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Overshooting of Agricultural Prices in Four Asian Economies

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ABSTRACT

This article examines the impacts of monetary policy on agricultural prices in four Asian economies using time series analysis and graph theory. The estimations clearly show that agricultural prices overshoot their long-run equilibrium values for Korea, Philippines, and Thailand, and the overshooting for agricultural prices is larger than for manufactured prices. Impulse-response functions and variance-decomposition analysis based on directed graphs and causal structures highlight the complex interplay among the variables in the model and how those relationships differ by country. Money supply changes clearly affect real variables and relative prices for all countries either through overshooting or non-neutrality of money.

Key Words: *agricultural prices, Asian economies, directed graphs, impulse-response functions, manufacturing prices, monetary policy, overshooting, variance-decompositions.*

Agricultural economists have long studied factors that move prices over time. In the last two decades they have been particularly interested in the effects of exchange rates and monetary policy on agricultural prices. The interest in this topic has heightened because of the idea that monetary shocks might cause large swings (even overshooting) on agricultural prices. This is understandable given the prominence of monetary policy in macroeconomic management.

A number of empirical studies have been conducted to investigate the relationship between monetary policy and agricultural prices. See for example Roberston and Orden for the New Zealand case; Taylor and Spriggs for the Canadian case; Bessler, Devadoss and Meyers for the U.S. case; and Issac and Rapach for the Brazil case. These studies showed a statistically significant relationship between monetary policy and prices of agricultural commodity.

Most studies applied the theoretical model developed by Dornsbusch who introduced the overshooting hypothesis to explain volatility in exchange markets and Frankel who advanced Dornsbusch's model to a closed economy. Frankel broadly divided the macroeconomy into a "fix-price" manufacturers and services sector, where prices adjust slowly, and a "flex-price" agricultural sector, where prices adjust instantaneously in response to money supply change. Frankel found that agricultural prices overshoot their long-run equilibrium values whenever there is a positive monetary shock because of the fix-price nature of the manufactured goods and services sectors.

However, there is no study to address this

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issue for developing country economies, where there is usually a different structure with respect to agricultural and financial sectors. With respect to the agricultural sector, for instance, the government in developing countries intervenes in agricultural markets with various policies that make agricultural prices stable and isolated from world markets. With respect to monetary policies, it is also often the case that the government in developing countries heavily regulates financial institutions and markets through various policies. These include imposing a ceiling on interest rates, control of exchange rates, controls on the flow of credit and extraction of seigniorage through money creation to finance government expenditures (Leeahtam, Patrawimolpon, and Supapongse).

The objective of this study is to investigate the effects of monetary policy on agricultural prices in four Asian countries (Korea, Philippines, Thailand and Indonesia) using contemporary nonstationary time series econometric methods. Specifically, we use Johansen's cointegration test along with a vector error correction model to investigate whether agricultural prices in four Asian countries overshoot in an open economy. This study adds to the empirical literature by applying the model to countries that have different structures with respect to agricultural and financial sectors in the economy.

Conceptual Framework

This study uses a model similar to Saghaian, Reed, and Marchant, a theoretical model developed based on Dornbusch and Frankel's model. In this model another sector is added to Frankel's model so that agricultural commodities are traded internationally. Agricultural prices and the exchange rate are assumed to be flexible and adjust quickly to monetary shocks, but the prices of industrial goods are assumed to be sticky. The main focus of the paper is on the time adjustment path of two (fix and flex) prices and the exchange rate in response to an unanticipated monetary shock. The analysis is "short-run" in the sense that the exchange rate is determined entirely in the asset market with a complete abstraction from the details of goods markets and the purchasing power parity in exchange rate determination.

A general feature of the theoretical model is that agricultural prices and the exchange rate will overshoot. A monetary expansion reduces interest rates and leads to the anticipation of a depreciated currency in the long run. These factors reduce the attractiveness of domestic assets, lead to a capital outflow, and cause the spot exchange rate to depreciate. As Dornbusch explains, the effect of monetary expansion is, therefore, to induce an immediate depreciation in the spot rate that exceeds the long-run depreciation, since only under these circumstances will the public anticipate an appreciating exchange rate and thus be compensated for the reduced return on domestic assets.

In this model agricultural prices will increase more than proportionally to the change in the money supply; they overshoot their new long-run equilibrium. For commodities to be willingly held they must be sufficiently overvalued such that there is an expectation of future price decreases large enough to offset the lower interest rate. The extent of overshooting of agricultural prices and exchange rate depend positively on the relative weight of sticky prices in the prices index, while it is a decreasing function of the relative weight of flexible prices (Saghaian, Reed, and Marchant; Frankel). The degree of overshooting also depends on the interest response of money demand and magnitude and speed of adjustment of agricultural prices. A high interest response of money demand dampens the overshooting because it implies that a given expansion in the quantity of money will only induce a small reduction in the interest rate. A small reduction in the interest rate requires only a small expectation of currency appreciation to offset it and, therefore, only a small depreciation of the spot exchange rate to generate that expectation.

