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不同物價環境下之匯率轉嫁效果

Exchange Rate Pass-through at Different Price Levels

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Exchange Rate Pass-through at Different Price Levels

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Abstract

This dissertation incorporates inflation and deflation in the analysis of exchange rate pass-through at different price levels. Because the existing literature generally consider deflation as part of low inflation, pass-through estimates tend to be considered the same for these two regimes. This study separates the effects of deflation and low positive inflation and estimates the pass-through for different price levels.

This dissertation uses a nonlinear model with aggregate and disaggregate import prices data from 1981–2008 in Taiwan to first examine the pass-through for two regimes of high inflation and low inflation. The results confirm the notion in the literature that a positive relationship exists between pass-through and inflation. Then, this dissertation extends the model to a three-regime setting, including high inflation,

low positive inflation, and deflation. When deflation is clearly defined in a three-regime model, the degree of exchange rate pass-through is found to be increasing in both high inflation and deflation. The positive relationship at all price levels is no longer valid while the effect of deflation is separated from that of low inflation. In Taiwan, the pass-through becomes inversely greater as the inflation rate falls into a deflationary regime. That the pass-through is higher in a deflationary regime became particularly obvious after the 1997 financial crisis. Contrary to the results predicted by the positive relationship, this analysis does not find an unlimited downward trend for the pass-through. A rebound occurs in the degree of pass-through once deflation is clearly identified, and this pattern is also found for half of the importing industries categorized using the Standard International Trade Classification (SITC).

In addition, the results are consistent with the notion that oil prices usually fluctuate much more than the prices of other imports. The estimates show that the pass-through changes the most for fuels and related materials. Obviously, fluctuations in the price of oil influence the measurement of the pass-through. The increase in the pass-through found in a deflationary regime becomes smaller when oil prices are excluded.

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Chapter 1 Introduction

1.1 Research Background

Exchange rate pass-through describes the extent to which the exchange rate changes the concerned prices. Because incomplete pass-through is found in many countries, numerous studies have been dedicated to determining the reasons for this phenomenon. The majority of these papers attribute the differences in the degree of exchange rate pass-through to microeconomic factors. Taylor (2000) is the first study suggesting that inflation has a positive effect on the degree of exchange rate pass-through. Related studies then demonstrate that pass-through is positively associated with inflation. However, this positive relationship is usually supported by empirical analysis performed for only two regimes: low and high inflation. No specific attention is paid to the effect of a deflationary environment. The pass-through in a deflationary environment is then considered the same as that in a low inflationary regime. The mixed effects of deflation and low inflation lead to a mixed result of pass-through for these two price levels. When price levels are not clearly defined for deflation and inflation, the result of a positive relationship for all price levels may be inaccurate.

As defined, deflation is a decrease in the general price level. A deflationary

environment in the importing country severely reduces foreign firms' profits through weak domestic demand and falling prices, making such firms more vulnerable to cost fluctuations. Any changes in the cost, including those attributable to exchange rate movements, are easily reflected in the prices. Exchange rate pass-through, or the extent to which import prices respond to changes in the exchange rate, thus becomes higher in the importing country. The intuition previously noted obviously contradicts the prediction of a positive relationship between exchange rate pass-through and inflation that lower pass-through should be observed in lower inflation. Therefore, when deflation is regarded as part of low inflation, the possible result of higher pass-through is easily ignored by the mixed effects of deflation and low inflation.

This dissertation focuses on the experience of Taiwan to investigate exchange rate pass-through because Taiwanese data are useful in studying this issue at different price levels.[1] From 1989 to 1997, Taiwan experienced rapid economic growth attributable to a thriving high-tech industry. The CPI inflation rates, as shown in Table 1 and Figure 1, were higher than 3% during this prosperous period. After 1997, the Asian financial crisis caused a slowdown in Taiwan's domestic economic growth. During subsequent years, the burst of the Internet bubble and the terrorist attacks in the U.S. also influenced Taiwan's economy. The Severe Acute Respiratory Syndrome

[1] Several papers also study different issues of exchange rate pass-through in Taiwan, such as Wu (1995), Wang and Wu (1999), Wang and Lin (2000), Liu and Chang (2000), and Huang, Lan and Kuo (2007).

Table 1.1
Taiwan's inflation and economic growth rates

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990
CPI growth rate (%)	2.96	1.37	-0.03	-0.16	0.7	0.52	1.29	4.41	4.13
Economic growth rate (%)	3.97	8.32	9.32	4.07	11.0	10.68	5.57	10.28	6.87
	1991	1992	1993	1994	1995	1996	1997	1998	1999
	3.62	4.47	2.94	4.1	3.67	3.07	0.9	1.68	0.18
	7.88	7.56	6.73	7.59	6.38	5.54	5.48	3.47	5.97
	2000	2001	2002	2003	2004	2005	2006	2007	2008
	1.25	-0.01	-0.2	-0.28	1.61	2.31	0.6	1.8	3.53
	5.80	-1.65	5.26	3.67	6.19	4.70	5.44	5.98	0.73

Sources: DGBAS Taiwan.

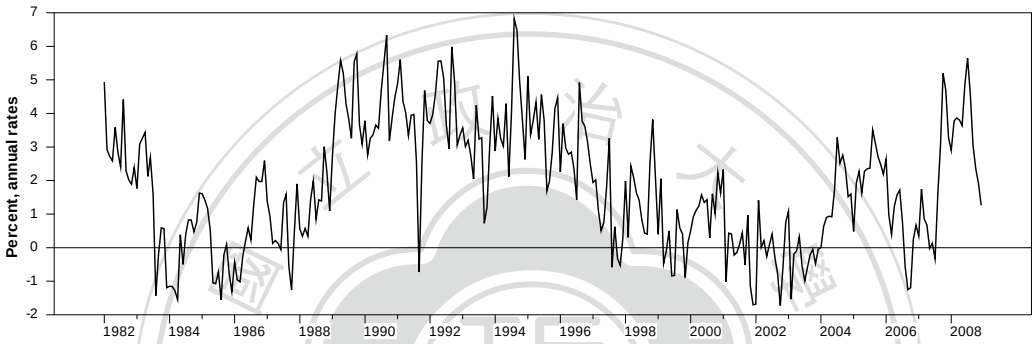

Figure 1.1 Taiwan's inflation rates 1982-2008

(SARS) epidemic in 2001 further dampened the domestic economy. Taiwan's CPI inflation rate became negative and continued to decline during these years.[2] The country's core CPI also exhibited a growth rate of –0.61% in 2003. According to Rogoff et al. (2003), Taiwan was one of the countries at risk of worsening deflation. Weak domestic demand put the island's economy on a path toward a recession. These characteristics of Taiwan's economic data allow an examination of the degree of exchange rate pass-through at different price levels and a more precise discussion of

[2] Taiwan's membership in the World Trade Organization (WTO) in 2002 also had a downward effect on inflation.

the relationship between exchange rate pass-through and different price levels.

1.2 Research Purpose

The main interest of this dissertation is to provide a more thorough investigation of pass-through at different price levels, which addresses the effect of deflation. This dissertation uses the intuition provided in the previous section and hypothesizes that a nonlinear relationship exists between the degree of exchange rate pass-through and inflation. Therefore, this study applies the threshold model proposed by Tsay (1998) for the empirical work.[3]

To achieve the purpose of this study, the degree of exchange rate pass-through is estimated by considering two regimes initially in the threshold model. The pass-through is first estimated when the inflation rate is either above or below 3%, providing a basis for comparison with the outcomes of the existing literature. Then, the model is extended to clearly distinguish a deflationary regime from a low inflationary regime. For the definition of deflation, this study adopts the suggestion in Rogoff et al. (2003) that deflation occurs when the inflation rate is lower than 1% rather than 0% because they note that a bias exists in CPI measurements. Measured inflation lower than 1% likely indicates deflation; thus, defining deflation as an

[3] Al-Abri and Goodwin (2009) re-examine the exchange rate pass-through into 16 OECD countries' import prices using the threshold cointegration estimation technique. Tica and Posedel (2009) apply a threshold model for investigating the exchange rate pass-through in Croatia.

inflation rate below 1% is more appropriate.[4]

Empirical data in such research on the estimation of pass-through often show the influences of oil prices on the estimation results due to its high volatility. Another purpose of this study is thus to identify the effect of oil prices on the pass-through. Regarding the influences of oil prices, related studies such as Marazzi and Sheets (2007), Sekine (2006), and Campa and Goldberg (2005) find evidence that oil prices affect the estimations of pass-through.[5] In Taiwan, Wang and Wu (1999) and Wang and Lin (2000) also indicate that studying the pass-through effect at the aggregate level might have biased results attributable to the characteristics of domestic petrochemical industry. They explain that the pass-through of this industry is expected to be higher because it is a large-scale and highly concentrated industry owning a relatively strong power of monopoly. To identify these influences of oil prices, a non-oil import price index is additionally provided in this study, which helps to obtain a more solid result in the estimation of pass-through at different price levels.[6]

[4] This assumption is later examined in robustness checks.

