Price Transmission Mechanisms among

Disaggregated Processing Stages of Food

: Demand-Pull or Cost-Push?

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ABSTRACT

The recent concurrent surges of food and commodity prices renew the debate on the causal directions between producer and consumer prices. To address this issue, we utilize the stage of processing system incorporating retail stage beyond crude, intermediate, and finished processing stages of food and employ the method proposed by Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996) of Granger causality tests. The overall results show that consistent with theory of derived demand, the demand-pull mechanisms coexist with the cost-push processes in 1985-2001. However, the upward cost-push pressures dominate the demand-pull mechanism through various transmission channels in 2002-2008.

INTRODUCTION

Over the past 20 years, the retail food prices were relatively stable and lower than the general inflation level. However, the food prices at the consumer level rapidly increased in recent period. For example, the Consumer Price Index (CPI) for all food increased 4.0 percent between 2006 and 2007, which is the highest annual increase since 1990 and is twice as high as the 2.3 percent gains of the overall CPI excluding the food and energy sectors for the same period. Furthermore, the United State Department of Agriculture (USDA) forecasts that the CPI for all food will increase 5.0 to 6.0 percent in 2008.

To understand the recent food inflation, numerous studies have been conducted but most of them focus to identify the causes of the recent hike in food prices (e.g., Abbott, Hurt, and Tyner 2008 and references in there). For example, a recent USDA report chronically summarizes factors that set the stage for the sharp increase in agricultural commodity prices since 2002. Beginning in 2002, as the U.S. dollar began to depreciate, the increased U.S. exports exerted upward pressure on U.S. prices for agricultural commodities. Rising crude oil prices also contributed to expanding of biofuel production since 2002 and eventually resulted in the increased agricultural production costs such as fertilizer and pesticide since 2004[1] (Trostle 2008).

Furthermore, many studies claims that the increases in farm commodity prices are large enough to affect retail food prices, despite the small portion of agricultural commodity values in retail food prices (cost-push mechanism). However, such claimed cost-push mechanism is implicitly assumed without providing conclusive empirical evidences. And little attention has been paid to how the farm commodity price at the producer level is actually transmitted to the food price at the retail level.

On the other hand, there has been long history of debate for the causal relationship between wholesale/producer and retail/consumer prices in the economic literature. Based on the mark-up models, one group claims that the changes in producer prices can provide important information to forecast the movements of consumer prices. This view relies on the notion that (i) transactions at the wholesale level occur prior to the retail sales and (ii) changes of the wholesale price, as the input cost, are transmitted to the final retail price through the distribution system (e.g., Engel 1978, Silver and Wallace 1980, and Guthrie 1981). Within the literature for the food sector, several studies (e.g., Goodwin and Holt 1999, and Goodwin and Harper 2000) inferred the uni-directional price transmission mechanism from farm to retail market through wholesale sector for a specific product such as pork or beef.

The other group, though, criticizes such views and argues that there are theoretical reasons to expect the causal flow from consumer price to producer price. For example, the economic theory of derived demand model suggests that the increase in aggregate demand raises the price of retail goods, which in turn escalate the prices of wholesale goods through the enhanced derived demand for the factors, especially with inelastic supply (e.g., Colclough and Lange 1982, and Granger, Robinsons and Engle 1986). Although some studies (e.g., Gordon 1975 and Engel, Granger, and Kraft 1984) attempt to combine and test these two theories empirically, the literature on the producer-consumer price relationship is mainly based on both cost-push view and demand-pull argument as summarized by Belton and Nair-Reichert (2007).

In this respect, the objective of this study is to explore the causal structures among wholesale/producer farm prices and retail/consumer food prices. Our approach is distinct from previous studies in several aspects and hence contributes the literature on the producer-consumer price relationships. First, while the previous studies focusing on a specific commodity such as beef (e.g., Goodwin and Holt 1999) or pork (e.g., Goodwin and Harper 2000), we explore causal structures for the broad food sector to understand the overall food inflation mechanisms in recent periods.