Characteristics of Agriculture and Monetary Policy in Four Asian Countries

The agricultural sector plays an important but decreasing role in the economies of the four

Asian countries chosen in this study. The agricultural sector in Indonesia accounted for around 35 percent of gross domestic product (GDP) in 1970 and declined to around 16 percent in 1996. Meanwhile, agriculture's share of GDP in Korea dropped from 27 percent to 6 percent over the 1970–1997 period, agriculture's share declined from 30 percent in 1970 to 11 percent in 1997 in Thailand, and agriculture's share in Philippines contributed 28 percent in 1970 and declined to 19 percent in 1997.

While the share of agriculture in GDP declined, the contribution of the manufactured sector in the economy increased. The manufactured sector's contribution increased from only 13 percent in 1970 to more than 30 percent in 1997 in Korea, and from 6 percent in 1970 to 27 percent in 1997 in Indonesia. In Thailand, manufacturing's share of GDP increased from 14 percent in 1970 to 28 percent in 1997, and Philippines manufacturing's share of GDP increased from 20 percent to 22 percent in 1997. Thus there has been a dramatic economic structural change in Korea, Thailand, and Indonesia as indicated by the declining contribution of the agricultural sector and a significant increase in the manufacturing sector. The structural change in the Philippines economy has been much slower.

Despite the declining role of the agricultural sector in these economies, historically agricultural markets were subject to government interventions with various policy instruments. These include price supports, input subsidies, provision of infrastructure, and various trade protectionist policies. The objectives of these policies were to protect the agricultural sector and stabilize agricultural prices. The degree of intervention differed among countries, but generally domestic agricultural prices were relatively stable and insulated from world price fluctuations.

However, in the early 1980s restrictions and controls on the agricultural sector were lifted gradually as a part of economic reforms adopted by governments. International pressures to open the domestic market, the implementation of the Uruguay Round agreement, and macroeconomic instability have caused governments to relax their control of and interventions in the agricultural sector. In particular, pressures from the International Monetary Fund (IMF) and the World Bank have forced these countries to gradually eliminate their control of the agricultural sector. The IMF launched its Structural Adjustment Loans (SAL) program in the mid-1980s to help governments in these countries overcome their macroeconomic instability. As conditions for loans the IMF imposed some structural reform measures for these economies and recommended stringent monetary and fiscal policies (Islam and Chowdhury). Import tariffs have been reduced, export taxes have been removed, and the distribution and trade of agricultural products have been lifted gradually. Therefore, domestic agricultural prices have been subject to the same fluctuations as world prices in recent years.

As in the case of the agricultural sector before the early 1980s, the conduct of monetary policy in these countries was characterized by heavy financial regulations including interest rate regulations, credit allocation controls, explicit and implicit taxes, and international capital controls. In addition, domestic financial systems often became an important source for financing fiscal deficits due to the government's inability to raise revenue from more conventional sources, such as income and property taxes. Domestic monetary policy was also closely coordinated with exchange rate policy to maintain a relatively stable but overvalued exchange rate. In effect, these policies have insulated these economies from the world.

Since the mid-1970s, however, these countries have liberalized their domestic financial systems and the way they conduct monetary policy. Interest rate controls have been relaxed, the allocation of credit for special provision (at preferential rates) has gradually been removed, and capital flows have been loosened. Along with these changes, there has been a move in exchange rate policy from fixed toward a managed floating exchange rate regime. As a result, financial institutions in these countries have become more market ori-

ented and more integrated with the world economy.

Econometric Model Development and Empirical Results

The empirical model underlying this study is built on the existing theoretical literature (Saghaian, Reed, and Marchant). First, we relax the closed-economy assumption by adding the exchange rate variables into the model. Thus we have four variables in the model: agricultural prices, manufactured prices, money supply and exchange rate. This is an extension of Orden and Fackler's model. Second, we build on Robertson and Orden's co-integration approach by using Johansen's method of estimation. Empirically, the first difference of each variable is represented as a function of its own lagged value, the lagged values of the other variables, and the co-integration equation.

Given the nature of the underlying data series, we first conduct stationary tests of the series using the augmented Dickey-Fuller test. Second, we perform a co-integration test to determine whether there exists a long-run relationship among the series in the system. If the series is integrated but not co-integrated, a VAR (Vector Autoregressive Model) is appropriate. If the series is integrated and co-integrated, a VEC (Vector Error Correction Model) is more appropriate to characterize the multivariate relationships among the series in each commodity (Ali; Enders; Engle and Granger). Finally, we specify a vector error correction model or a vector autoregressive model and conduct hypothesis testing within this framework. This is followed by calculation of the impulse response functions and variance decomposition analysis.

Stationary Testing

Monthly time series price data are collected from 1985:01 to 1997:07 for agricultural and manufacturing prices, exchange rate, and money supply in the four countries. Data for exchange rates and money supply come from International Financial Statistics published by International Monetary Fund (IMF) while data on agricultural and manufacturing prices index come from the Central Bureau of Statistics in each country. Descriptive statistics may be found in Table 1.

An augmented Dickey-Fuller (ADF) test is used to determine the order of integration of each univariate series. This test involves running a regression of the first difference of the series against the series lagged one period, lag difference terms, and a constant as follows:

$$\Delta Z_t = \alpha_0 + \alpha_1 Z_{t-1} + \sum_{j=1}^{n} \beta_j \Delta Z_{t-j} + \epsilon_t$$

where ΔZ_t is the first difference of the time series.