[5] Marazzi and Sheets (2007) recommend distinguishing the effects of oil prices attributable to their volatility. Sekine (2006) also controll for the price of oil in the regression while studying the degree of pass-through. However, Campa and Goldberg (2005) do not distinguish the effect of oil prices, but observe that energy prices "have the most anomalous behavior among all product categories, with country-estimated pass-through varying considerably."

[6] Most studies regarding the analysis of pass-through in Taiwan neglect the non-oil import price index because the government does not publish this data.

1.3 Organization of the Dissertation

The dissertation is organized as follows. Chapter 1 presents the motivations and purpose of the study. Chapter 2 reviews the related literature. Chapter 3 describes the theoretical framework used in this study. Chapter 4 presents and interprets the empirical analysis and the empirical results; possible structural change in the data and robustness checks are also included in this chapter. Chapter 5 provides the conclusion.

Chapter 2 Literature Review

Exchange rate pass-through is generally found to be incomplete in many countries. Both Dornbusch (1987) and Krugman (1987) explain the incomplete exchange rate pass-through from the theoretical framework of oligopolistic market. In their studies, a firm's mark-up is no longer constant and can adjust in response to an exchange rate shock. If there is a depreciation of the importing country's currency, a foreign exporter might cut its price in terms of its domestic currency. This act stabilizes the price in terms of the importing country's currency, which Krugman (1987) refers it to "pricing to market".

Literatures on incomplete exchange rate pass-through labeled as PTM have discussed several possible reasons for this phenomenon. A key paper of these studies is Hooper and Mann (1989). They study U.S. import prices of manufactures and find that foreign firms sustain substantial shifts in the profit margin on their exports to the U.S. as exchange rate changes. This is because firms are willing to suffer temporarily lower profits on export sales in order to maintain market share in importing countries.

Different from most literatures that attribute the changes of exchange rate pass-through to microeconomic factors, Taylor (2000) first suggested that inflation has a positive impact on the degree of pass-through exhibited by firms. In his study, higher exchange rate pass-through results from persistent cost changes under high

inflation, based on a staggered price setting model. As firms set prices several periods in advance, their prices are more responsive to cost increases if cost changes are perceived to be more persistent. According to the US data of 1960-1999 in the paper, regimes with higher inflation tend to have more persistent costs such that higher inflation increases the degree of exchange rate pass-through.

Additional studies have also find evidence of a positive relationship between these two variables (Gagnon and Ihrig, 2004; Choudhri and Hakura, 2006; Bouakez and Rebei, 2008; María-Dolores, 2010).

Gagnon and Ihrig (2004) distinguish periods of high and low inflation for 20 industrial countries during 1971-2003. They find that decreased exchange rate pass-through is the result of an inflation-stabilizing policy adopted by the government. The pass-through is positively related to the mean and standard deviation of inflation.

Choudhri and Hakura (2006) sort 71 countries into low to high inflation groups to explore the relationship between the pass-through to Consumer Price Index (CPI) and the inflation environment. Strong evidence of a positive and significant association is found between the pass-through and the average inflation rate across countries and periods. The inflation rate, in addition, dominates other macroeconomic variables in explaining cross-regime differences in the pass-through.

Bouakez and Rebei (2008) estimate the pass-through in Canada over the periods

before and after inflation targeting. They find that exchange rate pass-through is relatively low in economies with a credible monetary policy. That is, lower exchange rate pass-through tends to be related to stable inflation.

In María-Dolores (2010), she obtains the positive relationship between exchange rate pass-through and inflation by studying the prices of imports of some New Member States (NMSs) of the European Union. Among NMSs, the countries with inflation targeting in their monetary policies also have the smallest pass-through.

However, there are also several studies which do not agree with the positive relationship (Campa and Goldberg, 2005; Steel and King, 2004). Campa and Goldberg (2005) find that although higher inflation and exchange rate volatility are positively associated with higher import pass-through, the composition of imports play a much more important role in determining the pass-through. Steel and King (2004) study the data in New Zealand and conclude that the changes in the degree of exchange rate pass-through are not affected even when the economy is shifted to a low-inflation environment.

Chapter 3 Theoretical Framework

The exchange rate pass-through, according to Hooper and Mann (1989), can be broadly defined as the extent to which a change in the nominal exchange rate induces a change in the import price. In this study, we follow a narrower definition that describes pass-through as the partial derivative of the import price with respect to the nominal exchange rate. To allow for interaction between domestic and foreign firms, we begin with the markup model adopted by many previous analyses.[7] By operating through variations in the markup, foreign firms can, more or less, control their output prices.

Under the markup model, a foreign exporter's price (PX^*) can be expressed as the product of their marginal cost of production (MC^*) and the markup (θ):

$$PX^* = \theta MC^* \tag{1}$$

The import price of the importing country is derived by multiplying through by the exchange rate (ER) measured in terms of domestic currency per unit of foreign currency:

$$PM = PX^* ER = \theta MC^* ER \tag{2}$$

The markup, θ, is assumed to be variable, and it responds to both competitive

[7] See Athukorala (1991), Hooper and Mann (1989), Kim (1990), Knetter (1989, 1993, 1995), Campa and Goldberg (2004, 2005), and Gust, Leduc, and Vigfusson (2010).

pressures in the domestic market and demand pressures in foreign countries.[8] That is, $\theta = [P^d/(MC^* ER)]^\alpha Y^\beta$, where P^d is the average competitors' price level of the good in the domestic market and Y is the domestic demand. Substituting the expression for θ into equation (2) and taking the logarithm of the result yields:

$$pm_t = (1-\alpha)er_t + \alpha p_t^d + (1-\alpha)mc_t^* + \beta y_t \quad (3)$$

According to Hooper and Mann (1989), three versions of this model can be used to estimate the pass-through by relaxing the restrictions on the coefficients of p_t^d and mc_t^*. In line with numerous other studies, which generally adopt the least restrictive form for their estimations, this study also allows the coefficient on p_t^d to differ from α and the coefficient on mc_t^* to differ from $(1-\alpha)$.[9] Thus, equation (3) can be rewritten as:

$$pm_t = \rho_0 + \rho_1 er_t + \rho_2 p_t^d + \rho_3 mc_t^* + \rho_4 y_t + \varepsilon_t \quad (4)$$

where $\rho_1 = 1-\alpha$ is the exchange rate pass-through and $0 < \alpha < 1$. If $\alpha = 1$, foreign firms are price takers in the market, absorbing all of the changes in exchange rates with the markup so that $\rho_1 = 0$; hence, the exchange rate pass-through is zero. This is called local-currency pricing (LCP); fluctuations in exchange rates have no effect on

[8] The competitive pressures in the domestic market are measured by the gap between the domestic competitors' prices and the cost of foreign products in the domestic currency. Demand pressure on foreign output, according to Hooper and Mann (1989), is measured by capacity utilization. However, data for foreign countries' capacity utilization is difficult to obtain. Therefore, we replace it with domestic demand (Y) to represent the demand pressure on foreign output.

[9] See, for example, Campa and Goldberg (2005), Sekine (2006), Al-Abri and Goodwin (2009), Ceglowski (2010).

domestic import prices. If $\alpha = 0$, changes in exchange rates are completely reflected in import prices, and the pass-through coefficient $\rho_1 = 1$. Foreign firms set prices independently from domestic competitors, referred to as producer-currency pricing (PCP).