Second, we use more disaggregated information than previous studies to obtain more detailed information on the producer-consumer price transmission mechanism. For example, most studies gave attention on the relationships between CPI and PPI (Producer Price Index) or those of farm, wholesale, and retail levels. On the other hand, this study utilize the stage of processing (SOP) system incorporating retail stage beyond crude, intermediate, and finished processing stages of food. [2]

Third, our analysis incorporates the exchange rate in analyzing the relationship between wholesale and retail food prices. Under the global economy, it is plausible that the depreciation of the U.S. dollar since 2002 is one of key factors contributing to the recent food inflation. For example, the depreciation of the U.S. dollar stimulates agricultural exports and hence boosts food prices (e.g. Abbott, Hurt, and Tyner 2008). By including the exchange rate, we can empirically investigate role of the U.S. dollar depreciation in the recent food inflation.

Finally, The Granger causality (Granger 1969) is the most common concept for causality analysis in literature. However, the recent time-series literature identifies some drawbacks of previous testing approaches. To overcome such drawbacks, the testing method proposed by Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996) (TYDL) is adopted in this study. The recent simulation findings (e.g., Yamada and Toda 1998, Giles and Mirza 1999, and Clarke and Mirza 2006) demonstrate the robustness of the TYDL approach, compared to the vector error correction model (VECM) or fully modified VAR methods, over a wide range of stationary, near-integrated, and cointegrated systems.

EMPIRICAL MODEL

The producer-consumer price relationship of cost-push and demand-pull arguments can be incorporated into the empirical model based on Granger, Robins, and Engel (1986). Consider an economy with only two goods of farm commodity (X_i) and retail food (X_j) with corresponding prices (P_i and P_j). In the farm commodity market, the supply (X_i^S) is a function of its own price (P_i) and some supply shock (s) as $X_i^S = X_i^S(P_i, s)$. On the other hand, the demand function (X_i^D) depends on its own price (P_i) and food price (P_j) as $X_i^D = X_i^D(P_i, P_j)$, since demand for the commodity is derived from the retail food producer. This implies farm commodity price (P_i) is a function of food price (P_j) and supply shock (s) at market equilibrium condition as:

(1) $P_i = P_i(P_j, s)$ at $X_i^S = X_i^D$.

Equilibrium for the retail food market can be expressed similarly. The demand (X_j^D) relies on its own price (P_j) and certain some macroeconomic shock (m) as $X_j^D = X_j^D(P_j, m)$. And the supply function (X_j^S) depends on its own price (P_j) and farm commodity price (P_i) as $X_j^S = X_j^S(P_j, P_i)$, because the supply of food relies on the commodity price as input cost. Under this circumstance, the retail food price (P_j) is a function of farm commodity price (P_i) and macroeconomic shock (m) at market equilibrium condition as:

(2) $P_j = P_j(P_i, m)$ at $X_j^D = X_j^S$

Equations (1) and (2) can be formulated in a Vector Autoregressive (VAR) framework by allowing the general dynamic lag adjustment structure as:

(3) $A(L)\begin{bmatrix} P_i \\ P_j \end{bmatrix} = \begin{bmatrix} m \\ s \end{bmatrix}$, where $A(L) = A_o + A_1(L)$, $A_1(L) = \begin{bmatrix} a_{11}(L) & a_{12}(L) \\ a_{21}(L) & a_{22}(L) \end{bmatrix}$, and L is lag operator.

Following arguments by Granger, Robins, and Engel (1986), the VAR representation can be assumed to be driven by the unobservable shocks of s and m, whose forecastability can be immediately incorporated in the polynomials of $B(L)$. More specifically, we can re-write equation (3) as:

$$
\begin{aligned}
P_{it} &= a_{10} + \sum_{l=1}^{P} a_{11}(l) \cdot P_{i\,t-l} + \sum_{j=1}^{P} a_{12}(l) \cdot P_{j\,t-l} + \varepsilon_{1t} \\
P_{jt} &= a_{20} + \sum_{l=1}^{P} a_{21}(l) \cdot P_{i\,t-l} + \sum_{j=1}^{P} a_{22}(l) \cdot P_{j\,t-l} + \varepsilon_{2t}
\end{aligned} \tag{4}
$$

