Price Pass-Through, Household Expenditure and Industrial Structure: The Case of Taiwan

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Abstract

In order to calculate the pass-through effect from international commodity prices to domestic prices in Taiwan and evaluate their impact on household expenditure patterns and the industrial structure, we conducted an empirical study using data for Taiwan. We found that the price pass-through coefficients for food in Taiwan were in between those for advanced countries and developing economies, which is similar to the situation facing Taiwan in terms of its economic development. However, the estimated coefficients for energy-related prices were slightly different, and this may have resulted from the energy-related industries such as petroleum, electricity and water supply being either oligopolistic or monopolistic and the government mostly adopting subsidies when the fluctuations in energy prices were the largest. It was for these reasons that the price pass-through coefficients were higher.

International commodity price shocks were found to affect household consumption patterns by means of the pass-through effect. Although the coefficients for energy-related prices were higher, the decrease in the household consumption of these products was slight because of the government's subsidy policy. The expenditure on leisure, entertainment and education changed significantly owing to the high price elasticity and income elasticity. The pass-through effect will result in a shift in household expenditure patterns.

The impact of commodity shocks on the industrial structure was evident especially in primary industries and secondary industries. Due to food and energy commodities being mainly inputs of these primary and secondary industries, they would have changed more if the pass through effect had been higher.

I. Introduction

Due to Taiwan being a small open economy and lacking natural resources[1], the pass-through effect caused by global commodity prices will have a substantial impact on the Taiwan economy. In particular, as Taiwan's industrial structure and consumption patterns are being continuously upgraded, the price pass-through might have a different impact as time passes by.

From Table 1, we can find that Taiwan's per capita GNP was about 393 U.S. dollars in 1970, and it reached 17,524 U.S. dollars in 2008. According to the IMF (2008), the degree of price pass-through in food and energy appears to differ according to the level of economic development[2], For example, food-related price pass-through in advanced countries was found to be significantly higher than in developing countries, whereas energy-related price pass-through had the opposite outcome, i.e., the pass-through was lower in developing countries. The level of Taiwan's economic development lies in between that of the advanced countries and the developing countries. It needs to be asked: Does Taiwan follow the global trend in terms of the price pass-through effect or does she play her own unique tune?

Table 1   The Economic Performance in Taiwan during the Price Fluctuations

Period (average)	Per capita GNP(US$)	Economic Growth Rate (%)	2nd ind.GDP / GDP (%)	Household Expenditure-Food(%)	Household Expenditure-Energy(%)	Oil price (WTI)[2]
1972~74	722	9.2	40.9	49.2	19.9	19.6
1979~81	2360	7.4	43.2	40.9	23.1	109.0
1989~91	8451	7.2	38.7	28.9	30.4	72.3
1999~01	13935	3.1	28.9	24.1	29.7	82.9
2004~07	16275	5.2	27.4	24.0	29.2	194.8
2008	17524	0.1	25.0	24.0	28.0	328.5

Data Source: Self calculation based on DGBAS and AREMOS datasets.

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[1] Taiwan has to import about 99.9% of her crude oil. The import values of crude oil far exceeded Taiwan's trade surplus (25.2 billion in US dollars) in 2007.

[2] According to the IMF (2008), there are 25 advanced countries and 21 emerging economies.

As Taiwan's economic growth began to take off, the industrial structure started to be radically transformed. For example, the ratio of the secondary industry GDP to total GDP was around 36.0% in 1970, and reached 45.7 % in 1980. However, with the expansion of the service sector and the moving of Taiwan's manufacturing businesses to China and Southeast Asia that resulted in a major transformation of Taiwan's industrial structure, it gradually fell to about 25.0% in 2008.

The consumption pattern of household expenditure has been changing, with the proportion of food expenditure dropping from 50% in 1970 to about 24% in 2008. According to the "Survey on Household Income and Expenditure in Taiwan," published in 2007, the expenditures on food-related goods and energy-related goods and services[3] account for over half of disposable income, being assigned a weight of 52% for the lowest 20% of households[4]. The higher the price pass-through effect, the more adverse is its effect on low-income households. Although the weight attached to food prices amounts to only 26.1%[5] of the consumer price index (CPI) in Taiwan, the extent of the price pass-through is not only linked with inflation issues but also with income redistribution. It is thus worth discussing the relationship between price pass-through and household expenditures.

As for the factors that might affect the extent of the transmission, some studies have focused on structural factors such as the integration of international markets and energy efficiency, while others have emphasized government policies such as monetary policy, tax-related policies, and so on. There are many studies that have discussed the relationship between monetary policy and exchange rate orientation with pass-through, such as Engel (2009), Ito and Sato (2008), IMF (2008), Monacelli (2005), etc.

According to the IMF (2008), as they compared the responses to monetary and

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[3] The food-related goods include food, beverages, and tobacco and the energy-related goods and services comprise rent, water fees and electricity fees..

[4] The expenditures on food, rent, water fees and electricity fees account for under 40% of disposable income for the highest 20% of households.

[5] According to the OECD and FAO (2008), the average weights of the food-related prices in relation to consumer price inflation amount to around 39.3% in developing countries and 16.2% in the developed countries.

exchange rate policies, they found that although the quality of monetary policy had improved around the world, more than 80% of emerging and developing economies maintained heavily-managed exchange rate regimes in order to anchor inflationary expectations more easily, but this also restricted the ability of monetary policy to respond[6]. Taiwan has adopted a managed independently floating exchange rate policy since the mid of 1980s. However, the central bank of Taiwan has carefully managed the exchange rate regime in order to facilitate merchandise exports. Besides, the household expenditure patterns and transformation of the industrial structure have been more important than inflation to Taiwan's economy since the 1990s owing to Taiwan's businesses have move to China and Southeast Asia that have enforced industrial structure transforming sharply.

Besides, monetary policy evaluations usually involving the use of high-frequency data in order to trace the dynamic paths, studies on structural factors basically have a lower frequency. We didn't want to rule out that the monetary policies might result in lower pass-through but we based on the data availability and the features of the Taiwan economy, we hope to provide look at this issue from another perspective and to carefully consider the relationship between a commodity's price pass-through with structural factors on the real side. We will focus on the structural factors in terms of household expenditure patterns and industrial structures transforming.

Owing to the constraints on data availability, for example both the United Nations and the IMF have omitted Taiwan's statistics, there are no empirical results for Taiwan in studies such as De Gregorio, Landerretche and Neilson (2007), IMF (2008), and Jongwanich and Park (2008). We thus regard Taiwan as a case study both to make up for this omission and to serve as a source of reference for other economies.

In order to calculate the extent to which global commodity prices are passed through to domestic prices and to evaluate their impact on household expenditures in

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[6] See IMF(2008, PP. 105~106).

different categories, besides analyzing the relationship between pass-through, household expenditures and the industrial structure in Taiwan, we have employed an econometric model to perform the analysis in an attempt to answer the following questions:

• What is the pass through effect of the fluctuations in international commodity prices on domestic prices in Taiwan?

• Is the price pass through to the domestic price similar to that to the export price?

• Are there any implications for the results of the estimation if we compare them with the results for other countries?

• What are the impacts of the fluctuations in global commodity prices on Taiwan's major macroeconomic variables such as real GDP, CPI, and so on?

• Is there any different impact in different categories of expenditure for the households causing the degree of price pass-through?

• If prices have fluctuated heavily, which industries have been the most affected in Taiwan through the changes in household demands resulting from price pass-through? Which industries are the potential winners and losers?

• Is there any relationship between the pass-through and the industrial structure in Taiwan and what are the implications?

In order to answer the above questions, the empirical strategies can be separated into three stages. First we follow the IMF (2008) to employ a simple VAR model to estimate the coefficients of price pass-through. Then apply the macro-econometric model to simulate the impacts as global commodity price shocks occur. Finally, we utilize AIDS, the consumption conversion matrix and input-output tables to distribute the impacts.

