OP* at significant level. Finally, *cd* does not influence *OP* significantly.

Finally, it is noteworthy that the regression results of Equations (9)-(11) consistently indicate that the interactive relationship among domestic firms as well as that between domestic and foreign firms might both be collusive in the Taiwan's midstream petrochemical industries during the period of 1989-1997. We can reasonably doubt that the collusive behavior between domestic firms originates from the business relationship between them. For example, A firm could be B firm's subsidiary company or A firm's owner used to be B firm's employee. Then, it will be easier for the two firms to collude in order to increase their profits. This kind of collusion does take place in Taiwan. In addition, some importers are also domestic manufacturers or are invested by domestic manufacturers, partly explaining the

[18] This result is consistent with Bhattacharya's (2002) finding.

collusive behavior between domestic and foreign firms.

3.5 Conclusions

Since the liberalization policy was adopted by the government in 1986, the tariffs and import restrictions of petrochemical products in Taiwan have been continuously reduced. As a result, the changes in domestic firms' *PCM*, domestic concentration and the openness to trade show that there might exist simultaneous relationships among them. Therefore, dependent upon industry characteristics of Taiwan's midstream petrochemical products, an open-economy oligopoly model is established and used to derive causalities among domestic firms' *PCM*, domestic concentration and the openness to trade. Then, based on the derived results and by referring to the existing literature, a simultaneous-equation system consisting of domestic firms' *PCM*, domestic concentration and the openness to trade is built. Thereafter, by utilizing the 1989-1997 disaggregated data of Taiwan's midstream petrochemical industries, the simultaneous-equation system is estimated through 3SLS.

The regression results confirm the causalities derived from the theoretical model, and demonstrate that there do exist simultaneous relationships among domestic firms' *PCM*, domestic concentration and the openness to trade in Taiwan's midstream petrochemical industries.

Specifically, domestic concentration affects domestic firms' *PCM* positively while openness and import concentration affect domestic firms' *PCM* negatively. Domestic firms' *PCM*, openness, import share, import concentration and capacity utilization affect domestic concentration positively while market size affects domestic concentration negatively. Domestic concentration and import share affect openness positively while domestic firms' *PCM* and import concentration affect openness negatively. Based on the derived causalities, the above empirical results imply that the interactive relationship among domestic firms as well as that between domestic and foreign firms might both be collusive during the period of 1989-1997, and the collusive behavior probably has originated from their subsidiary or old employer-employee relationship.

Possible policy implications emerge directly from our empirical results. First, as the empirical results demonstrated above, import concentration not only reduces domestic firms' profitability but also increases domestic concentration. Its impacts should be carefully taken into account while the government formulates industrial and competitive policies since liberalization policy is inevitable. Second, collusion among domestic firms as well as that between domestic firms and foreign firms should be considered as an important factor in formulating industrial and trade policies because it is highly suspected that collusion does take place. Third, although trade liberalization is inevitable for developing countries, but, from our empirical results, the openness to trade not only reduces firms' profitability but also raises the industry concentration, and the firm's profitability and concentration also will affect the openness to trade significantly in vice versa. Therefore, the benefit and cost of openness to international trade should be taken into consideration more thoroughly. Nevertheless, the conjectural elasticity among domestic firms or that between domestic and foreign firms has not been incorporated as one of the explanatory variables in the empirical studies because of the technical problems in estimating it. These problems have to be overcome if we want to understand the determinants of domestic firms' *PCM*, domestic concentration and the openness to trade more thoroughly. Only in this way can more meaningful policy implications be obtained.

Appendix 3A

Equation (2A-11) can be presented as

$$PCM^{w}=\left(\frac{1}{\varepsilon^{ex}}+\frac{1}{\varepsilon^{w}}\right)\cdot\left[\sum_{i=1}^{n}\left(\frac{x_i^{e}}{X^{e}}\right)^{2}\cdot\frac{X^{e}}{X^{w}}\cdot(1-\gamma)+\frac{X^{e}}{X^{w}}\cdot\gamma+\frac{X^{f}}{X^{w}}\cdot\delta\right]$$

$$=\left(\frac{1}{\varepsilon^{ex}}+\frac{1}{\varepsilon^{w}}\right)\cdot\left\{\left[H^{e}\cdot(1-\gamma)+\gamma\right]\cdot(OP-\phi)\cdot\frac{X^{T}}{X^{w}}+\left(1-\frac{X^{e}}{X^{w}}\right)\cdot\delta\right\} \qquad (3A-1)$$

where $\phi\equiv X^{m}/X^{T}$ is the ratio between imports and domestic production, $OP\equiv(X^{e}+X^{m})/X^{T}$ is openness to trade, $H^{e}\equiv\sum_{i=1}^{n}(x_i^{e}/X^{e})^{2}$ is domestic firms' concentration in the foreign country.