We notice that (i) if $a_{12}(l) \neq 0,\ \forall\, l = 1, \cdots, P$, the Granger causality flow is from the consumer price to the producer price, implying the demand-pull price transmission mechanism. On the other hand, (ii) if $a_{21}(L) \neq 0,\ \forall\, l = 1, \cdots, P$, the Granger causal flow runs from the farm commodity price to the retail food price, suggesting the cost-push mechanism. In addition, (iii) $a_{12}(l) \neq 0$ and $a_{21}(L) \neq 0,\ \forall\, l = 1, \cdots, P$ represent the coexistence of demand-pull and cost-push mechanism.

ECONOMETRIC PROCEDURE

The most common concept for causality analysis in the previous studies is the Granger causality (Granger 1969), which is popularized by Sims' (1972 and 1980) application of causality test between real and monetary variables. The popularity of its utilization can be understood based on the facts that (i) it is atheoretical in the sense that it does not need any a priori restrictions on the relationship among variables to ascertain directions of causality and (ii) it provides information as to whether a set of variables helps to improve the predictions of another set of variables.

Given the definition of Granger non-causality (GNC) hypothesis[3], there have been three approaches to implement the Granger causality test depending on time-series properties of variables; a VAR model in the level data (VARL), a VAR model in the first-differenced data (VARD), and a vector error correction model (VECM). However, time-series literatures identify some drawbacks to all three testing approaches, since the non-stationary properties such as unit roots and cointegration can result in complications for testing GNC[4]. Especially, Toda and Phillips (1993) show that the asymptotic distribution of GNC test statistics in the VECM can be non-standard and may involve nuisance parameters unless certain cointegration rank conditions are satisfied[5]. In this respect, Toda and Phillips (1993) suggest a sequential test procedure involving non-stationary, cointegration, and rank condition of certain submatrices in the cointegration space. However, such pretesting strategy can also lead to the misleading conclusion for GNC. It is because the sequential pretesting procedure has unknown overall properties with generally low statistical power, leaving the possibility to chose the inappropriate model for GNC test (e.g., Yamada and Toda 1998, Giles and Mirza 1999, Clarke and Mirza 2006). To address this issue, Toda and Yamamoto (1995) and Dolado and Lutkepohl (1996) (TYDL, hereafter) proposed an alternative method that gives an asymptotic χ^2 distribution under the null hypothesis of GNC, irrespective of the system's integration or cointegration properties.

Given that the nonstandard asymptotic properties of the test statistics are due to the singularity of the asymptotic distribution of the LS estimator, the main issue is to find the alternative, which will result in a nonsingular asymptotic distribution of the relevant estimator to overcome the complicated nonstandard limiting properties. TYDL demonstrate that the singularity in a nonstationary system can be removed by fitting an augmented VARL model, whose order exceed the true order by the highest degree of integration in the system as:

(5) $Z_t = \sum_{i=1}^{k} \Phi_i Z_{t-i} + \sum_{j=1}^{d} \Phi_{k+j} Z_{t-k-j} + \varepsilon_t$, $\quad H_0 : R_M \, vec(\Phi_1, \cdots, \Phi_k) = 0$,

where k is the true lag length, d is the maximal order of integration, $vec(\cdot)$ represents to stack the row of a matrix in a column vector, R_M is the appropriate selection vector corresponding to a specific GNC hypothesis, and Z_t is vector of exchange rate and disaggregated food prices based on the SOP system.

TYDL also prove that the hypothesis can be tested based on asymptotic χ^2 distribution by using modified Wald statistics while ignoring the coefficient matrix of the augmented lag in the estimated equation, which is a zero matrix by assumption. They further show that it is valid to use the commonly used lag length selection procedure, even for the VAR model with integrated or cointegrated processes as far as the maximal order of integration (d) does not exceed the true lag length (p).