According to the results, we follow the IMF (2008) to divide the transmission channel into two stages. The first one is the global commodity price (GCP) pass-through to the domestic prices. The second is the pass-through from the domestic price to core CPI. We find that the pass-through coefficients are 13.5% and 17.3% for

the GCP to the domestic prices of food and energy, respectively. As for the price pass-through from domestic to core CPI, the estimated result for food of 18.9% is close to that in advanced economies. The percentage for energy is 19.2% which is higher in our case than the case of the IMF.

The estimated coefficients may reflect characteristics of the Taiwan economy. First, Taiwan follows the global trends in the price pass-through effect except for the domestic price to core CPI in energy-related goods. This means that Taiwan lies in between advanced economies and emerging economies in terms of its economic development, and so the price pass-through is situated between advanced economies and emerging countries both in terms of food and fuel, even though Taiwan is lacking in natural resources.

Next, the impact of domestic prices on the CPI in regard to energy seems to have a similar pass-through effect to core CPI with CPI in food, although the weights for CPI-energy are less than those for CPI-food. The energy-related industries are either monopolies or oligopolies. They are highly correlated with living industries, and since the government mostly adopts subsidies when the fluctuations in energy prices are greater, the price pass-through coefficient is higher.

Furthermore, the price pass-through in relation to XPI is lower than that for MPI for both food and energy. This also reflects the strength of world competitiveness for export-oriented policies. The price pass-through is also higher in relation to the producer production index (PPI), which is denoted here as whole sale price index (WPI)[7], than in regard to the consumer price index. This finding is similar to that of Jongwanich and Park (2008)

The price pass-through also causes the household's expenditure to change markedly. The expenditures on fuel and power, transport and communications decrease slightly less than in the food-related industries, although the global price pass-through domestic price included in core CPI is similar. This may reflect

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[7] The WPI (wholesale price index) is composed of XPI (export price index, weighted 36.5%), MPI (import price index, weighted 32.7%), and Domestic Sales excluding Imports (weighted 30.8%). There is no PPI (producer price index) in Taiwan, so the WPI is used instead.

diversification in food purchases and the government's subsidy policy.

Besides, we find that if the commodity price shocks occurred in the 1990s or the early 21st century, the shocks would have eventually ceased with the passing of time and almost all the price indexes would respond more quickly than real variables. The impact of commodity shocks on the industrial structure is obvious especially in primary industries and secondary industries. Due to food and energy commodities being mainly inputs of primary and secondary industries, they will change more if the pass through effect is higher.

II. The transmission mechanisms for price pass-through in Taiwan

The fluctuations in global commodity prices have an impact on the business cycle of a small economy. As for Taiwan, according to Figure 1, we find that the annual growth rate of the CPI was obviously high during the 1973 oil crisis and the 1979 energy crisis. However, from the 1980s onwards, the fluctuations in the prices of food-related items that were used in the calculation of the CPI, as compared with the prices of oil-related items within the CPI, were relatively smooth in Taiwan. This kind of situation was similar to the global trend.
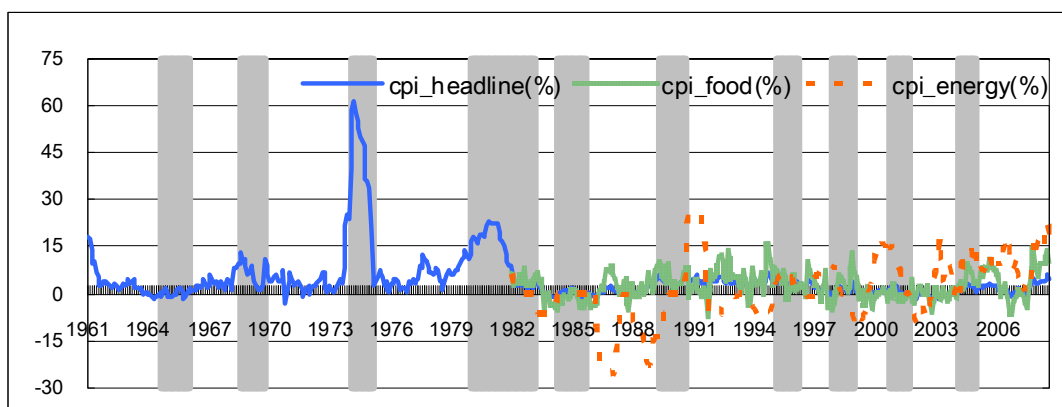
Note: The shaded areas denote the recession periods in Taiwan's business cycle.
Data source: The authors' calculation is based on the DGBAS and AREMOS datasets.

Figure 1 Price Fluctuations and the Business Cycle in Taiwan

The Figure 2 depicts the transmission channels for the fluctuations in global commodity prices transmitted to Taiwan's domestic prices and their impact on the

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Taiwan economy. The fluctuations in global commodity prices will affect the domestic prices by means of the trade sector and the domestically-produced processes, and will result in a change in relative prices. Then it may influence the consumer's choices and reflect the changing consumption patterns. As a result, each kind of goods and services should be adjusted over time and the degrees of variation might be diversified.

The changes in relative prices are not adjusted immediately and completely, for there is usually a time lag. In addition, the degree of global price pass-through is related to the industrial structure and the consumer's expenditure pattern. Therefore, the fluctuation in global commodity prices will result in a change in consumer expenditure and the cost of production, and the impact on different goods and services will be varied. For example, due to sluggish domestic demand and a diversified pass-through effect, the fluctuations in WPI and MPI are more consistent with the trends in global commodity prices, while the CPI is relatively more stable.
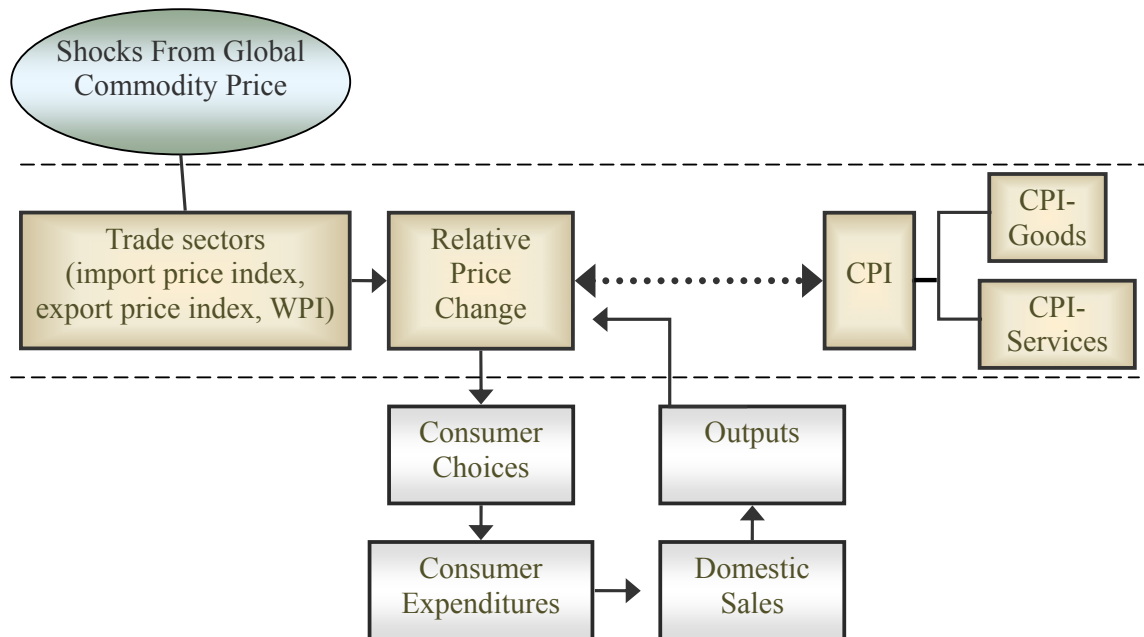