The results of the unit-root test are estimated by OLS and presented in Table 2. The second column of Table 2 summarizes the ADF test results for each original variable, while the third column presents the results for the first difference of each series. The second column of Table 2 shows that we failed to reject the null hypothesis of zero first-order autocorrelation at the 5-percent level of significance using the Durbin-Watson bounds test for each country. As shown in the second column of Table 2, the Augmented Dickey-Fuller (ADF) test statistics, in absolute value, for most series are smaller than the critical value. Given the MacKinnon critical value, the null hypothesis cannot be rejected meaning that those series are non-stationary.

Based on the ADF test results, all series need to be transformed to make them stationary because one must work with identical orders of integration for each series. The right-most column of Table 2 gives the results of the ADF test for the first difference transformation of the series. As shown, we are able to reject the null hypothesis and conclude that each series becomes stationary after first differencing. Based on this we conclude that each series is an integrated process of order 1 or I(1).

Johansen's Cointegration Tests

Based on the ADF test, co-integration is possible because most of the series are an integrated process of order 1 or I(1). Co-integration

Table 1. Descriptive Statistics of Continuous Variables in the Empirical Model

Variable	Mean	Standard Deviation	Minimum	Maximum
Korea, 1985:01–1997:07				
Agricultural Prices	77.09	18.42	50.09	105.50
Manufacturing Prices	90.93	6.89	83.26	103.52
Exchange Rate[a]	786.39	64.55	666.56	896.20
Money Supply, M1	18894.26	10496.06	5730.19	39542.10
Philippines, 1987:01–1997:06				
Agricultural Prices	175.60	42.16	103.30	254.80
Manufacturing Prices	158.93	26.02	105.80	191.20
Exchange Rate[a]	24.69	2.57	20.44	29.16
Money Supply	111.59	54.38	40.29	239.29
Thailand, 1985:01–1997:06				
Agricultural Prices	81.59	14.94	57.30	111.50
Manufacturing Prices	76.71	15.76	52.15	102.50
Exchange Rate[a]	25.62	0.61	24.55	28.06
Money Supply	125.83	134.51	45.03	431.49
Indonesia, 1988:01–1997:06				
Agricultural Prices	243.87	66.89	160.60	370.50
Manufacturing Prices	210.86	38.36	153.00	271.00
Exchange Rate[a]	2034.49	224.31	1657.88	2446.59
Money Supply	30709.36	13195.74	12393.30	62003.00

[a] Real weighted average domestic currency per U.S. dollar.

tests were performed using Johansen's method. The Johansen co-integration test is designed to determine whether the series are co-integrated and to determine the co-integrating rank, r, the number of co-integrating vectors in the system using the likelihood ratio (LR) (Holder and Perman; Vickner and Davis).

Theoretically, the rank r can be at most one less than the number of endogenous variables in the model. Two null hypotheses are tested in the co-integration tests. First, the null hypothesis that the series has no equilibrium condition or no co-integration. Second, the null hypothesis of r co-integrating vectors against the alternative hypothesis that $r + 1$ co-integrating vectors. In each test the null hypothesis is rejected if the test statistic is larger than the critical value.

Table 3 presents the results of co-integration tests for each country. For Korea and Philippines we reject the null hypothesis that $r = 0$, $r \leq 1$, and $r \leq 2$ at the 5-percent level. However, we failed to reject the null hypothesis that the co-integrating rank of the system is at most 3 at the 5-percent level. Thus, there exists a stationary, linear combination among agricultural prices, manufacturing prices, exchange rate and money supply in the Korea and Philippines models. For Thailand, we reject the null hypothesis that $r = 0$, and $r \leq 1$, but fail to reject the null hypothesis that the co-integrating rank of the system is at most 2 at the 5-percent level. This means that there exists a long-run stationary relationship among agricultural prices, manufacturing prices, and money supply in the Thailand model. For Indonesia we fail to reject the null hypothesis that there is no co-integration among four variables, which implies that there is no long-run relationship between money supply and agricultural price.

Vector Autoregressive Model (VAR) and Vector Error Correction Model (VEC)

The Johansen's co-integration test concluded that except for Indonesia the series are co-in-

Table 2. Augmented Dickey-Fuller (ADF)[a] Test Results

Variable	Test Results for Variables in Levels	Test Results for Variables after First-Differencing
Korea, 1985:01–1997:07		
Agricultural Prices	−2.07	−7.82***
Manufacturing Prices	−2.74	−6.25***
Exchange Rate[a]	−1.13	−4.57***
Money Supply, M1	−3.54**	−11.40***
Philippines, 1987:01–1997:06		
Agricultural Prices	−2.71	−8.52***
Manufacturing Prices	−3.31**	−5.77***
Exchange Rate[a]	−1.69	−5.46***
Money Supply, M1	−5.49***	−9.64***
Thailand, 1985:01–1997:06		
Agricultural Prices	−2.64	−8.42***
Manufacturing Prices	−2.30	−8.34***
Exchange Rate[a]	−3.53***	−6.02***
Money Supply, M1	−1.72	−8.61***
Indonesia, 1988:01–1997:06		
Agricultural Prices	−3.11	−6.19***
Manufacturing Prices	−1.18	−5.86**
Exchange Rate[a]	−2.04	−7.05***
Money Supply, M1	−1.74	−6.86***