Although there exists efficiency and power loss by augmenting extra lags, recent simulation studies (e.g., Yamada and Toda 1998, Giles and Mirza 1999, Clarke and Mirza 2006) demonstrate that (i) the power loss is relatively minor for the moderate and large sample sizes, (ii) the TYDL method is better control the type I error probability, and (iii) the TYDL approach results in consistent performance over a wide range of systems including stationary, near-integrated, and cointegrated systems, even for the mixed integrated systems. On the other hand, the VECM approach based on the sequential tests of cointegration exhibits serious size distortion, leading to severe over-rejection of non-casual null hypothesis. [6] Consequently, the TYDL approach is recommended (e.g., Yamada and Toda 1998, Giles and Mirza 1999, Clarke and Mirza 2006), when the research objective is not detecting the presence (or absence) of unit roots or possible long-run (cointegrating) relationships but testing Granger causality or some other economic hypotheses expressed as coefficient restrictions of (possible cointegrated) VAR models with I(0) /I(1) variables. This study follows this recommendation to investigate price transmission mechanisms among different processing stages of food.

DATA DESCRIPTION

In this study, we utilize the price data, covering overall food sector, in the stage-of-process (SOP) framework to get more detail information of the producer-consumer price transmission mechanism. More specifically, we collect several price indexes based on the

SOP system from January 1985 to July 2008: the PPI indexes of crude foodstuffs and feedstuffs (denoted by crude food), intermediate foods and feeds (intermediate food), and finished consumer foods (finished food), and CPI indexes for food at home (home food) and all food (retail food) from BLS.

The coverage of each index is as follows: wheat, corn, soybeans, fluid milk, etc. for the crude food; flour, prepared animal feeds, fluid milk products, etc. for the intermediate food; pork, dairy products, processed fruits and vegetables, etc. for the finished food. Although the CPI for all food is frequently used to measure food inflation at the consumer level, there exist some differences in the product coverage between the PPI of finished consumer foods and the CPI for all food, which covers substantial portions of service by the food away home component (e.g., BLS 2008). To incorporate such difference and allow the connections between PPI and CPI, the CPI of food at home is included[7]. All data is seasonally adjusted and log transformed. In addition, the real effective exchange rate variable is obtained from International Monetary Fund.

When the oil price shocks occurred in 1973-74, the Bureau of Labor Statistics (BLS) published the Wholesale Price Index (WPI) based on the All Commodities aggregation. However, this aggregation was based on the inappropriate weight schemes and thus overstated the inflation rate due to the multiple counting problems. Furthermore, the WPI include the full range of items irrespective of their degree of fabrications and thus mask or distort the analyses of the actual price transmission mechanism (Gaddie and Zoller 1988). To address this issue, the BLS shift the analytical focus from the All

Commodities Price Index to the Producer Price Index (PPI) based on the commodity-based stages of processing (SOP) price indexes since 1978 (BLS 2008).

The definition and purpose of the SOP system is clearly explained by Gaddie and Zoller (1988) as follows: “the basic idea of a stage of process system is that the economy can be subdivided into distinct economic segments which can be arranged sequentially so that the outputs of earlier segments become inputs to subsequent ones, up through final demand. As a simple example, one economic sector may produce wheat, which is input to another that produces flour, which is input to another that produces bread. To the extent that such a sequential system of processing stages can be defined, it is possible to trace the transmission of price change through the economy and to develop information on both the timing and magnitude of price passthroughs to final demand (page 4).”

Since then, several studies (e.g., Lee and Scott 1999 and Weinhagen 2005) adopt and extend price data of the SOP system to encompass the CPI indexes as the fourth stage of process, beyond the crude, intermediate, and finished goods of PPI indexes. Such methodological shift is utilized in this study to investigate price transmission mechanism among disaggregated processing stages of food sector.