Figure 2   The Price Transmission Flow Chart

III. Empirical Procedures

In order to clarify the pass-through effect from global commodity prices to

domestic price and evaluate the effect on household expenditure patterns and the industrial structure, the empirical procedure is described in Figure 3.
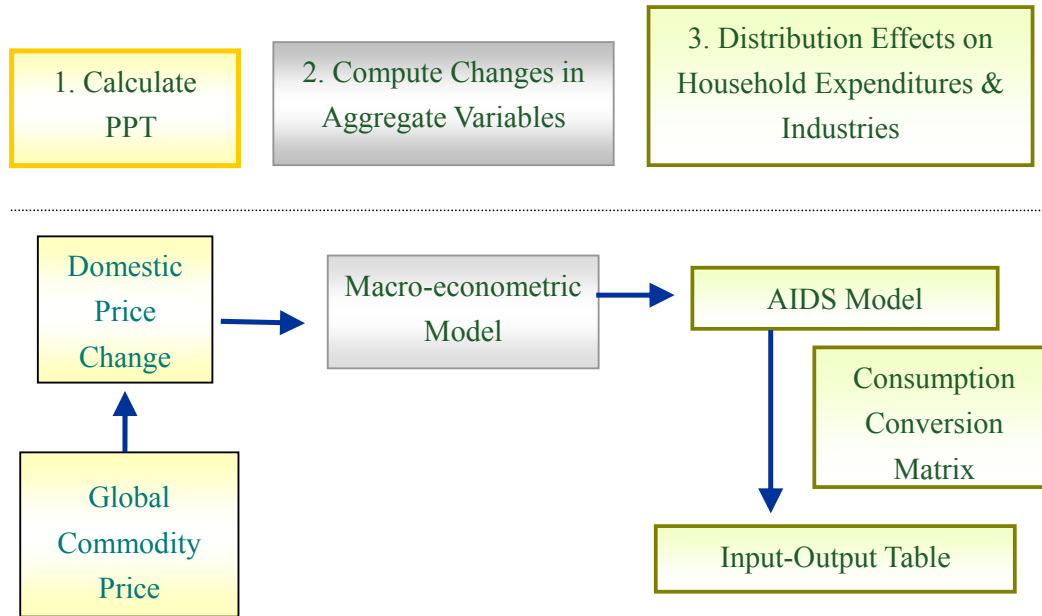

Figure 3   Empirical Study Flow Chart

To sum up, the empirical strategies can be separated into three stages. First we follow the IMF (2008) to employ a simple VAR model to estimate the coefficients of price pass-through. Then we modify and link the price pass-through effects to the macro-econometric model to simulate the impacts as global commodity price shocks occur and observe the interactions of the major macro variables. Finally, we utilize AIDS, a consumption conversion matrix and input-output tables to distribute the impacts. The price pass-through might have a distinct effect on the content of household expenditure, and so it must provide a more detailed description of private consumption and industrial structure. By means of the estimation of AIDS and the consumption conversion matrix, we can calculate the impact on the supply side.

The price pass-through might have distinct effects on the content of household expenditure, and so it must provide a more detailed description of private consumption which is subdivided into 12 categories in the macro-econometric model. We then apply the input-output tables based on the structures for 1996 and 2007, so

that we can determine whether the price pass-through might stimulate or reflect the effect in industrial transformation. Furthermore, if prices have fluctuated significantly, it needs to be asked which industries have been the most affected in Taiwan through the changes in household demand resulting from price pass-through. In addition, which industries are the potential winners and losers?

IV. The Estimation of the Commodity Price Pass-Through in Taiwan

1. The Empirical Model

To assess the potential impact of the changes in international commodity prices on domestic prices and other major macroeconomic variables in Taiwan, we refer to and modify the models of De Gregorio, Landerretche, and Neilson (2007) and the IMF (2008). In the case of the IMF (2008), there are two steps involved. The first one links the change in the domestic price (fuel and food) with the change in the global commodity price (fuel and food). The second links inflation (core CPI) to the changes in the fuel and food prices in terms of the domestic price, respectively, by controlling for changes in the output gap (the Phillips curve).The steps are stated briefly as follows. The first one involves using bivariate regressions of the following form[8]:

$$\pi_t^{domestic} = \alpha + \sum_{i=1}^{4} \beta_i \pi_{t-i}^{domestic} + \sum_{i=0}^{4} \delta_i \pi_{t-i}^{world} + \varepsilon_t \tag{1}$$

Here, π stands for the annualized quarter-over-quarter log difference (in percent) in, respectively, food or fuel prices (we also include seasonal dummies). The reported pass-through coefficients, which reflect the pass-through from international to domestic prices, are calculated as:

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[8] Owing to the specifications of the VAR model having taken the possible control variables into account by means of the log dependent variables, it may not be so necessary to add more control variables if there are no specific issues of concern. In fact, we have added an exchange rate index and tax as independent variables. However, there are no significant changes in the estimated results because some price indexes are in US dollars, and the tariffs have been declining since the mid-1990s as Taiwan prepared to enter the WTO.

$$price\ pass-through = \frac{\sum_{i=0}^{4} \delta_i}{1 - \sum_{i=1}^{4} \beta_i}$$

(2)

Second, the pass-through from domestic (food and fuel) prices to the CPI (or core CPI) is estimated using the following generalized Phillips curve equations:

$$\pi_t = \alpha + \sum_{i=1}^{4} \beta_i \pi_{t-i} + \sum_{i=0}^{4} \gamma_i (y_{t-i} - y_{t-i}^*) + \sum_{i=0}^{4} \phi_i \pi_{t-i}^{food} + \sum_{i=0}^{4} \varphi_i \pi_{t-i}^{fuel} + \varepsilon_t$$

(3)

$$food\ price\ pass-through = \frac{\sum_{i=0}^{4} \phi_i}{1 - \sum_{i=1}^{4} \beta_i}$$

(4)

$$fuel\ price\ pass-through = \frac{\sum_{i=0}^{4} \varphi_i}{1 - \sum_{i=1}^{4} \beta_i}$$

(5)

As pointed out above, π stands for the annualized quarter-over-quarter log difference (in percent) in core, food, and fuel prices, while y and y* denote the annualized quarter-over-quarter log difference (in percent) in, respectively, real and potential GDP (the equations also include seasonal dummies)[9]. We also limit contamination of the estimates by endogenous factors, and the pass-through from domestic commodity prices to core inflation is estimated using predicted values of domestic food and fuel inflation from the first-stage bivariate regressions.[10]

2.   The Estimation Results for the Price Pass-Through

According to the IMF (2008), the pass-through found in advanced economies in the 1970s was much higher than the pass-through observed in advanced economies more recently. In emerging economies, about one-half of the shock to domestic food

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[9] We followed the IMF (2008) by employing the Hodrick-Prescott filtered trend to estimate potential GDP.

[10] In this way, domestic food and fuel prices reflect only the variation that is due to changes in international prices and lagged effects of domestic price developments, rather than movements in labor, transportation, and retailing costs that may have common origins with overall inflation.

prices ultimately makes its way through to core inflation, whereas in advanced economies, less than one-quarter passes through. These findings are in line with the high share of food in consumption and the relative importance of material costs in production across emerging economies, which underscores these economies' sensitivity to food price developments.

The pass-through from international to domestic prices is substantially lower in emerging than in advanced economies. According to the IMF (2008), the low pass-through coefficients may reflect a combination of factors, including declining energy intensity, widespread fuel subsidies and controls in emerging economies, and high fuel taxes in many advanced economies.