Chapter 4 Empirical Analysis

4.1 Data Description

We use monthly data from Taiwan during 1981-2008. The data begin in 1981 because of limitations that were placed on exchange rates. Taiwan adopted a floating exchange rate system in 1978, and the data for the first three years do not provide much information. Therefore, we use 1981 as the beginning of the sample period. To separate the impact of oil prices, except domestic price (p_t^d) and domestic demand (y_t), we construct non-oil indices for import prices (pm_t), exchange rates (er_t), and foreign costs (mc_t^*). Except for the non-oil indices, all of the data are from the IMF-IFS database or the Directorate General of Budget, Accounting and Statistics, Executive Yuan (DGBAS) in Taiwan. More details regarding the composition of these indices are described below.

Import prices:

Aggregate import price data are a monthly index of the weighted import price for ten product categories published by the DGBAS. The list of products is: Animal and Vegetable Products and Prepared Foods; Mineral Products and Nonmetallic Mineral Products; Textiles and Textile Articles; Wood, Paper, Pulp and Articles Thereof; Chemicals, Plastics, Rubber and Articles Thereof; Primary Metals and Articles Thereof; Machinery, Optical and Precision Instruments; Electronic

Machinery; Transportation Equipment and Panels; and Miscellaneous Products.

Import prices of industries classified by SITC are Food & Edible Live Animals; Beverages & Tobacco; Inedible Crude Materials Except Fuels; Fuels & Related Materials; Chemicals & Related Products; Manufactured Goods Classified Chiefly by Material; Machinery & Transport Equipment; and Miscellaneous Products. Information about the proportions and the weights of these industries in aggregate imports and aggregate import price index is listed in Table 4.1.

Table 4.1
Proportions and Weights of SITC Industries in Aggregate Imports and Aggregate Import Price Index

		Proportions in Aggregate Imports (%)	Weights in Aggregate Import Price Index (%)
SITC 0	Food & Edible Live Animals	3.00	2.12
SITC 1	Beverages & Tobacco	0.69	0.74
SITC 2	Inedible Crude Materials Except Fuels	4.92	5.16
SITC 3	Fuels & Related Materials	12.77	18.51
SITC 5	Chemicals & Related Products	12.38	13.87
SITC 6	Manufactured Goods Classified Chiefly by Material	13.10	12.86
SITC 7	Machinery & Transport Equipment	41.94	38.26
SITC 8	Miscellaneous Products	8.38	8.44

Note: The proportions of SITC industries in total imports are the average of 1981to 2008.

Sources: DGBAS Taiwan.

Non-oil import prices:

To distinguish the impact of oil prices, we compute the non-oil import price index by excluding the mineral products item from the aggregate import price.

Nominal effective exchange rate:

We construct the nominal effective exchange rate (NEER) based on the prevailing method used in the related studies of Kohlscheen (2010), Ito and Sato (2008), Campa and Gonzalez (2006), Gagnon and Ihrig (2004), Knetter (1995), and Steel and King (2004). This variable is an imports-weighted average exchange rate index for 14 countries exporting to Taiwan. These countries are Australia, China, France, Germany, Hong Kong, Indonesia, Japan, Korea, Kuwait, Malaysia, Singapore, Saudi Arabia, the UK and the US. Purchases from these countries typically account for over 70% of the total imports. Among these 14 countries, except for major currencies, such as the Japanese Yen, Euro, UK Pound and the US Dollar, the bilateral exchange rates between the Taiwan NT-Dollar and the other currencies are replaced by the exchange rates with respect to the US-Dollar.

Non-oil nominal effective exchange rate:

This variable is computed by excluding the countries where Taiwan imports oil from. These countries are Saudi Arabia, Kuwait and Indonesia.

Foreign costs:

It is an imports-weighted average of producer price indices (PPI's) or the consumer price index (CPI) for 14 countries that export to Taiwan. Data on PPIs for

China, France, Hong Kong, Kuwait, Malaysia and Saudi Arabia are difficult to obtain, so we use the CPIs as a proxy for production costs in these countries.

Non-oil foreign costs:

Based on the data of foreign costs, this variable is computed by excluding Saudi Arabia, Kuwait and Indonesia, the countries where Taiwan imports its oil from.

Domestic price:

This is a monthly series of the wholesale price index for domestic products and sales in Taiwan. Instead of a general PPI or WPI, we select the wholesale price index of domestic products and sales to represent the domestic competitive price pressure to avoid endogeneity with import prices. As the products in this index are produced and consumed domestically, prices for these domestic products are not intercorrelated with import prices.

Domestic demand:

This variable is computed by the total value of private consumption, government consumption and gross fixed capital formation. The quarterly data are interpolated into monthly data using industrial production index.

Inflation rates:

This is a monthly series of the annual percentage changes in Taiwan's Consumer Price Indices (CPI).

When time-series data are utilized, tests for stationarity and cointegration of these data are needed. The standard tests for stationarity are the Augmented Dickey-Fuller and PP (Phillips and Perron, 1988) tests; both tests indicate that the series are non-stationary in logarithmic levels but stationary in first differences. Accordingly, a Johansen test for cointegration was performed on these series. At a 5% significance level, the null hypothesis of no cointegration cannot be rejected.[10] These test results suggest that we should estimate the relation of Eq. (4) in the following first-difference form:

$$\Delta\, pm_t = \lambda_0 + \lambda_1(\mathrm{L})\,\Delta\, er_t + \lambda_2(\mathrm{L})\,\Delta\, p_d + \lambda_3(\mathrm{L})\,\Delta\, \mathrm{mc}_t^* + \lambda_4(\mathrm{L})\,\Delta\, \mathrm{y}_t + \epsilon_t \qquad (5)$$

where $\lambda_1(L)$, $\lambda_2(L)$ and $\lambda_3(L)$ are lag polynomials.

4.2 Model Specification

As this study hypothesizes that there is a nonlinear relationship between exchange rate pass-through and inflation, we use the threshold autoregression model (TAR) in Tsay (1998) to estimate the effect of pass-through. If the pass-through

[10] The test involved two lags, no trend, and an intercept in the model.

differs as the inflation level changes, different degrees of pass-through should be observed in different inflation regimes. Because most studies suggest a positive relationship between exchange rate pass-through and inflation, a higher pass-through should appear in a higher inflation regime. Therefore, before focusing on analyzing the pass-through in deflation, we first employ the TAR model only for higher and lower inflation regimes.

In the two-regime TAR, we compare the pass-through when the inflation rate is above and below 3%. As described in the theoretical framework of Chapter 3, we adopt the least restrictive form of the markup model used in numerous other studies for the estimation, which relaxes the restrictions on the coefficients of p_t^d and mc_t^* presented in equation (5). Based on equation (5), the two-regime TAR is as follows:

$$\Delta pm_t^{i,j} = \begin{cases} \mu_1 + a_1^i \Delta pm_{t-1}^{i,j} + b_1^i(\mathrm{L})\Delta er_t^j + c_1^i(\mathrm{L})\Delta p_t^d + d_1^i(\mathrm{L})\Delta mc_t^{*,j} + e_1^i(\mathrm{L})\Delta y_t \\ \qquad + f_1^i \sum_{k=1}^{11} SD_{k,t} + v_t, \quad if\ \pi_{t-d} > 3\% \\ \mu_2 + a_2^i \Delta pm_{t-1}^{i,j} + b_2^i(\mathrm{L})\Delta er_t^j + c_2^i(\mathrm{L})\Delta p_t^d + d_2^i(\mathrm{L})\Delta mc_t^{*,j} + e_2^i(\mathrm{L})\Delta y_t \\ \qquad + f_2^i \sum_{k=1}^{11} SD_{k,t} + v_t,, \quad if\ \pi_{t-d} < 3\% \end{cases} \tag{6}$$

where $SD_{k,t}, k = 1,2,...11$ are seasonal dummy variables for the months of January to November, π_t is the monthly inflation rate in Taiwan and d denotes the lag number of threshold π_t, i denotes the aggregate and industries variables and $j = 0,1$ denotes the aggregate and nonoil variables respectively. We use the Akaike Information

Criterion (AIC) to determine the order of each lag polynomial on the estimates.[11] The coefficient b^i represents the effect of exchange rate pass-through. The sum of its current and lagged values is used as our estimate for the cumulative exchange rate pass-though.