EMPIRICAL RESULTS

Preliminary Analysis

We collect the time series data beginning in 1985, since previous studies (e.g., Blomberg and Harris 1995, Clark 1995, Furlong and Ingenito 1996, and Weinhagen 2002) found a significant change in the price transmission mechanisms of the PPI and CPI in the late

1980s. In this respect, Henerdon (2008) pinpoints 1985 as the year that grain prices return to normal ranges, after the grain price surge due to the combination of the third-largest acreage reduction in the U.S. history by the Payment-In-Kind program and the dismal crop growing conditions in 1983. In addition, several literatures (e.g., Abbott, Hurt, and Tyner 2008 and Trostle, 2008) identify 2002 as the year to set the stage for the recent food inflation. Especially, as Trostle (2008) summarized, the U.S. dollar began to depreciate, crude oil prices started to increase, and ethanol production rapidly increased since 2002. The sample, therefore, is divided into the 1985m1-2001m12 (period I) and the 2002m1-2008m7 (period II).

Following Toda and Yamamoto (1995), the general-to-specific method, based on sequential Likelihood Ratio (LR) test, is applied to determine appropriate lag length. For the period I, the hypothesis test of reduction of lag length from 3 to 2 results in a LR test statistic of 41.979 with a p-value of 0.228, while those from 2 to 1 are 82.230 and 0.000, respectively. Diagnostic statistics of the Lagrange Multiplier (LM) test for the absence of auto-correlation in residual show that the p-value of LM test for order 1 (and 2) are 0.390 (and 0.370) for the two lag length VAR specification. For the period II, the LR test statistic is 47.167 with p-value 0.100 for lag length reduction from 3 to 2, while those from 2 to 1 are 53.604 and 0.0297, respectively. The p-value of LM tests against order 1 (and 2) is 0.424 (and 0.224) for two lag length specification. These results suggest that lag length of two is appropriate for the subsequent analyses without concern for the autocorrelation problem for both period I and II.

Based on the above results, the Granger non-causality (GNC) tests are conducted based on the TYDL method, using the two lag length specification and assuming maximum integration order of one. The modified Wald statistics and corresponding p-values are reported in Table 1 and 2 for the first and second periods. By its construction, the lower and upper off-diagonal elements capture the GNC test for cost-push and demand-pull arguments, respectively. In addition, Figure 1 and 2 summarize the causal flows in Granger sense based on Table 1 and 2, respectively. The arrows in the upper and lower parts represent Granger causal flows for cost-push and demand-pull arguments, respectively (Belton and Nair-Reichert 2007).

Price Transmission Mechanism for the Period I

For the period I, the results show the coexistence of both cost-push and demand-pull mechanisms (table 1). Both mechanisms are identified in each of the sequential input-output relationships at the 1% significant level, with a p-value of less than 1% indicating that the null hypothesis of Granger non-causality can be rejected at the 99% confidence level. Although some direct causal flows do not exist in cost-push from intermediate to finished food and demand-pull from intermediate to crude commodity, causal flow from crude to finished food connects cost-push chain effect at the 1% significant level and those from home and retail food to crude commodity stage link sequential demand-pull causal flows at the 4.9 % and 3.3% significant level, respectively. In addition, the PPI of finished consumer food price cost-pushes the CPI for all food at retail level at the 0.1% significant level, while the CPI for all food (and CPI for food at home) demand-pulls the

PPI of intermediate and finished food price (PPI for food at intermediate processing stage) at the 0.7 and 0.2% (1.5%) significant level.

The overall results can be interpreted on the basis of the detailed information of the SOP system. The SOP system is constructed such that wheat, flour, and bread analogy can be used to explain the division of food at crude, intermediate, and finished stages, so we can expect transactions along the sequential series of input-output relationships (e.g., Gaddie and Zoller 1988). However, the complicated industrial relationships preclude the clear division of U.S. goods into three stages, especially for the intermediate stage. As explained in BLS (2008), the crude goods are defined as the unprocessed commodities that are not sold directly to the consumer, while the finished goods are ready for sale to the final consumption. On the other hand, the intermediate goods are defined as residuals so that some goods of a given stage can be consumed within that stage of the process (internal flow in the SOP system). Furthermore, economic transactions in practice do not always follow such sequential SOP system. Part of the output of a given stage of the process can be used by stages of the process beyond the next sequential stage (skip mechanism in the SOP system, hereafter). For example, crude goods, e.g., agricultural commodities, can skip the intermediate stage of production and be exported as part of final demand (e.g., Gaddie and Zoller 1988 and BLS 2008).