The estimated results for international price pass-through are shown in Table 2 and Figure 4. The former three estimated results were extracted from the IMF (2008).
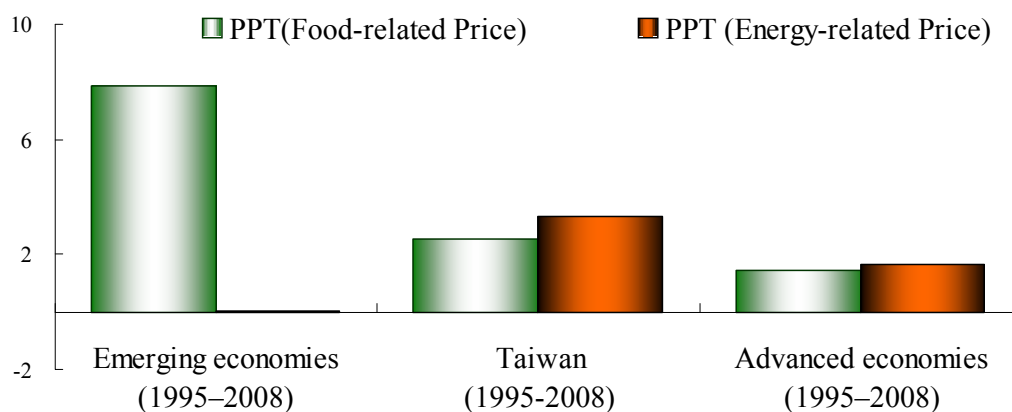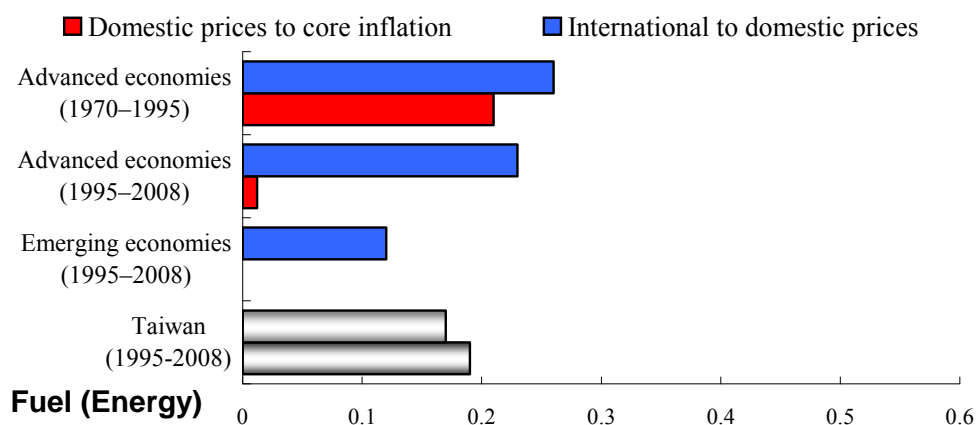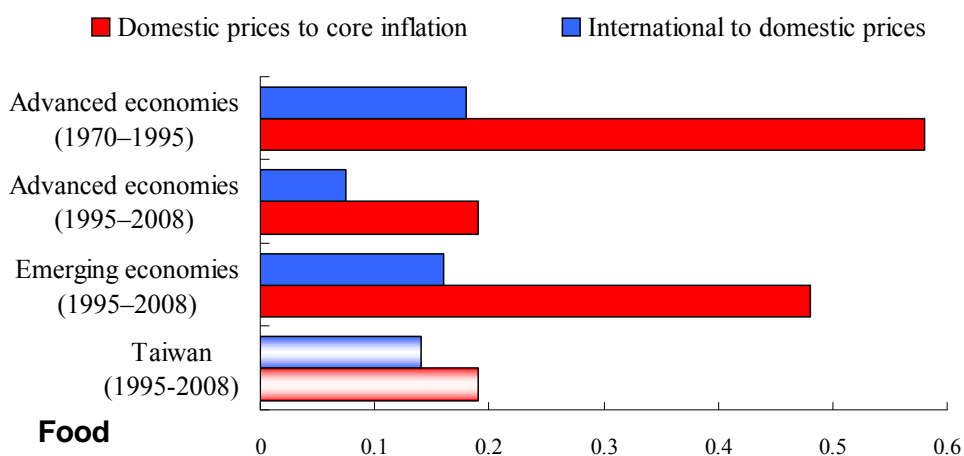
Table 2 The Price Pass-through in Taiwan

Dependent Variable		Independent Variables	Sample Period: 1995Q1-2008Q3
A. Baseline estimation results (following the IMF(2008))			
Domestic price (CPI_FOOD)		(a) Global commodity price-Food	0.1346
Domestic price (CPI_ENERGY)		(b) Global commodity price-Energy [1]	0.1733
core CPI		(c) Domestic price (CPI_FOOD)	0.1894
		(d) Domestic price (CPI_ENERGY)	0.1921
Total Price Pass-Though	Food	(e)=(a)*(c), Global commodity price-Food	0.0255
	Energy	(f)=(b)*(d), Global commodity price-Energy [1]	0.0333
B. Other estimation results			
Import Price Index (MPI)	Food	Global commodity price-Food	0.4233
	Energy	Global commodity price-Energy [1]	0.1904
Export Price Index (XPI) [2]	Food	Global commodity price-Food	0.2252
	Energy	Global commodity price-Energy [1]	0.0961
Domestic Sales Excluding Imports Price Index(DSPI)	Food	Global commodity price-Food	0.2588
	Energy	Global commodity price-Energy [1]	0.0713
WPI [3]	Food	Global commodity price-Food	0.3004
	Energy	Global commodity price-Energy [1]	0.1193

Notes: 1. In the IFS database, the world price index for energy starts from 1992Q2.
2. There is no energy-related index in XPI (Export Price Index), so we can not calculate the price pass-through for energy goods in the export price index.
3. WPI is composed of MPI (weighted 32.7%), XPI (weighted 36.5%), and DSPI (weighted 30.8%).
Data Source: Self calculation based on estimation results.

Food

Fuel (Energy)

Data Source : 1. calculation based on IMF(2008)
2. Self calculation based on estimation reuslts.

Figure 4   The price pass-through effect

We can see that the estimated coefficients of price pass-through in Taiwan were 0.13 and 0.18, respectively, in respect of food-related prices; the former was the pass-through effect from the global food price index to the domestic food-related price index. According to the IMF (2008), the estimated coefficients of advanced countries and developing countries were about 0.09 and 0.15, respectively, and the estimated value for Taiwan was in the middle. The latter figure (0.18) was the pass-through effect from the domestic food-related price index to core CPI, and the estimated coefficients of advanced countries and developing countries were about 0.18 and 0.48, respectively. If compared with the estimated results, Taiwan lies between the developed countries and the developing economies, and it is similar to the position of Taiwan in terms of its economic development.

As for the global energy-related price index pass-through effect, the estimated results are 0.18 and 0.19, respectively. The former is the pass-through from the global price index to the domestic price index. According to the IMF (2008), the estimated coefficients of advanced countries and developing countries were 0.23 and 0.12, respectively. Taiwan was still between the two groups. However, the latter result, i.e., the domestic price index to core CPI, was both higher than for advanced countries (0.01) and developing countries (0), but was similar to the advanced countries (0.21) over the 1970-1995 period.

If we take the two stages in the estimation of the price pass-through into consideration simultaneously, and define the total pass-through effect as the product of the two stages of estimated coefficients, i.e., the total price pass-through effect = the pass-through from the global price index to the domestic price index × the pass-through from the domestic price to core CPI, according to Figure 5, we can find that the total food price pass-through lies between those for advanced countries and developing countries, but the total energy price pass-through is found to be significantly higher than those for advanced countries and developing countries in the 1995-2008 period. Besides, the energy pass-through is slightly higher than the food price pass-through. This estimated result reflects some characteristics of the Taiwan

economy.

The coefficients of price pass-through in Taiwan approximately follow the global trend except for pass-through from domestic prices to core CPI for energy-related prices, although Taiwan lacks natural resources such as oil, soybeans or wheat, depending on foreign supplies.