Note: *** 1-percent significance level, ** 5-percent significance level, * 10-percent significance level.
[a] In absolute value and compared to MacKinnon (1991) critical values.

tegrated, though the rank of co-integration is different among the countries. Thus the VEC model is appropriate for the case of Korea, Philippines, and Thailand, and the VAR model is appropriate for the Indonesian case. In the VAR model the first difference of each variable is represented as a function of its own lagged values and the lagged values of the other variables. The difference with the VEC model is that the VEC model also captures the co-integrating equation, which represents the long-run relationship among the variables due to the presence of co-integration. In our case we have four variables for each country. Thus the specification of the VAR and VEC model used to conduct the analysis is as follows:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \epsilon_t$$

where ΔX_t is an (4×1) matrix (ΔX_{1t}, ΔX_{2t}, ΔX_{3t}, and ΔX_{4t} represent agricultural prices, manufacturing prices, exchange rate, and money supply, respectively); α_0 is an (4×1) vector of intercept terms; $\Gamma_i \Delta X_{t-i}$ terms reflect the short-run relationships among elements of the X_t matrix, that is between agricultural prices, manufacturing prices, exchange rate, and money supply; and the Π matrix captures the long-run relationship among the variables and provides the foundation to empirically address the overshooting hypothesis.

The Π matrix can be decomposed into two $p \times r$ matrices, α and β, where $\Pi = \alpha\beta'$. Matrix β contains the co-integrating vectors that represent the underlying long-run relationship and the α matrix describes the overshooting or the speed of adjustment at which each variable moves back to its long-run equilibrium. Co-integration requires the β matrix to contain parameters such that Z_t, where $Z_t = \beta' X_t$, is stationary (Johansen and Juselius; Schmidt; Crane and Nourzad). The α_0, α_{nj}, and β_{nj} are unknown parameters to be estimated

Table 3. Johansen Cointegration Test Results

Null Hypothesis[a]	Likelihood Ratio Statistic	5-percent Critical Value	Eigenvalue
Korea			
$r = 0$	51.47	39.89	0.152
$r \leq 1$	26.98	24.31	0.091
$r \leq 2$	12.75	12.53	0.061
$r \leq 3$	3.31	3.84	0.022
Philippines			
$r = 0$	58.14	39.89	0.237
$r \leq 1$	24.74	24.31	0.093
$r \leq 2$	12.63	12.53	0.083
$r \leq 3$	1.89	3.84	0.015
Thailand			
$r = 0$	60.42	47.21	0.183
$r \leq 1$	30.50	29.68	0.127
$r \leq 2$	10.31	15.41	0.052
$r \leq 3$	2.38	3.76	0.015
Indonesia			
$r = 0$	28.58	47.21	0.119
$r \leq 1$	14.42	29.68	0.085
$r \leq 2$	4.46	15.41	0.035
$r \leq 3$	0.47	3.76	0.004

[a] r is the cointegrating rank.

and ϵ_t represents a vector of stochastic errors or innovations.

In a VEC system it is difficult to characterize the qualitative relationships among variables and the expected sign of the unknown parameters to be estimated. However, we expect that β_{nj} (i.e., β_1, β_2, and β_3; the long-run equilibrium relationship) to be positive in the case of the relationship among agricultural prices, manufacturing prices and money supply because expansionary monetary policy is expected to increase the level of agricultural prices and manufacturing prices. The relationship between agricultural prices and the money supply, for instance, can be expressed as $\epsilon_{t-1} = X_{1t-1} - \mu_1 - \beta_1 X_{4t-1}$, where X_1 and X_4 are agricultural prices and money supply, respectively. This is the one-month lagged 'disequilibrium residuals' from the respective cointegrating equations. We expect β_1 to be positive (i.e., $X_{1t-1} = \mu_1 + \beta_1 X_{4t-1} + \epsilon_{t-1}$) since expansionary monetary policy is expected to increase agricultural prices. This is also true for manufacturing prices. Further, we also conjecture a positive relationship between the exchange rate and money supply since expansionary monetary policy would lower interest rates and lead to depreciation of the domestic currency.

The speed of adjustment parameters, or the α_{nj}, represent overshooting parameters that indicate how quickly the system moves back to its underlying long-run equilibrium. We conjecture that α_{nj} s (α_{11}, α_{22}, α_{33}) will be negative, indicating that agricultural and manufacturing prices must fall after a monetary shock to reestablish the long-run equilibrium among the money supply, agricultural prices, and manufacturing prices. In the model we assume that manufacturing prices are more sticky than agricultural prices, hence we expect that $|\alpha_{11}| > |\alpha_{22}|$, which means that agricultural prices will move back to their long-run equilibrium faster than manufacturing prices. Finally, we also expect that α_{33} (effects of a money supply change on the exchange rate) to be negative which implies that the domestic currency must appreciate relative to other currencies to restore equilibrium.