Considering such subtle aspects, overall results are consistent with the bidirectional relationship between producer and consumer prices found by Colclough and Lange (1982). In accordance with the argument of Granger, Robins, and Engel (1986), there exist demand-pull causal flows through the derived demand mechanisms. This finding is also consistent with some historical observations. For example, as the demand for chicken wings at the retail level dramatically increased in the mid 1980s, the wholesale price rose from 37.99 cents/lb in 1985 to 61.79 cents/lb in 1994 and has continued to increase throughout the rest of the 1990s (Light and Shevlin 1998).

Price Transmission Mechanism for the Period II

The estimated price transmission mechanisms for the recent period are quite different from those for the early period (table2). All the demand-pull price transmission mechanisms have disappeared, except the relationship from the CPI for all food (retail) to the CPI for food at home (home) only at the 10.0% significant level. On the other hand, the results reveal the more fortified cost-push pressures. All the sequential cost-push mechanisms along the consecutive input-output relationships are identified at the 1% significant level, except the demand-pull mechanism from finished to intermediate food is reversed to the cost-push pressure only at the 8.8% significant level. In addition, the cost-push pressures from the agricultural commodity price (crude) to the CPI for all food (retail) are reinforced by the several skip mechanisms. Those mechanisms from crude (and finished) to finished (retail) foods, which are already identified during the previous period, are augmented by the additional skip process from intermediate to home food at the 1.1% significance level, that from intermediate to retail food at the 2.4% significance level, and that from crude to home food at the 7.5% significance level.

These findings provide empirical evidences for the notion, which is central to understanding the recent food inflation phenomenon, that the increase of farm commodity prices is large enough to affect retail food prices, despite a small portion of agricultural product share in retail food prices. Such cost-push mechanism is also consistent with the previous findings (e.g., Boyd and Brorsen 1985, Goodwin and Holt 1999, and Goodwin and Harper 2000) of the price transmission mechanism from farm to retail market through the wholesale for a specific product such as pork or beef sector. For example, Goodwin and Harper (2000) use the impulse response functions from threshold cointegration model and focus on the pork sector based on weekly data of farm, wholesale, and retail prices. While they gave attention on the asymmetric adjustment to positive and negative price shocks, our study focus on the causal structure itself based on the TYDL Granger Non-Causality tests. In addition, our results provide detailed causal information among five processing stages of crude, intermediate, finished, home, and retail food based on the monthly price data covering more broad food sector.

The relationship between the exchange rate and the producer-consumer price structure is also different between the first and second periods. While there were no relationships between exchange rate and the food prices at various stages in the first period, the movements of the exchange rate provide significant information for the price structure through crude food price in the second period. This finding is consistent with the explanations of the recent food inflation found in several studies. For example, Trostle (2008) argues that due to the depreciation of the U.S. dollar since 2002, the increased U.S. exports put forth the upward pressure on prices of agricultural commodities. Furthermore, Abbott, Hurt, and Tyner (2008) claim that the depreciating dollar is related to the over half of the crude oil price increase, which provided incentives to expand biofuel production since 2002 and eventually resulted in the increased agricultural production costs since 2004.

CONCLUDING REMARKS

Most of studies for recent food inflation focused to identify the causes of the recent hike in food prices and implicitly assumed the cost-push mechanism from commodity to food prices without providing conclusive empirical evidences. In fact, little attention has been paid to how the farm commodity price at the producer level is actually transmitted to the food price at the retail level in discussions on the recent food inflation, On the other hand, there has been long history of debate of cost-push or demand-pull mechanism between wholesale/producer and retail/consumer prices in the economic literature.

In this respect, this study explores the price transmission mechanism for the overall food sector based on the TYDL method of Granger causality test. By using the disaggregated processing stages of food classified by the BLS, this study aims to identify the causal structures among five stages of process (crude, intermediate, finished, home, and retail foods), while previous studies focus those among the two or three stages (farm, wholesale, and retail foods) for a specific product.