According to the IMF (2008), the low pass-through coefficients for energy-related prices may reflect a combination of factors, including declining energy intensity, widespread fuel subsidies and controls in emerging economies, and high fuel taxes in many advanced economies. The price pass-through from domestic price to core CPI is higher in Taiwan. This may reflect some facts such as opposite effects to those mentioned above, a shortage of energy and government subsidies[11].

The pass-through effect in energy-related prices was found to be slightly higher than food-related prices. Owing to energy-related industries being either monopolies or oligopolies, they are highly correlated with living industries, and the government mostly adopts subsidy-related treatments as the fluctuations in energy related prices are particularly large. Therefore the price pass-through coefficients for energy-related prices are higher than those for food-related prices.

In order to compare and analyze the export-oriented countries such as Taiwan, we examined the price pass-through effects of global prices to domestic prices, import prices and export prices. We extended the approach of the IMF (2008) to estimate price pass-through in the MPI and XPI[12]. The estimated results are as shown in Table 2, which shows that global price pass-through in XPI was lower than that in MPI (for both food or energy prices). This may be due to taking world competition into consideration. The lower the XPI, the higher the world competitiveness, and a lower XPI would have a positive effect on Taiwan's merchandise exports. In order to benefit

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[11] The price control may cut down the price pass-through effects, but the subsidy may have some positive effect to encourage the pass-through effects.
[12] The XPI and MPI which are denoted as price indexes are expressed in terms of US$, while the others are expressed in terms of NT$. We have added the exchange rate index (er@tw) to remove the effect of the exchange rate. However, the results are similar regardless of whether there is an er@tw or not.

from international competition, a firm may mostly pass through the fluctuations in global commodity prices to the domestic market but keep the XPI stable.

Owing to there being no PPP (Produce Price Index) in Taiwan, we use the WPI instead of PPP. In Taiwan, the compilation of WPI was composed of XPI, MPI and DSP. If we compare the price pass-through to core CPI with WPI, we find that the pass-through from the global commodity price to WPI is lower than that to core CPI. This finding is similar to that of Jongwanich and Park (2008).

The pass-through coefficients tend to be lower for consumer prices than for producer prices. The gap between these two price indices depends on the ability of firms to pass higher costs on to consumers. For example, in the face of intense market competition, private producers may cut their profit margins instead of immediately charging higher prices to consumers. As the global commodity prices rise sharply, the private producers may cut their profit margins instead of immediately charging higher prices to consumers in order to maintain their market shares. Besides Government policy measures such as price controls, energy taxes, etc. might be used to reduce or delay the pass-through to the CPI.

V. The Analysis of Simulation Results

1. The Simulation Results of the Macro-Econometric Model

Hamilton (2009), who explored similarities and differences between the run-up of oil prices in 2007-08 and earlier oil price shocks, also looked at what caused the price increases and what effects they had on the economy. He found that regardless of whether the oil price shocks were primarily caused by physical disruptions in supply or were caused by strong demand confronting stagnating world production, the consequences for the economy appear to have been very similar to those observed in earlier episodes, with significant effects on overall consumption spending and purchases of domestic automobiles in particular.

Due to Taiwan being a small open economy lacking in natural resources, she plays the role of a price taker in the global commodity market. Furthermore, based on

Hamilton (2009), regardless of whether oil price shocks are primarily caused by physical disruptions in supply or are caused by strong demand, the consequences for the economy appear to have been very similar. So we regard the global commodity shocks as being exogenous, and utilize the price pass-through estimation results and macro-econometric model to simulate the impacts on the Taiwan economy as the commodity price shocks occurred.

In order to capture the trend of the historical price change in Taiwan and depict the characteristics of the Taiwan economy, the features of the macro-econometric model are included as shown below. First, the model makes a detailed distinction between various price indices, namely, the GDP deflator, WPI, MPI, XPI, CPI and private consumption deflator, among others. For the settings of the price functions, we follow the setting of the pass-through mentioned above and also consider the impact of the transmission and co-movement between the different price indices. Second, the model is demand driven[13]. Third, as for the composition of GDP on the expenditure side, each one has its own behavioral equations except for the government sectors. We take the government sectors as being exogenous. Fourth, the household expenditure is classified into 12 categories based on the characteristics of the goods and services. In this way, the household expenditure can be described in more detail[14].

Based on the transmission process and the feedback effect, we capture the variables' interactions. In the process of selecting the behavioral function, the independent variables are specified and recognized based on related theories. In addition to modeling concisely, each estimator satisfies the statistical diagnoses.

In order to calculate the pass-through effect from international commodity prices to domestic prices in Taiwan, and evaluating the impact on household expenditure

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[13] Due to the labor market being stable in Taiwan, for example, the unemployment rate is almost under 4.5% except in 2002~2003, the rigidities in labor market is not so serious, and we have the term (y-y*) in the price pass-through equations which is denoted as the generalized Phillips curve equations and is treated as proxy for the supply side effect. In view of this, we model the labor market as simple as possible.

14 We have adopted the suggestions proposed by the referee to re-estimate the macro-econometric model and AIDS model using the sample periods from 1992Q2 to 2008Q3, so the estimated equations' sample period could coincide with the simulation results. We also conducted the structural break test such as Chow test, evidence for the structural break was little.

patterns and the industrial structure, we set some scenarios and perform simulations. The scenarios are as follows:

(1) Scenario 1: Assume the food-related price shock and energy-related price shock both occurred in 1993[15]. That is, we consider how much of an impact these had on the Taiwan economy in the 1990s as the food-related price index and energy-related price index both rose sharply in 1993.

(2) Scenario 2: Assume that the food-related price shock and energy-related price shock both occurred in 2004. That is, we consider how much of an impact these had on the Taiwan economy in the 21st century as the food-related price index and energy-related price index both rose sharply in 2004.

From Figure 4, we can find that the shocks will pass away as time passes. The changes in Real GDP will be close to zero in the 5th year. The paths for the change in the price indexes, such as CPI, XPI, and MPI, will respond more quickly than the real sectors. They will tail off as time passes by. That is, by comparing the change and trend from real GDP (or the real sectors) with CPI (or the price index), we realized that the price indexes have a quicker response. The price index almost responds perfectly within a period of two years. Then the negative effect tails off.

If we compare the simulation results for the only food-related price shock with the only energy-related price shock, we find that the food-related shock has a heavier impact even though the pass-through effect is higher. Owing to the energy-related price fluctuating more frequently, the government mostly adopts subsidy-related treatments. Besides, there is a gearing effect related to the domestic food-related prices. That is, it is easier for the food-related prices in the domestic market to rise than it is for them to fall. Therefore the food-related price shock has a more serious impact on the Taiwan economy.

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[15] Due to the energy index in IFS starting from 1992 and resulting in the availability of historical data being shorter than the food index which starts from the 1960s, as we set the scenario, we refer to the food index rather than the energy index. We assume that the annual growth rate of the commodity price shocks (both the food and energy indexes) rose by 80% of the growth rate of the food price index in 1973.
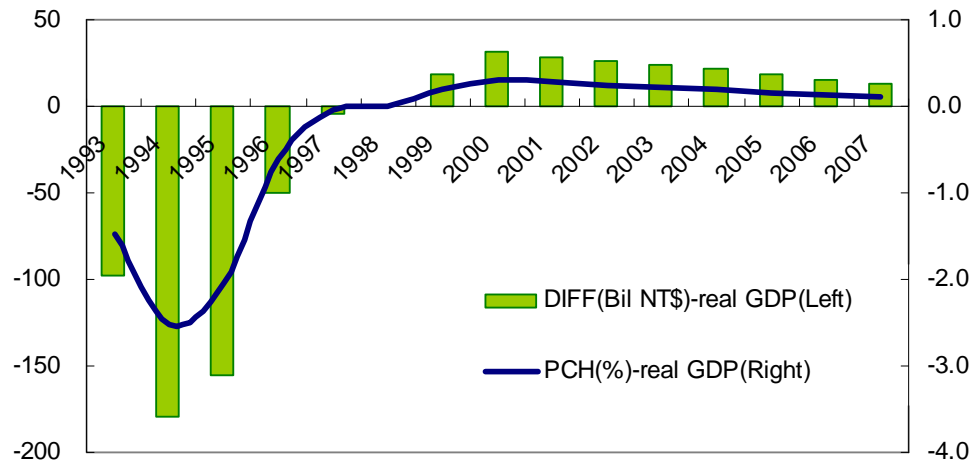
Data Source   based on estimation results.