Then, we separate deflation from the regime of low inflation and model (6) is extended to three regimes. Here, we adopt the suggestion put forward in Rogoff et al. (2003) and assume that there is deflation when the inflation rate is below 1%. The three-regime TAR is modeled as follows:

$$\Delta pm_t^{i,j} = \begin{cases} \mu_1 + \tau_1^i \Delta pm_{t-1}^{i,j} + \beta_1^i(\mathrm{L})\Delta er_t^j + \gamma_1^i(\mathrm{L})\Delta p_t^d + \delta_1^i(\mathrm{L})\Delta mc_t^{*,j} + \varphi_1^i(\mathrm{L})\Delta y_t \\ \qquad +\omega_1^i \sum_{k=1}^{11} SD_{k,t} + v_t, \qquad if\ \pi_{t-d} > 3\% \\ \mu_2 + \tau_2^i \Delta pm_{t-1}^{i,j} + \beta_2^i(\mathrm{L})\Delta er_t^j + \gamma_2^i(\mathrm{L})\Delta p_t^d + \delta_2^i(\mathrm{L})\Delta mc_t^{*,j} + \varphi_2^i(\mathrm{L})\Delta y_t \\ \qquad +\omega_2^i \sum_{k=1}^{11} SD_{k,t} + v_t, , \qquad if\ 1\% < \pi_{t-d} < 3\% \\ \mu_3 + \tau_3^i \Delta pm_{t-1}^{i,j} + \beta_3^i(\mathrm{L})\Delta er_t^j + \gamma_3^i(\mathrm{L})\Delta p_t^d + \delta_3^i(\mathrm{L})\Delta mc_t^{*,j} + \varphi_3^i(\mathrm{L})\Delta y_t \\ \qquad +\omega_3^i \sum_{k=1}^{11} SD_{k,t} + v_t, , \qquad if\ \pi_{t-d} < 3\% \end{cases} \quad (7)$$

The notations of $SD_{k,t}, \pi_t, i$ and j are the same with those in model (6) except that the pass-through effect is now measured by β^i. Again, the sum of its current and lagged values is used as our estimate for the cumulative exchange rate pass-though.

Model (7) clearly describes the central theme of this study. The degree of exchange rate pass-through is analyzed in three regimes. The low positive inflation regime indicates low but positive inflation rates, which do not include deflation. High inflation, low positive inflation and deflation are defined as inflation rates of more than 3%, between 1 and 3%, and less than 1%, respectively. Through the three-regime TAR, we are able to obtain the pure effect that deflation has on exchange rate

[11] The regression is run in first differences with current and two lags of exchange rate, current and one lag of domestic price level, current foreign costs, and a domestic demand term with ten lags.

pass-through.

4.3 Threshold Tests

In this section, a nonlinearity test is performed to check whether the specification of the model is appropriate. The test statistic $C(i)$ is used in Tsay (1998) to detect nonlinearity in the model. We assume that the influence of inflation on the exchange rate pass-through would not last more than a year. The test results for twelve threshold lags are provided in Table 4.2 for the aggregate and disaggregate import prices.

Table 4.2
Results of the Threshold Nonlinearity Test

i	1	2	3	4	5	6	7	8	9	10	11	12
All Goods												
						$m_0 = 50$ [a]						
$C(i)$ [b]	34.75	46.48	78.29	56.04	25.81	56.00	34.83	36.83	21.95	45.63	46.21	26.98
	(0.01)[c]	(0.00)	(0.00)	(0.00)	(0.14)	(0.00)	(0.01)	(0.01)	(0.29)	(0.00)	(0.00)	(0.11)
						$m_0 = 60$						
	36.88	44.78	76.43	57.31	27.14	59.14	34.33	33.26	20.36	42.30	42.52	25.84
	(0.01)	(0.00)	(0.00)	(0.00)	(0.10)	(0.00)	(0.02)	(0.02)	(0.37)	(0.00)	(0.00)	(0.13)
						$m_0 = 100$						
	44.40	77.12	67.36	49.97	28.86	42.05	41.89	28.25	16.15	42.89	43.73	29.42
	(0.00)	(0.00)	(0.00)	(0.00)	(0.07)	(0.00)	(0.00)	(0.08)	(0.65)	(0.00)	(0.00)	(0.06)
Non-oil Goods												
						$m_0 = 50$						
$C(i)$	24.26	33.17	55.20	33.04	15.88	39.88	22.98	7.88	5.54	20.61	17.57	17.32
	(0.18)	(0.02)	(0.00)	(0.02)	(0.66)	(0.00)	(0.23)	(0.98)	(0.99)	(0.35)	(0.55)	(0.56)
						$m_0 = 60$						
	26.61	30.40	53.08	32.16	16.02	43.29	22.64	7.85	4.72	20.29	16.55	16.78
	(0.11)	(0.04)	(0.00)	(0.03)	(0.65)	(0.00)	(0.25)	(0.98)	(0.99)	(0.37)	(0.62)	(0.60)
						$m_0 = 100$						
	41.05	52.48	53.16	28.33	9.57	31.41	29.83	19.58	6.64	26.97	15.33	25.22
	(0.00)	(0.00)	(0.00)	(0.07)	(0.96)	(0.03)	(0.05)	(0.42)	(0.99)	(0.10)	(0.70)	(0.15)

Table 4.2 (continued)
Results of the Threshold Nonlinearity Test

i	1	2	3	4	5	6	7	8	9	10	11	12
SITC 0	Food & Edible Live Animals											
						$m_0 = 50$						
$C(i)$	33.34	20.72	31.48	23.54	10.71	13.76	19.51	16.94	10.68	19.91	25.90	14.83
	(0.12)	(0.35)	(0.04)	(0.21)	(0.93)	(0.80)	(0.42)	(0.59)	(0.93)	(0.40)	(0.13)	(0.73)
						$m_0 = 60$						
	29.18	19.80	28.35	22.77	10.41	12.05	22.17	18.77	8.63	23.62	22.19	13.65
	(0.16)	(0.41)	(0.08)	(0.24)	(0.94)	(0.88)	(0.28)	(0.47)	(0.98)	(0.21)	(0.27)	(0.80)
						$m_0 = 100$						
	27.85	20.92	29.68	18.53	13.45	17.74	33.13	24.07	12.19	30.30	22.24	15.62
	(0.09)	(0.34)	(0.06)	(0.49)	(0.81)	(0.54)	(0.02)	(0.19)	(0.88)	(0.05)	(0.27)	(0.68)
SITC 1	Beverages & Tobacco											
						$m_0 = 50$						
$C(i)$	29.40	22.13	26.36	13.19	11.76	15.32	11.69	17.40	16.01	13.48	16.74	24.32
	(0.06)	(0.28)	(0.12)	(0.83)	(0.90)	(0.70)	(0.90)	(0.56)	(0.66)	(0.81)	(0.60)	(0.18)
						$m_0 = 60$						
	27.67	22.50	26.02	13.23	10.73	16.27	11.45	16.45	14.74	13.20	16.24	22.83
	(0.09)	(0.26)	(0.13)	(0.83)	(0.93)	(0.64)	(0.91)	(0.62)	(0.74)	(0.83)	(0.64)	(0.25)
						$m_0 = 100$						
	32.23	27.18	24.94	10.80	10.45	24.95	41.92	32.91	30.62	25.87	24.73	33.66
	(0.03)	(0.10)	(0.16)	(0.93)	(0.94)	(0.16)	(0.10)	(0.02)	(0.04)	(0.13)	(0.17)	(0.12)
SITC 2	Inedible Crude Materials Except Fuels											
						$m_0 = 50$						
$C(i)$	13.63	19.07	10.98	11.66	7.65	13.98	18.89	14.65	15.52	13.65	18.22	12.63
	(0.80)	(0.45)	(0.09)	(0.90)	(0.99)	(0.79)	(0.46)	(0.74)	(0.69)	(0.80)	(0.51)	(0.86)
						$m_0 = 60$						
	13.37	18.60	9.77	10.55	6.94	14.20	18.18	15.32	13.22	13.83	21.13	11.92
	(0.82)	(0.48)	(0.08)	(0.94)	(0.99)	(0.77)	(0.51)	(0.70)	(0.83)	(0.79)	(0.33)	(0.89)
						$m_0 = 100$						
	12.82	17.85	19.32	10.06	6.85	11.15	15.67	14.51	13.14	15.63	16.63	11.90
	(0.85)	(0.53)	(0.07)	(0.95)	(0.99)	(0.92)	(0.68)	(0.75)	(0.83)	(0.68)	(0.61)	(0.89)
SITC 3	Fuels & Related Materials											
						$m_0 = 50$						
$C(i)$	29.36	45.07	45.27	35.93	34.47	36.57	33.83	39.44	41.70	42.58	38.38	40.04
	(0.08)	(0.00)	(0.00)	(0.01)	(0.01)	(0.09)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
						$m_0 = 60$						
	28.03	43.29	41.05	33.98	36.72	35.62	34.22	40.83	40.85	39.64	35.12	39.82
	(0.03)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
						$m_0 = 100$						
	31.64	40.29	34.57	39.99	40.18	33.26	39.01	39.06	28.64	34.39	38.82	39.81
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.07)	(0.00)	(0.00)	(0.00)