The overall findings can be summarized as follows. Consistent with theory of derived demand (Marshall, 1961), the demand-pull mechanisms coexist with the cost-push processes in 1985m1-2001m12. On the other hand, the upward cost-push pressures dominate the demand-pull mechanism through various transmission channels in 2002m1-2008m7. These findings provide empirical evidences for the notion, which is central to understanding the recent food inflation phenomenon, that the increase of farm commodity prices is large enough to affect retail food prices, despite a small portion of agricultural product share in retail food prices. We also identified how the movements of the exchange rate and the agricultural commodity price are transmitted to the food prices at the retail level through various price transmission channels. The exchange rate significantly contributes to the recent food inflation by affecting the (crude) agricultural commodity price only in the recent period. This finding provides an empirical evidence for claimed effect of the exchange rate on commodity price through the change of the agricultural export level (e.g., Trostle 2008).

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Table 1. Modified Wald Test Result for the Period I.

Dependent Variables	Crude	Intermed.	Finished	Home	Retail	ExRate
Crude	-	1.299	0.938	6.015	6.816	3.300
	-	0.522	0.626	0.049**	0.033**	0.192
Intermed.	24.785	-	11.409	8.428	9.969	1.097
	0.000***	-	0.003***	0.015**	0.007***	0.578
Finished	9.255	0.012	-	11.184	12.183	1.918
	0.010***	0.994	-	0.004***	0.002***	0.383
Home	0.708	3.269	13.444	-	6.240	3.504
	0.702	0.195	0.001***	-	0.044**	0.173
Retail	1.039	3.542	13.802	11.364	-	3.347
	0.595	0.170	0.001***	0.003***	-	0.188

Note: Crude, Intermed, Finished, Home, and Retail denote the PPI index of crude foodstuffs and feedstuffs, intermediate foods and feeds, and finished consumer foods, and CPI indexes of food at home and for all food, respectively. The asterisks of ***, **, and * represent statistically significant at 1, 5, and 10 %, respectively. For each cell, first and second number is χ^2 statistic value and corresponding p-value, respectively.

Table 2. Modified Wald Test Result for the Period II.

Dependent Variables	Crude	Intermed.	Finished	Home	Retail	ExRate
Crude	- -	4.046 0.132	2.323 0.313	3.884 0.143	3.534 0.171	6.454 0.040**
Intermed.	14.448 0.001***	- -	1.472 0.479	1.497 0.473	2.027 0.363	3.958 0.138
Finished	6.292 0.043**	4.855 0.088*	- -	3.855 0.145	3.350 0.187	3.367 0.186
Home	5.177 0.075*	9.074 0.011**	38.562 0.000***	- -	4.596 0.100*	1.964 0.374
Retail	2.807 0.246	7.434 0.024**	28.577 0.000***	9.446 0.009***	- -	1.576 0.455

Note: see note in Table 1

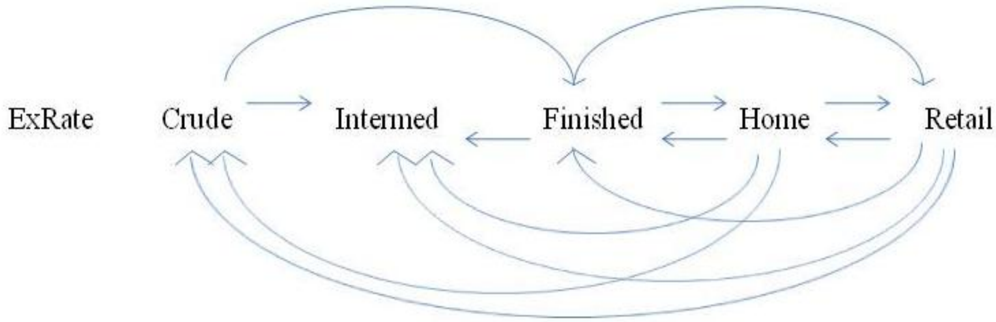

Figure 1. Price Transmission Mechanism for the Period I.

Note: see note in Table 1 and refer Table 1 for a specific significant level. The upper (bottom) part summarizes cost-push (demand-pull) causal flow, respectively. Each arrow represents causal flow in Granger sense at 5% significant level.