Empirical Results

Table 4 presents a summary of the empirical estimates of the β's (long-run equilibrium relations) and α's (speed of adjustment parameters) for Korea, Philippines, and Thailand. The results for long-run equilibrium parameters are consistent with a priori expectations for these countries. A 1-percent increase in the money supply leads to 0.43 percent and 0.41 percent, 0.98 percent and 0.94 percent, and 0.19 percent and 0.19 percent increase in agricultural and manufacturing prices in Korea, Philippines, and Thailand, respectively. In the case of Korea and Thailand, the relationship between agricultural price and money supply is significantly different from zero, but the long-run rate of increase in agricultural price is not unit proportional to the rate of increase in the money supply. Thus long-run money neutrality does not hold in these cases. Long-run money neutrality holds in the case of the

Table 4. Parameter Estimates for the Long-run Equilibrium Relationship (β) and Overshooting Parameters (α): Korea, Philippines, and Thailand

Parameter Estimates	Countries
Long-run Equilibrium Relationship (β)	Korea
β_{11} (Agricultural)	0.43***
β_{22} (Manufacturing)	0.41***
β_{33} (Exchange Rate)	0.61***
Overshooting Parameters (α)	
α_{11} (Agricultural)	−0.10***
α_{22} (Manufacturing)	0.01**
α_{33} (Exchange Rate)	−0.01**
Long-run Equilibrium Relationship (β)	Philippines
β_{11} (Agricultural)	0.98***
β_{22} (Manufacturing)	0.94***
β_{33} (Exchange Rate)	0.59***
Overshooting Parameters (α)	
α_{11} (Agricultural)	−0.14***
α_{22} (Manufacturing)	−0.06***
α_{33} (Exchange Rate)	−0.06**
Long-run Equilibrium Relationship (β)	Thailand
β_{11} (Agricultural)	0.19**
β_{22} (Manufacturing)	0.19**
Overshooting Parameters (α)	
α_{11} (Agricultural)	−0.12**
α_{22} (Manufacturing)	−0.01

*** 1-percent significance level, ** 5-percent significance level, * 10-percent significance level.

Philippines where a 1-percent increase in money supply leads to almost a 1-percent increase in agricultural and manufacturing prices.

To investigate the ramifications of these findings on money neutrality (or non-neutrality), we can go to the quantity theory of money and restate the well-known premise that MV = PY where M is the money supply, V is the velocity of money, P is the price level, and Y is real output. The finding that money is neutral in the Philippines says that as M increases, P will increase by approximately the same percentage. In this case the velocity of money remains constant and money supply has no impact on real output. With non-neutral money, which is the case with the other three countries, money supply increases are correlated with some other occurrence.

The cases of Korea and Thailand show that money supply changes are positively related to prices, but not with unit elasticity. This implies that money supply increases are either negatively related to the velocity of money or positively related to real output changes (or both). The velocity of money is usually assumed constant for most analyses, so it is likely that money supply increases have resulted in real output changes during the observation period.

During the 1990s, when Korea and Thailand were growing so fast, it may be that money supply lubricated the economy and made financing more available to firms for expansion. These countries grew rapidly during the late 1980s and early 1990s (each experienced annual per-capita GDP increases averaging between 7.5 and 8.5 percent). However, there are probably limits to how long this positive relationship between money supply and real output can occur and the financial crisis of the late 1990s might be, in part, caused by the change in this relationship. Remember that the data series used for this study is before the Asian financial crisis which began in mid-1997. It is possible that money supply increases in the late 1990s no longer stimulated real output growth, but instead lead to increased domestic prices and downward pressure (either through draining of foreign currency reserves or through short-term portfolio flows) on their currencies. In that sense these results might partially explain why the crisis occurred and was so severe in these countries (note that the financial crisis had little impact on the Philippines).

For Indonesia, where there is no long-run relationship among prices and the money supply, we have the extreme case where there are large real output changes associated with money supply changes (again, assuming that the velocity of money is constant). Indonesia experienced per-capita GDP growth rates similar to Korea and Thailand for the study period (approximately 7 percent per annum). Indo-

nesia suffered (and continues to suffer) more than the other three countries in terms of its economy and currency value, though political upheaval is also a part of their suffering and no doubt that political upheaval has adversely affected the real economy. It appears that these results support the idea that Indonesia (and Korea and Thailand) enjoyed short-term benefits from expansionary monetary policy during the early and mid-1990s, but they suffered the consequences later.

The empirical estimates of overshooting parameters, the α's, are also presented in Table 4. The results are consistent with a priori expectation and statistically significant for all cases, except for manufacturing prices in the Korean case, where the sign is not consistent with the expectation. The coefficient for agricultural price (α_{11}) in Korea, -0.10, implies that if the money supply increases, there will be a short-run positive departure of agricultural prices from the long-run money supply relationship, so agricultural prices must fall to restore equilibrium. Similar interpretations can be drawn from the Philippine and Thai cases.

Agricultural prices overshoot relative to manufacturing prices in all cases ($|\alpha_{11}|>|\alpha_{22}|$). This is despite the notion that, historically, agricultural prices in those countries have been subject to government interventions through various policy instruments. However, as mentioned earlier, this study covered the periods of 1986–1997, when the governments began to launch economic reform by, among other things, removing controls on agricultural prices. Thus the structures of the agricultural and manufacturing sectors are becoming similar to those in developed countries in the sense that the agricultural price and exchange rate are more "flexible" and manufacturing price is more "sticky" during the study period.