Figure 4-1 The simulation results of Scenario 1
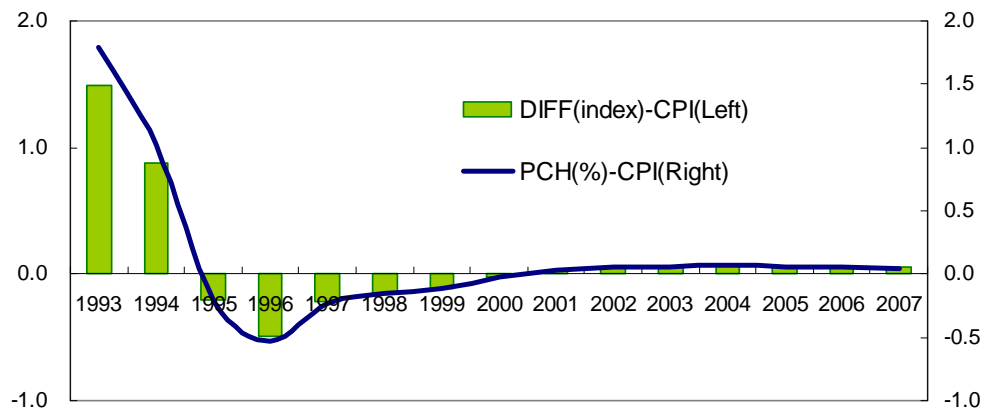
Data Source: based on estimation results.
Figure 4-2 The simulation results of Scenario 1

2.   Almost Ideal Demand System (AIDS) Estimation and Application

In the literature on demand-driven systems, some models are used such as the Linear Expenditure System (LES), Rotterdam system, and Almost Ideal Demand System (AIDS). In particular, the Almost Ideal Demand System (AIDS), which was promoted by Deaton and Muellbaurm (1980), is widely used because of its good statistical properties. The equations of the AIDS model satisfy the features of aggregation, homogeneity, and symmetry.

As for the AIDS model, we apply national income data to estimate different price

indices. The data comprise twelve categories of household consumption. The sample period is from 1993Q1 to 2008Q3 and 2001 is set as the base year.

Owing to the classification of household expenditure being based on the features of goods and services, we need to apply the consumption conversion matrix to project the 12 categories of the goods and services into 161 sectors. Basically, the consumption conversion matrix and input-output tables are based in 1996 and 2007[16], respectively. In order to simplify the analysis, we have re-classified the household expenditures into 4 categories. They are "food-related consumption" which includes different kinds of food, beverages, and tobacco, "energy-related consumption" which is composed of fuel, light, rent, and water charges, "entertainment-related consumption" which is composed of recreation, entertainment, education and cultural services, and "other goods and services" which includes various kinds of clothing, transport, communications and so on.

In what follows, the analysis is based on scenario 1 and scenario 2, i.e., it is assumed that the food price shock and energy price shock both occurred. Basically, the energy-related industries are public utility services, the substitution is lower, and the government mostly adopts subsidy-related treatments as the fluctuations in energy related prices are quite large. As Figure 5 shows, we find that the impact on energy-related consumption is smaller as the shocks occur.

As to the food-related consumption, they are living necessaries, and the elasticity of price is generally low. However, owing to the beverages having higher price elasticity, and there being a more diversified selection of food-related goods, so the impact on food-related consumption is more serious than that on energy-related consumption. However, the impact on entertainment-related consumption is the heaviest because they tend to be luxuries and their income elasticity is higher.

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[16] The 2007 Consumption Transformation Matrix is extended using 2001 as the base. The 2007 Input Output Table is also extended using 2004 as the base by means of RAS which is provided by Professor Hao-Yen Yang.

36 ▬ Share of Expenditure (%,Right)
◻ Percentage change in Expenditure (%,as of 1996&2007,Left)
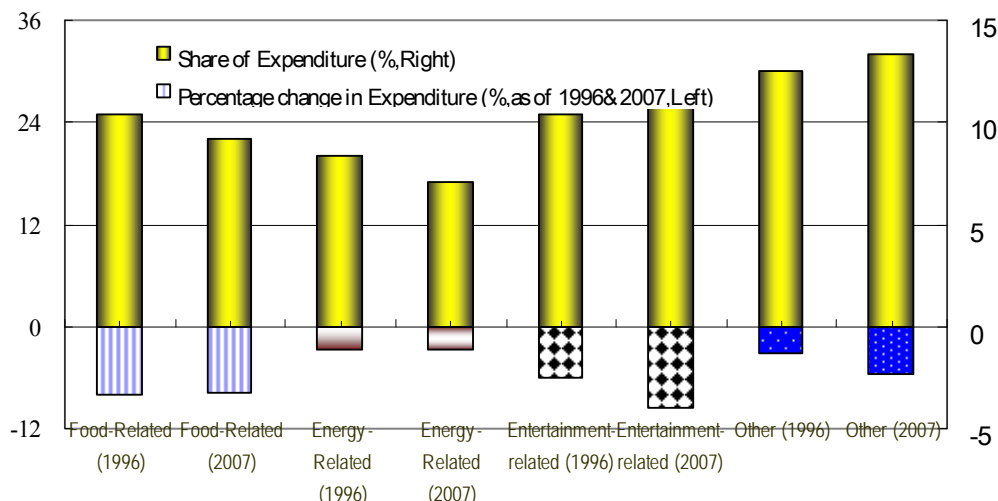
Data Source : based on estimation results.

Figure 5 Price Pass-through and Household Expenditure

3. Input-Output Model: Quantitative Model

In general, the input-output model is good at describing the industrial structure[17], and so it may be the tool that we can use to analyze the impact of industrial shocks that result in final demand such as household consumption expenditure, export-oriented and promotional policies and so on. Here, we apply the input-output tables to the analysis and describe the price pass-through from the household expenditure to the industrial structure that is caused by the global food and energy price shocks.

Although the shocks lasted over one year, however, the impact will cease to be felt as time passes by. The change in the real sector will be close to zero in the 4th year after the shocks occurred, and the price deflators will respond more quickly than the real sector. Due to the national incomes and input-output tables being compiled annually, we calculate their impact by using weighted averages[18], and take the base years as 1996 and 2007.

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[17] The frequency for the input-output tables in Taiwan is every 5 years. Owing to the data availability, what we can do is just link the tables in different eras to capture the trends. If more data were available, we could express them in terms of a dynamic process, but this is not the case here.

[18] We calculate the weighted average by real GDP. The time path is 4 years.

Although the input-output tables in 1996 and 2007 classify industries into 161 sectors, based on considerations of keeping the analysis concise, we focus on 9 sectors which are "agriculture and minerals," "manufacturing—traditional industries," "manufacturing—chemical and petroleum-related industries," "manufacturing—heavy Industries," "construction," "electricity, gas and water," "transportation, telecommunications, wholesale and trading," "finance, insurance and real estate services," as well as "other services."