Since PCM^{d} is the weighted average of domestic firms' *PCM*s in two countries, then

$$PCM^{d}=\frac{X^{h}}{X^{T}}\cdot PCM^{h}+\frac{X^{e}}{X^{T}}\cdot PCM^{w} \qquad (3A-2)$$

Substituting Equation (2A-7) and Equation (3A-1) into Equation (3A-2), we obtain

$$PCM^{d}=\frac{1}{\varepsilon^{d}}\cdot(1+\phi-OP)\cdot\left\{(1-MR)\cdot\left[H^{d}\cdot(1-\alpha)+\alpha\right]+\beta\cdot MR\right\}$$

$$+\left(\frac{1}{\varepsilon^{ex}}+\frac{1}{\varepsilon^{w}}\right)\cdot(OP-\phi)\cdot\left\{\left[H^{e}\cdot(1-\gamma)+\gamma-\delta\right]\cdot\frac{X^{e}}{X^{w}}+\delta\right\} \qquad (3A-3)$$

we assume that $\gamma=0$, $\delta=0$ and $X^{e}/X^{w}=0$, then Equation (3A-3) becomes

$$PCM^{d}=\frac{1}{\varepsilon^{d}}\cdot(1+\phi-OP)\cdot\left\{(1-MR)\cdot\left[H^{d}\cdot(1-\alpha)+\alpha\right]+\beta\cdot MR\right\} \qquad (3A-4)$$

Equation (3A-4) can be presented as

$$PCM^d = \frac{1}{\varepsilon^d} \cdot (1 + \phi - OP) \cdot \left\{ (1 - MR) \cdot \left[H^d \cdot (1 - \alpha) + \alpha \right] + \beta \cdot MR \right\}$$

where $\phi \equiv X^m / X^T$, $OP \equiv (X^e + X^m) / X^T$ is the openness to trade, $(1 + \phi - OP) \equiv X^h / X^T$, $(1 + \phi - OP) > 0$.

Appendix 3B

PCM^d Equation

Substituting Equation (2B-8) into Equation (2B-7) and (3A-2) yields

$$PCM^d = (1+\phi-OP)\cdot\left(\frac{1}{\varepsilon^d}\cdot MR\cdot H^m - cd\right) \qquad (3B\text{-}1)$$

where $cd=(CD/P^d)$. Taking partial differentiation of Equation (3B-1) with respect to cd gives us the impact of cd on PCM^d as:

$$\frac{\partial PCM^d}{\partial cd} = -(1+\phi-OP) < 0$$

Substituting $cd = \left[\overline{C}^h - ex\cdot(\overline{C}^w + f^w + t^h)\right]/P^d$ into Equation (3B-1) yields

$$PCM^d = (1+\phi-OP)\cdot\left(\frac{1}{\varepsilon^d}\cdot MR\cdot H^m - \frac{\overline{C}^h - ex\cdot(\overline{C}^w + f^w + t^h)}{P^d}\right)$$

Taking partial differentiations of the above equation with respect to t^h, f^w and ex, respectively, gives us the impacts of t^h, f^w and ex on PCM^d as:

$$\frac{\partial PCM^d}{\partial t^h} = \frac{(1+\phi-OP)\cdot ex}{P^d} > 0$$

$$\frac{\partial PCM^d}{\partial f^w} = \frac{(1+\phi-OP)\cdot ex}{P^d} > 0$$

and

$$\frac{\partial PCM^d}{\partial ex} = \frac{(1+\phi-OP)\cdot(\overline{C}^w + f^w + t^h)}{P^d} > 0$$

OP Equation

By reformulating Equation (3B-1), OP can be rewritten as:

$$OP = 1 + \phi - \frac{PCM^d \cdot \varepsilon^d}{MR \cdot H^m - cd \cdot \varepsilon^d}$$

Then, by taking partial differentiation of the above equation with respect to *cd*, the impact of *cd* on *OP* can be derived as:

$$\frac{\partial OP}{\partial cd} = -\frac{(\varepsilon^d)^2 \cdot PCM^d}{(H^m \cdot MR - \varepsilon^d \cdot cd)^2} < 0$$