The degree of overshooting is influenced by the structure of the economy, especially with regard to the share of agriculture and manufacturing in the economy. The relatively large "fixed" manufacturing sector will lead to more overshooting of agricultural prices relative to manufacturing prices given a "flexible" agriculture sector. Thus it is anticipated that agricultural prices will overshoot most in Korea, since the share of the manufacturing sector in the economy is the largest, followed by Thailand and the Philippines. We also expect that manufacturing prices adjust more in the Philippines than in Korea and Thailand, given the relatively small "fixed" manufacturing sectors and "flexible" agricultural sector.

The study does not support these hypotheses, though. Instead, agricultural prices overshoot most in Philippines where the share of the manufacturing sectors in the economy is smallest. Yet, as expected, manufacturing prices adjust more in the Philippines than in Korea and Thailand. A possible explanation is that both of the agricultural and manufacturing sectors in Korea and Thailand are characterized by more government controls or monopolistic structures relative to the Philippines leading to a situation where both manufacturing and agricultural prices adjust more in the Philippines. In addition, it may be the case that the interest rate elasticity of money demand in the Philippines was lower than in Thailand and Korea during the period of study. A low interest response of money demand, as mentioned earlier, increases the degree of overshooting because it implies that a given expansion in the quantity of money will induce a large reduction in the interest rate.

For Indonesia, the Johansen's co-integration test showed that there is no co-integration among variables so that the VAR model is more appropriate. This means that there is no long-run equilibrium relationship among the variables and no overshooting of agricultural price in the case of Indonesia. Table 5 presents a summary of the estimation results for the VAR model, which describes the short-run relationship among variables with the associated standards errors and relevant specification diagnostics. The estimation results are consistent with a priori expectations. As the agricultural price equation shows, the parameter estimates for the one-period lag of agricultural prices is positive and statistically significant. The coefficient on the exchange rate and money supply are also positive and statistically significant at the 5-percent level. This indicates that a money supply shock will lead to a 0.06-per-

Table 5. Vector Autoregression Model Parameter and Diagnostic: Indonesia

Variables	Agricultural Prices (AGP)	Manufacturing Prices (MANPR)	Exchange Rate (EXCHR)	Money Supply (MS)
Intercept	4.59**	0.39	0.44*	−1.61
Trend	0.01**	0.003	0.001	0.003**
AGP	0.87***	−0.01	0.001	0.09
MANPR	0.17	1.02***	0.01	−0.63**
EXCHR	0.73**	−0.08	0.92***	0.87*
MS	0.06**	0.01**	0.01**	0.77***
R-squared	0.94	0.95	0.95	0.97
AIC (Akaike Information Criterion)	−4.99	−7.92	−9.05	−3.54
Schwarz Criteria	−4.85	−7.78	−8.91	−3.40

*** 1-percent significance level, ** 5-percent significance level, * 10-percent significance level.

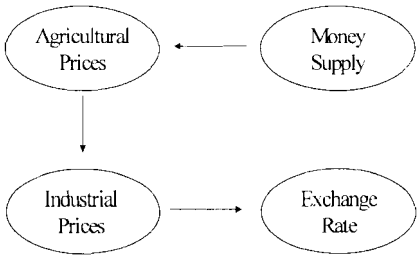
cent increase in agricultural prices. In the manufacturing price equation, the coefficient of money supply is also positive and statistically significant at the 5-percent level, while the coefficient for the exchange rate is not significant. In this regard, a 1-percent increase in money supply will lead to a 0.01-percent increase in manufacturing price.

Impulse Response Functions and Variance Decompositions

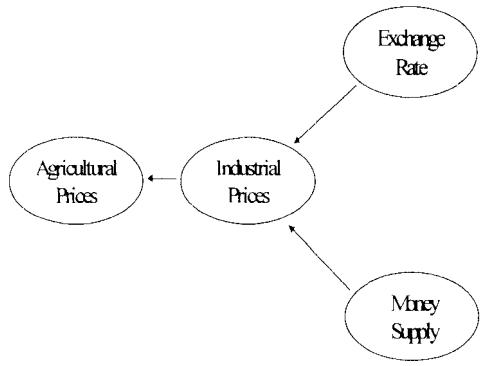
An impulse response function tracks the evolution of economic shocks through the system. It traces the response of current and future values of an endogenous variable (e.g., agricultural or manufacturing prices) to a one-standard deviation shock to one of the innovations (i.e., money supply in this case). Any inference on responses of agricultural and manufacturing prices to shocks in money supply requires a careful investigation of contemporaneous correlation among corresponding innovations. In a case where contemporaneous correlation among the errors are present, calculation of impulse response functions and variance decompositions may be distorted because of the effects of innovations in another variable in the system at the same time.

We performed a formal test of contemporaneous causal structures before calculating the impulse-response and variance-decomposition. We first applied directed graph theory, as in Bessler and Akleman and Yang, Bessler, and Leatham. Spirtes, Glymour, and Scheine suggest a PC algorithm to assign causal flows based on the existing data's partial correlations. The algorithm begins with an undirected graph in which all the variables are originally connected. The program removes adjacent edges when partial correlations are not statistically significant from zero at an identified significant level and assigns causal flow directions for the remaining edges. This method helps to ensure that the orderings of the errors for impulse-response and variance-decomposition analysis are reasonable given the data set.