Here, we divide manufacturing industries into "traditional industries" which are processed foods, beverages, tobacco, textile mill products, wearing apparel and accessories, leather & leather products, wood & wood products, paper & paper products & printed matter, and so on; "chemical and petroleum-related industries" which are chemicals, artificial fibers, plastic, plastic & rubber products, miscellaneous chemical manufactures, and petroleum refining products; and "heavy industries" which may be defined as hi-tech industries, and they include iron and steel products, metallic products, machinery, electronic products, information products, communications equipment, electronic components & parts, electrical machinery and so on. We divide manufacturing into more detailed descriptions owing to the differences in technology level, energy intensity and energy efficiency. Besides, we can more closely observe the relationships between the price pass-through caused by the food and energy shocks and the economic structure in Taiwan.

Due to the food-related goods and energy-related goods being classified into the "agriculture and minerals" sectors, and also being the main intermediate inputs of "agriculture and minerals," this sector and other related industries are seriously affected by means of forward linkages and backward linkages.

From Table 3, we can calculate the industrial linkage effect for the food shock and energy shock. Here, we list the simulation results for Scenario 1 and Scenario 2. In Scenario 1, we rank the first 3 industrial impacts according to their percentage change as "agriculture and minerals," "electricity, gas and water," and "manufacturing—traditional industries," and their percentage changes are all over

-2.5%. In Scenario 2, the ranks are similar to those in Scenario 1 except that the third is exchanged with the second.

The final demand for "agriculture and minerals," which included food-related goods and crude oil, suffered the most owing to the direct effects caused by the commodity price shocks. The "electricity, gas and water" inputs are mostly the intermediate inputs to the other sectors and their energy intensity is also higher than the others. Therefore, their final demand also decline as the shocks occur. The energy efficiency of "manufacturing—traditional industries" is basically lower, and some industries such as processed food industries are still using food-related goods as intermediate inputs, and so the final demand is also likely to be affected.

If we compare the results for Scenario 1 (based on 1996) with those for Scenario 2 (based on 2007) in terms of final demand, the percentage change is smaller in 2007 but the gap is extremely small. The impacts are smaller in "agriculture and minerals," "manufacturing—chemical and petroleum-related industries," "electricity, gas and water," and "finance, insurance and real estate services," while the impacts in other industries such as "manufacturing - traditional industries," "manufacturing - heavy industries," "construction," "transportation, telecommunications, wholesale and trading" are greater.

In general, those industries in which the percentage change are going to be smaller almost all use food-related or energy-related goods as intermediate inputs. For example, "agriculture and minerals" include food-related goods and crude oil, etc., and the energy-related goods are the main intermediate inputs for "manufacturing—chemical and petroleum-related industries," and "electricity, gas and water." They are both highly correlated with global commodity shocks. As technology innovation focuses more on energy efficiency, energy-saving improvements and a reduction in energy-dependency, the impacts become smaller.

The impact on "finance, insurance and real estate services" is diminished, and it might be correlated with the de-regulation and globalization in the financial sector since the mid-1990's. However, the difference is not apparent—it is only 0.1%.

The impacts are widened in "other services," "manufacturing—traditional industries," "transportation, telecommunications, wholesale and trading," and "manufacturing—heavy Industries". Due to the big reduction in expenditures on "entertainment-related consumption," the entertainment-related industries saw a bigger reduction in 2007 than in 1996.

The impact on "manufacturing—traditional industries" also deepened owing to their greater emphasis on technology related to energy efficiency and energy-saving upgrades that slowly resulted from the industrial hollowing out to mainland China since the mid-1990s. The gaps in relation to the impacts for 2007 and 1996 on "transportation, telecommunication, wholesale and trading," and "manufacturing—heavy industries" are heavier in 2007, but the gap is just under 0.1%. They are basically not significant.

We can derive the results of the simulation on output and value added by means of input-output tables. However, the changes and trends are similar in each industry. For example, if we calculate the impact in output, the percentage change is -1.3% in Scenario 1, while the impacts on "agriculture and minerals," "manufacturing—traditional industries," and "finance, insurance and real estate services," which are all over -2%, are heavier. In Scenario 2, the percentage change is -1.3%, while the impacts on "agriculture and minerals," and "manufacturing—traditional industries" are still larger than for the other sectors.

To summarize, the commodity price shocks will affect Taiwan's economy by means of a price pass-through effect. How large are the impacts? This will depend on the degree of pass-through, household expenditure patterns and industrial structures. However, the good-related goods and energy-related goods mostly belong to the "agriculture and minerals" sectors which will be affected directly, and so the impact will be the most serious regardless of whether they are accounted for in final demand, output and value added. However, the impacts will become smaller as the technological innovation moves toward energy efficiency, energy-saving improvements and reduced energy dependency.

Among the manufacturing industries, the higher the technology level, the lighter will be the impacts. The impacts in traditional industries are the heaviest, followed by the chemical and petroleum-related industries. Although the heavy industries are relatively energy-intensive, however, they also have higher energy efficiency and are more energy-saving, so that the impacts could be smaller than for the traditional industries and petroleum-related industries. The services sectors are also affected as commodity shocks occur by means of the industrial linkage effect, but the impacts are even smaller than those for the "agriculture and minerals" industries and manufacturing industries.

Table 3 Simulation Results in Input-Output Tables for Scenario 1 and Scenario 2

Final Demand (Percentage Change (%)) No. Industries	1996 Base (millions)	(a) Scenario 1	2007 Base (millions)	(b) Scenario 2	(c)= (b)-(a)
1 Agriculture and Minerals	263012	-4.952	412417	-4.037	0.915
2 Manufacturing—Traditional Industries	1213545	-2.534	1412253	-2.746	-0.212
3 Manufacturing—Chemical and petroleum-related industries	583044	-0.600	1701082	-0.532	0.068
4 Manufacturing—Heavy Industries	3232880	-0.130	7564001	-0.194	-0.065
5 Construction	861800	0.000	1081775	0.000	0.000
6 Electricity, Gas and Water	87044	-2.911	155599	-2.254	0.658
7 Transport, Telecom & Trading	1483245	0.038	2925416	-0.069	-0.106
8 Finance, Insur. & Real Estate Services	1317928	-1.576	2745917	-1.477	0.099
9 Other services	1928251	-0.792	2975259	-1.346	-0.554
Total	10970749	-0.816	20973719	-0.788	0.028
Output (Percentage Change (%)) No. Industries	1996 Base (millions)	(a) Scenario 1	2007 Base (millions)	(b) Scenario 2	(c)= (b)-(a)
1 Agriculture and Minerals	488894	-7.753	687090	-7.331	0.422
2 Manufacturing—Traditional Industries	1690809	-2.917	1893071	-3.463	-0.546
3 Manufacturing—Chemical and petroleum-related industries	1662753	-1.508	3931377	-1.253	0.254
4 Manufacturing—Heavy Industries	4060134	-0.439	8596517	-0.541	-0.101
5 Construction	1013445	-0.121	1251176	-0.152	-0.032
6 Electricity, Gas and Water	366281	-1.731	623621	-1.652	0.079
7 Transport, Telecom & Trading	2894714	-0.329	4288290	-0.458	-0.129
8 Finance, Insur. & Real Estate Services	1523656	-2.092	4175374	-1.512	0.580
9 Other services	2549009	-1.092	4496904	-1.451	-0.359
Total	16249695	-1.273	29943420	-1.242	0.031
Value Added (Percentage Change (%)) No. Industries	1996 Base (millions)	(a) Scenario 1	2007 Base (millions)	(b) Scenario 2	(c)= (b)-(a)

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1	Agriculture and Minerals	180714	-10.893	335824	-8.070	2.823
2	Manufacturing—Traditional Industries	455928	-2.637	456809	-3.562	-0.925
3	Manufacturing—Chemical and petroleum-related industries	492224	-1.206	883516	-1.325	-0.119
4	Manufacturing—Heavy Industries	1083427	-0.337	1928870	-0.511	-0.174
5	Construction	350008	-0.097	289792	-0.181	-0.084
6	Electricity, Gas and Water	174621	-1.371	251572	-1.554	-0.183
7	Transport, Telecom & Trading	2053243	-0.307	2611210	-0.475	-0.167
8	Finance, Insur. & Real Estate Services	1051525	-2.100	3042128	-1.391	0.708
9	Other services	1714111	-0.975	2836047	-1.431	-0.455
	Total	7555801	-1.180	12635768	-1.303	-0.123

Data Source: Own calculation based on simulation results.