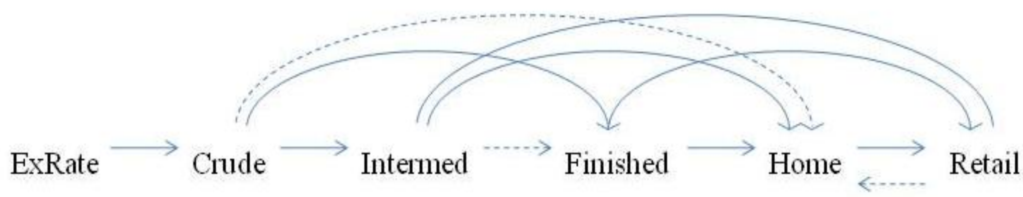

Figure 2. Price Transmission Mechanism for the Period II.

Note: see note in Figure 1 and refer Table 2 for a specific significant level. The dotted arrow represents causal flow in Granger sense at 10% significant level.

[1] These short-term factors, combined with the tight market conditions due to the long-term trends of more rapid expansion in demand and slower growth in production since 1990s, resulted in declining global stock-to-use ratios which fell to the lowest levels since 1970s (Trostle 2008).

[2] Several studies (e.g., Lee and Scott 1999 and Weinhagen 2005) encompass the CPI for commodities as the additional stage of process, beyond the crude, intermediate, and finished stages of process in the PPI indexes.

[3] For the Formal definition of Granger Causality and complications related to its implications, we refer to Lütkepohl (1993). Note that there exist conceptual difference between philosophical notion based on manipulation and statistical concept based on predictability and thus we need to be cautions against over-interpreting the empirical results based on the Granger causality concept (e.g., Pearl 2000). Note also that there exist three approaches of formal tests of restrictions, innovation accounting of impulse response functions and forecast error variance decompositions (e.g., Lütkepohl 1993), and incremental predictive performance comparison (e.g., Gelper and Croux 2007), we focus on the formal restriction test in this study.

[4] The VARL can involve a singular covariance matrix that may result in a non-standard asymptotic null distribution (e.g., Toda and Phillips, 1993) and the Least Square (LS) regression involving variables with unit roots may give rise to a spurious regression (e.g., Granger and Newbold 1974). On the other hand, the VARD may be misspecified when the series are cointegrated as potential causality from the long-run relationship and thus some forecastability or causality from one variable to the other is ignored (Engel and

Granger 1987). Consequently, the VECM is frequently used when cointegration is suspected.

[5] For example, if we are interested in whether the n_2 elements are not causing the n_1 elements, the dimension of cointegrating space (β) for the n_2 elements or the speed of adjustment space (α) for the n_1 elements must meet full rank conditions, which is not always satisfied under the null hypothesis. If such conditions are not satisfied, the limiting distributions under the null hypothesis need to be simulated in each relevant case and may depend on possibly unknown nuisance parameters, making it difficult or even impossible to use the appropriate statistical test.

[6] Fully Modified VAR (FM-VAR, Phillips 1995) also does not require a pretest for a unit root and cointegration, thus can avoid pretest bias. However, Yamada and Toda (1998) show that FM-VAR method does not always guarantee a desirable asymptotic size. Depending on the number and location of unit roots in the system, the test can be quite conservative under the null hypothesis, which may cause loss of power under the alternative. Furthermore, Kauppi (2004) prove that FM-VAR estimator has second-order bias effects when some roots are local to unity. These bias effects are shown to result in potentially severe size distortions in FM-VAR testing when the hypothesis involves near unit root variables.

[7] There are conceptual and definitional differences between the PPI and CPI indexes. For example, the CPI includes services, imports, and sales taxes to measure the changes in the cost of living, while the Producer Price Index (PPI) excludes them but covers capital

equipments to measure real growth in output. The most comparable indexes are the PPI finished consumer goods index and the CPI commodities Index, in terms of product coverage (BLS 2008). Similarly, the PPI finished consumer food index is comparable to the CPI for food at home. The results except the CPI for food at home provide almost similar causal structures among prices at different level of process stages.