Table 4.2 (continued)
Results of the Threshold Nonlinearity Test

i	1	2	3	4	5	6	7	8	9	10	11	12
SITC 5	Chemicals & Related Products											
						$m_0 = 50$						
$C(i)$	15.53	19.03	34.04	28.24	15.74	25.31	18.33	18.49	16.23	22.30	25.05	17.04
	(0.69)	(0.45)	(0.02)	(0.08)	(0.67)	(0.15)	(0.50)	(0.49)	(0.64)	(0.27)	(0.16)	(0.59)
						$m_0 = 60$						
	19.11	18.80	33.12	26.18	19.61	27.13	18.67	20.88	16.71	24.99	26.40	15.16
	(0.45)	(0.47)	(0.02)	(0.13)	(0.42)	(0.10)	(0.48)	(0.34)	(0.61)	(0.16)	(0.12)	(0.71)
						$m_0 = 100$						
	17.72	27.44	23.81	21.17	19.94	30.34	13.24	14.17	13.58	33.72	23.36	22.43
	(0.54)	(0.09)	(0.20)	(0.33)	(0.40)	(0.05)	(0.83)	(0.77)	(0.81)	(0.02)	(0.22)	(0.26)
SITC 6	Manufactured Goods Classified Chiefly by Material											
						$m_0 = 50$						
$C(i)$	23.73	17.41	13.04	19.69	18.67	28.77	19.77	23.06	16.36	22.65	16.10	13.31
	(0.21)	(0.56)	(0.83)	(0.41)	(0.48)	(0.07)	(0.41)	(0.23)	(0.63)	(0.25)	(0.65)	(0.82)
						$m_0 = 60$						
	22.48	16.23	11.57	19.84	17.48	33.49	22.39	21.93	15.52	16.98	11.90	13.19
	(0.26)	(0.64)	(0.90)	(0.40)	(0.56)	(0.02)	(0.27)	(0.29)	(0.69)	(0.59)	(0.89)	(0.83)
						$m_0 = 100$						
	30.63	22.26	11.57	15.86	17.75	28.71	25.84	16.44	10.39	26.54	11.08	19.27
	(0.04)	(0.27)	(0.93)	(0.67)	(0.54)	(0.07)	(0.13)	(0.63)	(0.94)	(0.11)	(0.92)	(0.44)
SITC 7	Machinery & Transport Equipment											
						$m_0 = 50$						
$C(i)$	32.08	40.60	44.09	34.01	22.55	36.91	23.67	17.43	15.71	20.93	25.81	22.60
	(0.03)	(0.00)	(0.00)	(0.01)	(0.26)	(0.00)	(0.21)	(0.56)	(0.68)	(0.34)	(0.14)	(0.26)
						$m_0 = 60$						
	31.68	41.35	44.36	33.89	26.38	40.09	23.84	16.87	15.84	21.88	25.83	22.44
	(0.03)	(0.00)	(0.00)	(0.07)	(0.12)	(0.00)	(0.20)	(0.60)	(0.67)	(0.29)	(0.14)	(0.26)
						$m_0 = 100$						
	35.53	54.56	36.79	28.50	20.35	32.42	19.19	25.14	17.48	25.40	28.24	28.81
	(0.01)	(0.00)	(0.00)	(0.07)	(0.37)	(0.03)	(0.44)	(0.16)	(0.56)	(0.15)	(0.08)	(0.07)
SITC 8	Miscellaneous Products											
						$m_0 = 50$						
$C(i)$	24.83	34.90	33.28	44.26	26.61	43.33	18.69	19.80	13.76	27.89	26.26	13.43
	(0.17)	(0.01)	(0.02)	(0.00)	(0.11)	(0.00)	(0.47)	(0.41)	(0.79)	(0.08)	(0.12)	(0.82)
						$m_0 = 60$						
	23.71	33.50	31.52	45.25	26.12	42.34	18.78	17.40	13.45	26.39	24.94	12.56
	(0.21)	(0.02)	(0.03)	(0.00)	(0.13)	(0.00)	(0.47)	(0.56)	(0.81)	(0.12)	(0.16)	(0.86)
						$m_0 = 100$						
	28.73	38.95	26.83	32.83	21.27	36.94	16.85	15.52	14.48	34.49	19.64	17.72
	(0.07)	(0.00)	(0.11)	(0.03)	(0.32)	(0.00)	(0.60)	(0.69)	(0.75)	(0.02)	(0.42)	(0.54)

Note:

[a] m_0 is the starting point of the recursive least squares.

[b] C(i) is the test statistic for threshold lag i.

[c] Numbers in parentheses are p-values.

Under the null hypothesis, the import price series is linear and hence model (6) reduces to a linear model. The test statistics in the table significantly reject the null hypothesis for several lag numbers in each category, suggesting threshold nonlinearity when the inflation rate is given these lag periods. Among these lag periods, the maximum value of $C(i)$ suggests the appropriate threshold lags. The numbers of appropriate threshold lags for the aggregate and disaggregate import prices are listed in Table 4.3.

Table 4.3
Optimal number of threshold lags

		Optimal Number of threshold lags (d)
	All Goods	3
	Non-oil Goods	3
SITC 0	Food & Edible Live Animals	3
SITC 1	Beverages & Tobacco	1
SITC 2	Inedible Crude Materials Except Fuels	3
SITC 3	Fuels & Related Materials	3
SITC 5	Chemicals & Related Products	3
SITC 6	Manufactured Goods Classified Chiefly by Material	6
SITC 7	Machinery & Transport Equipment	3
SITC 8	Miscellaneous Products	4

4.4 Explanations of Estimation Results

Table 4.4 shows the long-run estimates of the exchange rate pass-through in the two-regime TAR. For Taiwan aggregate import prices, as displayed in the table, the pass-through are both greater when the inflation rate is over 3%. It is approximately 28% higher for all import goods and 16% higher for non-oil import goods. Over fifty

percent of the industries classified by SITC also show higher pass-through in the high inflation regime.[12] These results are consistent with multiple other studies that find that higher inflation increases the pass-through. As presented in the above results, we find that similar evidence also exists in Taiwan if only two regimes are considered.

Table 4.4
Long-run exchange rate pass-through for two regimes

		High inflation ($\pi_{t-d} > 3\%$)	Low inflation ($\pi_{t-d} < 3\%$)
	All Goods	0. 79	0.50
	Non-oil Goods	0.71	0.56
SITC 0	Food & Edible Live Animals	-0.02	0.66
SITC 1	Beverages & Tobacco	0.43	0.50
SITC 2	Inedible Crude Materials Except Fuels	0.32	0.22
SITC 3	Fuels & Related Materials	1.76	-0.20
SITC 5	Chemicals & Related Products	0.96	0.60
SITC 6	Manufactured Goods Classified Chiefly by Material	-0.01	0.71
SITC 7	Machinery & Transport Equipment	0.83	0.69
SITC 8	Miscellaneous Products	0.79	0.77

Turning to the results of three regimes, we first examine the OLS estimates for the import prices of all goods and non-oil goods from model (7) in Table 4.5. Model characteristics, such as sample size, R-squared and a test for the presence of autocorrelation in the residuals, are displayed at the bottom of the table. For all goods

[12] For the results of negative exchange rate pass-through, Froot and Klemperer (1989) indicates that the sign of the pass-through depends on whether exchange rate changes are thought to be temporary or permanent. In the United States, for example, foreign exporting firms to the United States may raise the dollar price in response to a temporary appreciation of the dollar because they expect that the dollar will depreciate over time and may erode the value of future profits.