VI. Conclusion

In order to calculate the pass-through effect from international commodity prices to domestic prices in Taiwan, and evaluate the impact on household expenditure patterns and industrial structure, we conducted an empirical study that was focused on Taiwan.

Taiwan is a characteristic case due to her special experience in the economic development process. She has been referred to as an "Asian tiger" and praised for her "economic miracle." Besides, Taiwan is a small open economy that is lacking in natural resources, and a pass-through effect caused by global commodity prices will have a substantial impact on the Taiwan economy. In particular, Taiwan's industrial structure and consumption patterns are being upgraded continuously, and the price pass-through might have different impact as time passes by.

According to the results, we follow the IMF (2008) to divide the transmission channel into two stages. The first one is the global commodity price (GCP) pass-through to the domestic price. The second is the pass-through from the domestic price to core CPI. We find that the pass-through coefficients are 13.5% and 17.3% for the GCP pass-through to the domestic prices of food prices and energy prices, respectively. As for the price pass through from domestic to core CPI, the estimated result for food of 18.9% is close to that in advanced economies. The percentage for

energy is 19.2% and is higher in our case than in the case of the IMF.

The estimated results reflect some characteristics of the Taiwan economy. First, the coefficients of price pass-through in Taiwan approximately follow the global trend except for pass-through from the domestic price to core CPI in energy-related prices, even though Taiwan lacks natural resources, and for its oil, soybeans or wheat, she depends on foreign supply.

The pass-through effect for energy-related prices was slightly higher than that for food-related prices. Owing to the energy-related industries being either monopolies or oligopolies, they are highly correlated with living industries. Thus, the government mostly recommends subsidy-related treatments as the fluctuations in energy-related prices are particularly large, and therefore the prices pass-through coefficient in energy-related industries is higher than that for food-related prices.

We also calculate the pass-through in the export-oriented countries including Taiwan. The results show that price pass-through for XPI was lower than that for MPI. This may result from taking world competition into consideration. The lower the pass-through effect in the case of XPI might be positive effect in higher world competitiveness. The firms, in order to benefit from international competition, may mostly pass through the fluctuations in global commodity prices to the domestic market but keep the XPI stable.

We also find that the pass-through coefficients tend to be lower for consumer prices than producer prices. As the global commodity prices rise sharply, the private producers may cut their profit margins instead of immediately charging higher prices to consumers in order to maintain their market shares. Besides, government policy measures such as price controls, energy taxes, etc., might either reduce or delay the pass-through to CPI.

If we compare the simulation results for the only food-related price shock with the only energy-related price shock, we find that the food-related shock has a heavier impact even if the pass-through effect is greater. Owing to the energy-related prices

having fluctuated more frequently, the government has mostly adopted subsidy-related treatments as the fluctuations in energy-related prices have been quite significant. Besides, there is evidence of a gearing effect in domestic food-related prices. That is, it is easy for food-related prices in the domestic market to rise, but it is more difficult for them to drop. Therefore the food-related price shock has a more serious impact on Taiwan's economy.

If the food price shock and energy price shock both occur, the energy-related industries are public utility services, where the degree of substitution is lower, and the government mostly adopts subsidy-related treatments in view of the large fluctuations in energy-related prices. The impact on energy-related consumption is smaller as time passes after the shocks occur.

As to the food-related consumption, since they are living necessaries, the elasticity of price is generally low. However, owing to beverages having higher price elasticity and there being a more diversified selection of food-related goods, so the impact on food-related consumption is more serious than on energy-related consumption. However, the impact on entertainment-related consumption is the heaviest owing to this type of consumption being focused on luxuries where income elasticity is higher.

The commodity price shocks will affect the Taiwan economy by means of the price pass-through effect. How significant are the impacts? This will depend on the degree of pass-through, household expenditure patterns and industrial structures and so on, as well as monetary policy, exchange rate policy and tax policies. However, the good-related goods and energy-related goods mostly belong to the "agriculture and minerals" sectors which will be affected directly, so the impact will be the most serious no matter which is accounted for in final demand, output and value added.

Among the manufacturing industries, the higher the technology level, the smaller the impacts. The impacts on the traditional industries are the heaviest, followed by the chemical and petroleum-related industries. Although the heavy industries are relatively energy-intensive, they are also higher in terms of energy efficiency and

being energy-saving. Therefore, the impacts could be smaller than in the case of the traditional industries and petroleum-related industries. The services sectors are also affected as commodity shocks occur by means of the industrial linkage effect. However, the impact is smaller than that of the "agriculture and minerals" and manufacturing industries.

Basically, we have followed the IMF (2008), De Gregorio, Landerretche, and Neilson (2007), and Blanchard and Gali (2007) to employ a simple VAR model to estimate the coefficients of price pass-through. Owing to the specifications of the VAR model having taken the possible control variables into account by means of the log dependent variables, it may not be so necessary to add more control variables if there are no specific issues of concern. In fact, we have added an exchange rate index and tax as independent variables. However, there are no significant changes in the estimated results because some price indexes are in US dollars, and the tariffs have been declining since the mid-1990s as Taiwan prepared to enter the WTO.

The lower pass-through is not only the result of changing the industrial structure. In fact, in regard to the lower pass-through, the IMF (2008) has, for example, proposed some factors that might affect the extent of pass-through (from international commodity prices to domestic prices). These factors are exchange rate movements, taxes levied or subsidies granted the extent to which the domestic economy is aligned with international commodity markets as well as the cost structure of domestic production. Structural factors such as the intensity of energy use and monetary policy also play a very important role.

Besides, lower pass-through in recent years may also be attributable to the success of monetary policy. There are a lot of papers that discuss and analyze the relationship between monetary policy, exchange rate orientation with pass-through. According to the IMF (2008), as they compared the responses to monetary and exchange rate policies, they found that although the quality of monetary policy had improved around the world, more than 80% of emerging and developing economies maintained heavily-managed exchange rate regimes in order to anchor inflationary

expectations more easily, but this also restricted the ability of monetary policy to respond. Taiwan has adopted a managed independently floating exchange rate policy since the mid of 1980s. However, the central bank of Taiwan has carefully managed the exchange rate regime in order to facilitate merchandise exports. Besides, the household expenditure patterns and transformation of the industrial structure have been more important than inflation to Taiwan's economy since the 1990s owing to Taiwan's businesses have move to China and Southeast Asia that have enforced industrial structure transforming sharply.

Therefore, we have not emphasized the response of the pass-through to the monetary policy, but have looked closely at the relationship between pass-through and the structural change in terms of household behavior following the shocks. We have set up a simple money market which considers the money supply (M2), interest rate, rediscount rate, exchange rate and all kinds of price indexes and deflators which are all assumed to be in equilibrium.

In taking the labor market into account, we have considered generalized Phillips curve equations in the price pass-through equations which are treated as the supply side effect. Furthermore, we basically focus on the relationship between structural transformation, such as household expenditure and industrial structures, and price pass-through effects. Besides, the labor market is blunter in Taiwan. For example, the unemployment rate is almost always under 4.5% except during the bursting of the dot.com bubble in 2002~2003. So we keep the supply side as simple as possible.

We set the government sector as exogenous in the model, and we focus on the relationship between structural transformation such as household expenditure and industrial structures with price pass-through effects. Basically, we consider the pass-through in terms of the overall effect, i.e., the estimation results for the price pass-through obtained from the VAR model should be considered as a total effect from changing tax policy, exchange rate and so on. Much more complicated modeling would be involved and more detailed data would need to be collect, for the purpose of isolating each individual effect.

These items may be regarded as our limitations in this study and we might revise our paper to take account of them in the future.

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