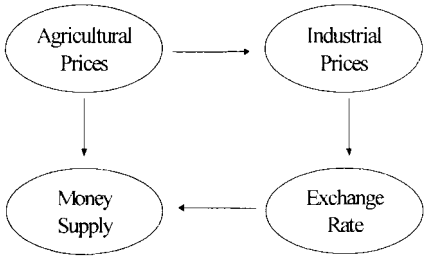
Figure 1 presents the causal flow on innovations from the four Asian economies generated by the TETRAD II-Version 3.1 software (Spirtes et al.) under a 10-percent significance level. The results indicate that the causal structures of the four variables—agricultural prices, industrial prices, exchange rate, and M1—are very different for the four countries. The results for Indonesian data show there is no direct residual relationship between M1 and exchange rate, and the effects of money supply changes on exchange rate residuals is indirect through agricultural and industrial prices. The Korean results indicate no relationship, direct or indirect, between the money supply and exchange rate in the residual data, while innovations in both of these



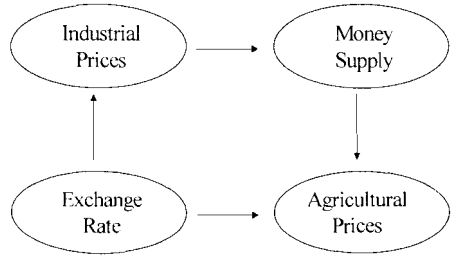
Causal structure for Indonesia



Causal structure for Korea



Causal structure for Philippines



Causal structure for Thailand

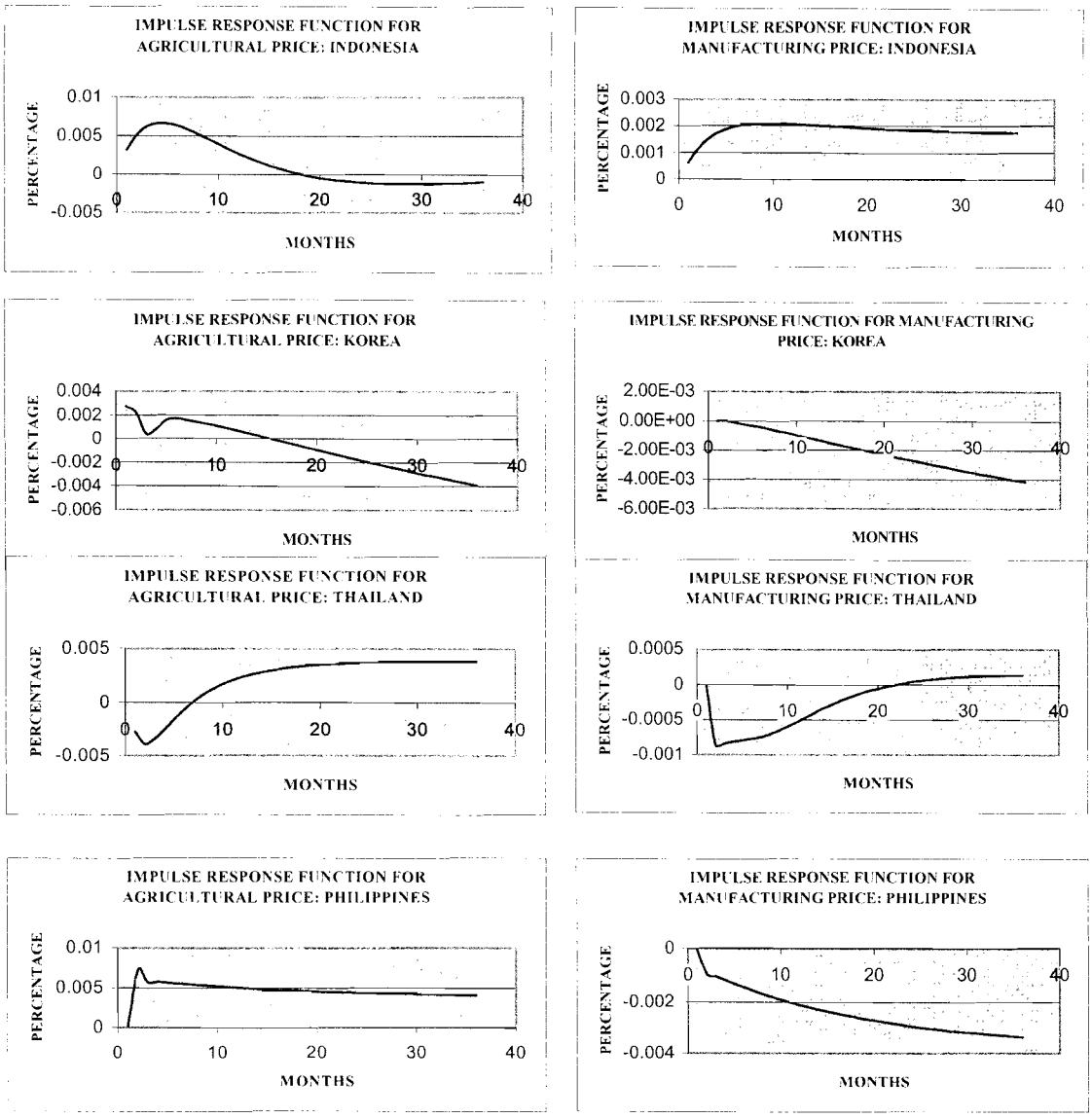
Figure 1. Causal flow on innovations from four Asian economies

variables directly affect residuals in the industrial prices. The money supply and exchange rate affect agricultural price residuals indirectly through industrial prices.