Table 4.5
OLS estimated results for the aggregate import prices in three regimes

	All Goods			Non-oil Goods		
	High inflation [a]	Low positive inflation [a]	Deflation [a]	High inflation	Low positive inflation	Deflation
j [b]	0	0	0	1	1	1
constant	-0.0022	0.0064	0.0025	0.0000	0.0004	0.0028
	(0.0046) [c]	(0.0047)	(0.0045)	(0.0029)	(0.0033)	(0.0035)
$\Delta pm_{t-1}^{i,j}$	0.3022**	0.0212	0.2500***	0.2016*	0.2951***	0.1314
	(0.1336)	(0.1005)	(0.0935)	(0.1120)	(0.1031)	(0.0988)
Δe_t^j	0.7474***	0.5683***	0.5918***	0.6481***	0.5532 ***	0.5059 ***
	(0.1018)	(0.1047)	(0.1050)	(0.0601)	(0.0708)	(0.0801)
Δe_{t-1}^j	-0.3361**	-0.2665**	-0.1345	-0.1573	-0.1705*	0.0063
	(0.1437)	(0.1252)	(0.1143)	(0.0960)	(0.0947)	(0.0969)
Δe_{t-2}^j	0.1397	-0.0763	0.0368	0.0778	-0.0642	-0.0858
	(0.1009)	(0.0966)	(0.1114)	(0.0591)	(0.0652)	(0.0867)
Δp_t^d	0.6915***	0.6538***	0.1858	0.3058**	0.4766***	0.2121
	(0.1812)	(0.1819)	(0.2319)	(0.1182)	(0.1241)	(0.1832)
Δp_{t-1}^d	-0.1891	-0.0897	0.2706	0.1378	-0.0436	0.3169*
	(0.1944)	(0.1898)	(0.2188)	(0.1056)	(0.1365)	(0.1712)
$\Delta mc_t^{*,j}$	0.4189**	0.8108**	1.0825***	0.1884	-0.0904	0.5059**
	(0.2071)	(0.3365)	(0.2798)	(0.2377)	(0.2274)	(0.2220)
Δy_{t-10}	0.0252	-0.0083	0.0191	0.0209	0.0013	0.0281*
	(0.0206)	(0.0237)	(0.0215)	(0.0128)	(0.0167)	(0.0168)
$SD_{1,t}$	-0.0023	-0.0137**	-0.0078	-0.0011	-0.0080**	-0.0036
	(0.0064)	(0.0055)	(0.0068)	(0.0039)	(0.0039)	(0.0053)
$SD_{2,t}$	-0.0026	-0.0125**	-0.0051	-0.0011	0.0034	-0.0052
	(0.0063)	(0.0062)	(0.0067)	(0.0039)	(0.0044)	(0.0052)
$SD_{3,t}$	0.0067	-0.0051	-0.0120	0.0022	-0.0004	-0.0070
	(0.0066)	(0.0054)	(0.0074)	(0.0041)	(0.0038)	(0.0058)
$SD_{4,t}$	-0.0073	-0.0085	-0.0056	-0.0079*	-0.0020	-0.0057
	(0.0070)	(0.0052)	(0.0070)	(0.0044)	(0.0036)	(0.0055)
$SD_{5,t}$	-0.0003	-0.0072	-0.0062	-0.0043	-0.0026	-0.0094*
	(0.0062)	(0.0058)	(0.0068)	(0.0040)	(0.0041)	(0.0053)
$SD_{6,t}$	0.0023	-0.0066	-0.0011	0.0014	-0.0031	-0.0013
	(0.0061)	(0.0061)	(0.0067)	(0.0038)	(0.0042)	(0.0053)
$SD_{7,t}$	-0.0059	-0.0007	-0.0100	-0.0084	0.0018	-0.0097*
	(0.0063)	(0.0061)	(0.0063)	(0.0039)	(0.0042)	(0.0050)
$SD_{8,t}$	0.0042	-0.0036	-0.0001	-0.0024	0.0008	-0.0054
	(0.0066)	(0.0058)	(0.0065)	(0.0042)	(0.0041)	(0.0051)
$SD_{9,t}$	-0.0003	-0.0061	-0.0003	-0.0042	0.0000	-0.0033
	(0.0064)	(0.0054)	(0.0068)	(0.0040)	(0.0038)	(0.0053)
$SD_{10,t}$	-0.0071	-0.0020	-0.0065	-0.0084	0.0015	-0.0055
	(0.0059)	(0.0064)	(0.0064)	(0.0037)	(0.0045)	(0.0050)
$SD_{11,t}$	0.0026	-0.0098*	-0.0030	0.0022	-0.0024	-0.0024
	(0.0062)	(0.0054)	(0.0067)	(0.0038)	(0.0038)	(0.0052)
Sample size	95	95	124	95	95	124
$\overline{R}^2$ [d]	0.6243	0.4644	0.3144	0.6668	0.6236	0.3518
Breusch-Godfrey statistic (p-values)	1.5388 (0.2148)[e]	0.1065 (0.7441)	1.7052 (0.1916)	1.0117 (0.3145)	0.2587 (0.611)	1.4071 (0.2355)

Note: [a] High inflation, low positive inflation, and deflation regimes denote the monthly inflation rate (π) of $\pi > 3\%$, $1\% < \pi < 3\%$ and $\pi < 1\%$.

[b] $j = 0,1$ denotes the aggregate and nonoil variables respectively.

[c] The figures in parentheses below the coefficients are standard errors, with significance levels denoted as: *=10%, **=5%, ***=1%.

[d] Adjusted R^2.

[e] The figures in parentheses are p-values for the Breusch-Godfrey statistic; all the p-values show that the null hypothesis of no autocorrelation in residuals is not rejected.

and non-oil goods, the long-term effects of these variables are consistent with the theoretical predictions.[13] The cumulative exchange rate pass-through is measured by the sum of the coefficients β_i .

Before discussing the model's estimated results for the degree of exchange rate pass-through, the coefficients on the domestic price level changes (Δp_t^d) in Table 4.5 provide related information and merit attention. Examining the estimated results for the deflation regime in Table 4.5, the coefficients on the domestic price changes (Δp_t^d) in the short-run are smaller and not significant, indicating that foreign firms do not match changes in the importing countries' prices. In the long-run, the coefficients become larger but are still not significant, suggesting that the price-taking behavior of foreign firms weakens in a deflation regime.[14]

As deflation occurs, the importing market is less competitive because of its weak domestic demand. Foreign firms react less to their competitors' price level in the importing market when setting their export prices. Smaller responses to the competitive price in the importing country are made by foreign firms. According to theory, a lower magnitude of the competitive price level implies that most of the costs from changes in the exchange rate would be passed through. Therefore, the coefficients on Δp_t^d primarily predict that there would be a greater exchange rate pass-through in the deflation regime.

We now proceed to examine the results for the degree of exchange rate

[13] We check the long-run effect of each variable through the sum of its contemporaneous and lagged coefficients.

[14] Long-run effects are measured by $\gamma(1)/(1-\rho)$, where $\gamma(1)$ is the sum of current and lagged coefficients on the domestic price level changes (Δp_t^d).

pass-through. Table 4.6 presents the long-run exchange rate pass-through for the aggregate and disaggregate import prices. Notably, the pass-through estimates for the import prices of all goods and non-oil goods show greater values in deflation and high inflation regimes. Approximately 60-70% of the change in the exchange rate is reflected in the import price for these two regimes, while only 20-50% is passed through in the low positive inflation regime. Most of the disaggregate import prices also show higher pass-through in the low positive inflation regime compared with the low inflation regime. As the previous section shows, the finding that higher pass-through is correlated with higher inflation remains the same. The increasing pass-through in the deflation regime, however, sheds new light on the connection between exchange rate pass-through and the initial low inflation regime.

Table 4.6
Long-run exchange rate pass-through for three regimes

		High inflation ($\pi_{t-d} > 3\%$)	Low positive inflation ($1\% < \pi_{t-d} < 3\%$)	Deflation ($\pi_{t-d} < 1\%$)
	All Goods	0. 79	0.23	0. 67
	Non-oil Goods	0.71	0.45	0.60
SITC 0	Food & Edible Live Animals	-0.02	0.48	0.67
SITC 1	Beverages & Tobacco	0.43	0.46	0.51
SITC 2	Inedible Crude Materials Except Fuels	0.32	0.21	0.23
SITC 3	Fuels & Related Materials	1.76	-1.48	0.63
SITC 5	Chemicals & Related Products	0.96	0.84	0.49
SITC 6	Manufactured Goods Classified Chiefly by Material	-0.01	0.69	0.79
SITC 7	Machinery & Transport Equipment	0.83	0.81	0.69
SITC 8	Miscellaneous Products	0.79	0.87	0.70

According to previous literature, the exchange rate pass-through is expected to decrease as inflation continues to fall due to the positive relationship that has been found for many countries.[15] The results of our model, however, indicate that although the degree of pass-through is higher in high inflation regimes and decreases with a falling inflation rate, this pattern does not persist once the inflation rate has fallen enough to be considered deflation. From the results of the three-regime TAR, the decreasing trend stops and then reverses. The degree of the exchange rate pass-through is v-shaped. Higher degrees of pass-through are possible in a deflation regime.

Regarding firms' attitudes toward cost changes, the higher pass-through estimates of 0.67 and 0.60 for the aggregate import prices in Table 4.6 imply that firms only absorb 33-40% of exchange rate changes in a deflation regime. This percentage is initially up to 45-49% when deflation is still included in low inflation (Table 4.4). This substantial decrease shows that firms are less willing to incur these exchange rate costs. The initial estimates obviously understate the degree of pass-through in this regime. The lower estimates found in low inflation regimes cannot explain the pricing behavior of firms in deflation regimes. In fact, the broadly defined low inflation regime includes the impacts of deflation and low but positive inflation. There is a huge difference between these two regimes.

In an economy that experiences low positive inflation, as long as the market demand remains strong, falling prices within this inflation range imply that firms are able to produce goods at lower prices. Profits would increase, and this would enhance firms' capabilities for dealing with cost shocks. Having a more flexible profit margin

[15] In Gagnon and Ihrig (2004), 20 industrial countries exhibit lower pass-through rates by adopting inflation stabilizing policies. Choudhri and Hakura (2006) find strong evidence for a positive relationship between the pass-through and inflation in 71 countries. Bouakez and Rebei (2008) report a result of low pass-through at low inflation for Canada.

apparently enables firms to rely less on pass-through. Therefore, in a low positive inflation regime, import prices respond less to exchange rate fluctuations. In contrast, when an economy undergoes deflation, the implication is that the overall economic conditions are becoming worse, as is demand. Suffering from a continued decline in selling prices, the profit margin on sales to the importing country is severely reduced; this leaves little space for firms to accommodate any cost changes.[16] Consequently, the costs resulting from exchange rate changes are largely reflected in the prices of imports; thus, a greater degree of exchange rate pass-through occurs in a deflation regime.

Regarding the pass-through of disaggregate import prices, most studies agree that the pass-through of each industry is unique and may be similar across countries (Goldberg and Knetter, 1997; Campa and Goldberg, 2005). Observed changes in the pass-through rates into aggregate import prices more closely reflect changes in the composition of import bundles (Campa and Goldberg, 2005). However, there is still little known about the difference of pass-through across industries. In this study, we suppose that the industries with lower profits are easily affected by the economic fluctuations so that higher pass-through happens when demand shrinks in a deflation.

Therefore, based on these long-run pass-through estimates, we find a positive impact of deflation on the degree of exchange rate pass-through. As the initial two-regime model does not address deflation, the initial pass-through estimates underestimate the influence of deflation and also overestimate the influence of low positive inflation. Mixed impacts of these two regimes likely produce biased results for the pass-through. The evidence shows that firms actually exhibit greater degrees of exchange rate pass-through in deflation.

[16] In the markup model, the profit margin can be measured by the difference between import prices and the sum of the exchange rate and foreign costs.

To ascertain the impact of oil prices, we go back to Table 4.5 and compare the estimates on the left and the right columns in the table. The degree of pass-through for non-oil import goods is higher in the low positive inflation regime and is considerably lower in the other two regimes. The sharp 43% increase in the pass-through previously found for the deflation regime drops to a mild 14% when the price of oil is excluded. With smaller changes in the point estimates, the changes in the degree of pass-through apparently become smoother for non-oil import goods. The pass-through in the fuel industry also shows a greatest fluctuation across three regimes, which explains the greater changes in the pass-through of all goods. Therefore, fluctuations in the price of oil influence the measurement of the pass-through. However, the v-shape of the degree of exchange rate pass-through remains unchanged. Although the price of oil is dropped from the model, the pass-through is still found to be higher in deflation.

4.5 Possible Structural Change in 1997

The Asian financial crisis of July 1997 influenced the economic performance of most Asian countries. Here, we examine the influence of this possible structural change in the aggregate import prices.

To get the pass-through effect before and after the crisis, we estimate the pass-through for two sub-sample periods split by February 1997. The degree of pass-through is estimated using models (5) and (6) based on these two sub-samples. The results are presented in Table 4.7.

The pass-through estimates in Table 4.7 show that a positive relationship between the exchange rate pass-through and inflation existed before the financial crisis. The pass-through for the period of 1981-1997.6 (before financial crisis) is

Table 4.7
Long-run exchange rate pass-through, Sub-samples

		All Goods	Non-oil Goods
I. 1981-1997.6 (before the financial crisis)			
Two regimes			
High inflation	$\pi > 3\%$	0.90	0.76
Low inflation	$\pi < 3\%$	0.43	0.42
Three regimes			
High inflation	$\pi > 3\%$	0.90	0.75
Low positive inflation	$1\% < \pi < 3\%$	0.15	0.26
Deflation	$\pi < 1\%$	0.72[ab]	0.53[ab]
II. 1997.7-2008 (after the financial crisis)			
Two regimes			
High inflation	$\pi > 3\%$	-5.98[ab]	2.47[ab]
Low inflation	$\pi < 3\%$	0.87	0.81
Three regimes			
High inflation	$\pi > 3\%$	4.86[ab]	4.12[ab]
Low positive inflation	$1\% < \pi < 3\%$	0.92[a]	0.99[a]
Deflation	$\pi < 1\%$	0.93	0.81

Note:
a. The degree of freedom of the estimation result is less than 30.
b. The adjusted R^2 is negative for the estimation result.

approximately 0.4 in the low inflation regime and rises to 0.9 and 0.76 in the high inflation regime under model (6). After the financial crisis, the pass-through rates for the period of 1997.7-2008 in the low inflation regime are 0.87 and 0.81 under model (6) and 0.93 and 0.81 in the deflation regime under model (7). According to these estimates, in the two-regime analysis, the pass-through in low inflation became higher after the financial crisis. For three regimes, the pass-through in deflation were also higher after the financial crisis. Compared with the results obtained for the whole period of 1981-2008 in Table 4.6, the pass-through rates after the crisis show an increase of over 20% in deflation.[17] The evidence indicates that the impact of deflation on the pass-through is greater after the financial crisis.

However, some estimates in Table 4.7 are not persuasive due to an insufficient number of sub-samples. Therefore, we cannot conclude that the pass-through rates are

[17] In Table 4.7, the pass-through estimates in the deflation regime during the period of 1997.7-2008 (after the financial crisis) are 0.93 and 0.81, which are 20% higher than those of 0.67 and 0.60 obtained from the whole sample period of 1981-2008 in Table 4.6.

definitively higher in deflation than in low positive inflation if the data are split according to the financial crisis.

4.6 Robustness Checks

In this section, we use the aggregate import price data and make some robustness checks regarding the definition of deflation and the threshold values to examine the results in this paper.

As noted above, this study essentially adopts the suggestion in Rogoff et al. (2003) that deflation occurs when the inflation rate is less than 1% and observes a higher pass-through rate in deflation. To check the robustness of this result, we estimate the degree of pass-through for the aggregate import price data if deflation is defined as an inflation rate less than 0%.

Table 4.8 shows the results of pass-through in model (7) with deflation defined as inflation less than 0%. The first panel is the pass-through estimated for the whole period; the second and the third panels present the pass-through estimated before and

Table 4.8
Long-run exchange rate pass-through with deflation is defined as negative inflation

		All Goods	Non-oil Goods
I. Whole period (1981-2008)			
High inflation	$\pi > 3\%$	0.79	0.71
Low inflation	$0\% < \pi < 3\%$	0.47	0.48
Deflation	$\pi < 0\%$	0.85	0.64
II. 1981-1997.6 (before the financial crisis)			
High inflation	$\pi > 3\%$	0.89	0.75
Low inflation	$0\% < \pi < 3\%$	0.34	0.32
Deflation	$\pi < 0\%$	1.65[a]	0.37[ab]
III. 1997.7-2008 (after the financial crisis)			
High inflation	$\pi > 3\%$	4.86[ab]	4.12[ab]
Low inflation	$0\% < \pi < 3\%$	0.85	0.90
Deflation	$\pi < 0\%$	0.90[a]	0.72[a]

Note:
a. The degree of freedom of the estimation result is less than 30.
b. The adjusted R^2 is negative for the estimation result.

after the 1997 Asian financial crisis. For the whole period (the first panel), the pass-through of 0.85 and 0.64 are found in deflation, which are higher than the 0.47 and 0.48 values in low positive inflation. For the sub-samples in the second and the third panels, the pass-through rates are also higher in deflation than in low positive inflation, except for non-oil goods after the crisis. In light of this evidence, we conclude that the higher pass-through rate in deflation is not a result of our choice in definition of deflation.

In the TAR estimation model, the degrees of pass-through for the three regimes in model (7) are estimated under the specification that the threshold values are exogenous. As another test of the robustness of the results, the pass-through rates are estimated with threshold values that are endogenously generated from the model. According to Tsay (1998), the grid search method determines the appropriate threshold values in a TAR model.[18] Based on this approach, the threshold values endogenously generated from the data for the lower bound of a high inflation regime and the upper bound of a deflation regime in model (7) are, respectively, 2.83% and 0.8% (for the whole period); 2.85% and 0.8% (before the financial crisis); 2.8% and 0.8% (after the financial crisis). By using these values as the threshold values for the regimes in model (7), the pass-through rates are estimated for these three redefined inflation regimes. The estimated long-run pass-through are presented in Table 4.9. In the first panel for the whole period, although the pass-through for non-oil goods in deflation (0.56) is slightly lower than that in low positive inflation (0.58), the pass-through for all goods in deflation is 0.60 and is obviously higher than that of 0.36 in low positive inflation, indicating that the result of higher pass-through in deflation is consistent with the result in this study. In the second and the third panels

[18] See Tsay (1998) for a description of the grid search process.

Table 4.9
Long-run exchange rate pass-through with endogenously generated threshold values

		All Goods	Non-oil Goods
I. Whole period (1981-2008)			
High inflation	$\pi > 2.83\%$	0.76	0.71
Low positive inflation	$0.8\% < \pi < 2.83\%$	0.36	0.58
Deflation	$\pi < 0.8\%$	0.60	0.56
II. 1981-1997.6 (before the financial crisis)			
High inflation	$\pi > 2.85\%$	0.89	0.75
Low positive inflation	$0.8\% < \pi < 2.85\%$	0.28[a]	0.37[a]
Deflation	$\pi < 0.8\%$	0.57[ab]	0.39[ab]
III. 1997.7-2008 (after the financial crisis)			
High inflation	$\pi > 2.8\%$	2.36[ab]	0.18[ab]
Low positive inflation	$0.8\% < \pi < 2.8\%$	0.65[a]	0.91 [a]
Deflation	$\pi < 0.8\%$	0.97	0.86

Note:
a. The degree of freedom of the estimation result is less than 30.
b. The adjusted R^2 is negative for the estimation result.

of the sub-samples, the estimates also show a higher degree of pass-through in deflation than in low positive inflation, except for the non-oil goods after the crisis. Nonetheless, with endogenous threshold values, the increase in the degree of pass-through in deflation holds in the sub-samples. In addition, the pass-through of 0.97 and 0.86 in deflation for the period of 1997.7-2008 (after the financial crisis), which are higher than the 0.60 and 0.56 values obtained for the whole sample period of 1981-2008, indicates that, after the financial crisis, the pass-through increase more in deflation than they do over the whole period. This also implies that a higher degree of pass-through can be found in deflation, whether the threshold values are exogenous or endogenous to the model.[19]

The above results of Tables 4.8 and 4.9 all show the increasing pass-through in deflation that are reported in this study. Although some of the estimated pass-through rates for the sub-samples are not empirically persuasive due to the limited sample size,

[19] Stronger positive impacts of deflation on the pass-through rates after the financial crisis are found both in the results estimated from the models with exogenous (Table 4.6) and endogenous (Table 4.9) threshold values.

the robustness checks performed on the data for the whole period all show higher pass-through rates in deflation. Therefore, we conclude that the observed results are robust under these checks.

Chapter 5 Conclusions

Because the existing literature generally regard deflation as part of low inflation and conclud that a positive relationship exists between exchange rate pass-through and inflation, the effect of deflation is easily ignored. When deflation occurs in the importing country, exporting country firms' profits are severely reduced attributable to weak demand and falling prices in the importing country. Any cost changes, including those from exchange rate movements, are supposed to be largely reflected in exporting firms' products and, therefore, in the import prices of the importing country. The effect of pass-through thus should increase with deflation. Based on this intuition, which contradicts the positive relationship between pass-through and inflation, this study investigates the exchange rate pass-through at different price levels by focusing on the division between deflation and low positive inflation. Using a nonlinear threshold model on Taiwan's import price data, this study finds that the degree of exchange rate pass-through increases as the inflation environment becomes one of deflation. In contrast to the existing literature, the results of this study indicate that the degree of exchange rate pass-through is v-shaped across deflationary and inflationary regimes. The pass-through increases with both positive inflation and deflation, and this increasing trend is found in both the aggregate and half of the disaggregate import prices. According to the estimation results, the increasing trend in the deflationary regime is only observed when deflation is clearly identified. If deflation is not separated from the broadly defined low inflationary regime, a biased result may arise and the degree of pass-through will be inaccurate.

Regarding the effect of the petroleum industry that has a unique market

structure, this dissertation also obtains the pass-through effects of non-oil import goods. By separating the effect of oil prices, changes in the degree of pass-through are indicated to be less variable once the price of oil is excluded. The measurement of the degree of pass-through differs under the influence of oil prices. However, the pattern of increasing degrees of pass-through in a deflation regime is unchanged. The evidence shows that higher pass-through in a deflationary environment is observed not only on all import goods including oil, but also on non-oil import goods.

Furthermore, this study reveals some policy implications. According to the pattern of exchange rate pass-through at different price levels, the V-shape characteristic of pass-through across deflation and inflation regimes does not ensure a low pass-through for unboundedly low price levels. The results of this study suggest that, although keeping inflation as low as possible is beneficial because it lowers the effect that exchange rates have on import prices, this strategy no longer works during periods of deflation. The strategy only works when inflation is maintained above a certain level. Therefore, the differing impacts of inflation and deflation on the degree of pass-through should be considered carefully.

Finally, the results in this dissertation may differ if other countries' data or empirical models are applied. Nevertheless, these results suggest that the effects of deflation cannot be ignored in studying the pass-through at different price levels. Future study may consider the effect of expectations in the model of exchange rate pass-through. Additional country data regarding deflation from countries such as Japan could also be used to examine the results of higher pass-through in the deflationary environment that is found in this dissertation.

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