The results for the Philippines show residuals in the agricultural prices and exchange rate directly affect residuals in money, while agricultural price residuals affect industrial prices directly and exchange rate indirectly through industrial prices. The results for Thailand indicate that residuals in the money supply and exchange rate directly affect residuals in the agricultural prices with exchange rate directly affecting industrial price residuals as well.

Figures 2 through 9 present the corresponding impulse response functions for agricultural and manufacturing prices in each country from a one standard deviation shock in money supply over a 36-month forecast horizon. As shown, agricultural prices increase immediately after the monetary shock, except for Thailand's.

Agricultural prices in Indonesia are immediately responsive to the monetary shock and they continue to increase for six months. After that they start to decline and reach a stable pattern after 36 months. The response of Philippine agricultural prices is more volatile. They jump up in the first three months and



Figures 2–9. Impulse response functions for agricultural and manufacturing prices

start to decline afterward, but throughout this period they are still positively influenced by the money supply change. After 20 months agricultural prices are slightly lower due to the money supply change.

The response of agricultural prices in Thailand shows an opposite pattern to the Philippines for early months. Agricultural prices fall slightly in the first three months, but rebound quickly and respond positively until reaching equilibrium after approximately 20 months. In Korea, agricultural prices are not immediately responsive to a money supply shock. They decrease for the first four months and then start to increase for the next four months; after that they begin to decline. After approximately 25 months the effect on agricultural prices becomes negative and continues to decline. All the agricultural price responses display a cyclical pattern in the very short run, two to four months, but it seems that agricultural prices in Philippines increase the most from a money supply increase in the short run.

Manufacturing prices begin to fall imme-

diately after the money supply shock in the cases of Korea, Philippines, and Thailand, but they climb back gradually and reach equilibrium after 35 months for Thailand. Meanwhile, in the Korean and Philippines cases, they continue to decline even after 36 months. After the initial increase in manufacturing prices from the money supply shock, manufacturing prices in Indonesia begin to fall slightly and reach equilibrium after 20 months. Meanwhile, manufacturing prices' response in Thailand increases after two months and reaches equilibrium after 30 months. Overall, manufacturing prices are somewhat more stable than agricultural prices.

The variance decomposition estimates the percentage of variation in the forecast error of an endogenous variable explained by its own shocks and the proportion explained by shocks in other variables. In our case we would like to know the variance decomposition for the effects of a positive money supply shock on agricultural and manufacturing prices.

Table 6 summarizes the variance decomposition for a positive money supply shock on agricultural and manufacturing prices. As shown, 76 percent, 87 percent, 4 percent, and 57 percent of agricultural price in Korea, Philippines, Thailand, and Indonesia, respectively, are explained by its own shock. Shock in money supply explains 1 percent, 1.5 percent, 3 percent, and 12 percent of agricultural price in Korea, Philippines, Thailand, and Indonesia, respectively. Further, it also shows that 23 percent, 4.5 percent, 95 percent, and 1 percent of manufacturing price in Korea, Philippines, Thailand, and Indonesia, respectively, are explained by its own shock. Shock in money supply explains 21 percent, 1.5 percent, 0.1 percent, and 17 percent of manufacturing price in Korea, Philippines, Thailand, and Indonesia.

The variance decompositions show how the variables in the model interplay to influence one another. The results show striking contrasts by country and sector. For the Korean agricultural sector there are strong direct linkages with the manufacturing sector; however, there is little linkage between agricultural prices and money supply. In contrast, the linkage between Thailand's agricultural sector and manufacturing sector is going one way, for the most part from manufacturing to the agricultural sector. Money supply changes have some influence on Indonesian agricultural and manufacturing sectors. The money supply's influence is greatest for Korean and the least for Thailand's manufacturing prices. Each country seems to have very different variance decompositions, implying a very different structure for price relationships. However, once all the interrelationships are taken into consideration, monetary policy has a larger impact on agricultural prices in Indonesia than any other country, a result that was not expected a priori.

For the manufacturing sector, one notices a strong indirect monetary linkage for Korea through agricultural prices and the exchange rate, which is a bit surprising given that Korean agricultural prices were not influenced

Table 6. Variance Decomposition on the Effects of Money Supply Changes on Agricultural Price and Manufacturing Prices (36-month Horizon)

	Agricultural Prices	Manufacturing Prices
Korea		
Agricultural Prices	76.45	49.35
Manufacturing Prices	19.91	22.94
Exchange Rate	2.80	6.66
Money Supply	0.84	21.03
Philippines		
Agricultural Prices	87.28	53.35
Manufacturing Prices	0.12	4.50
Exchange Rate	11.10	40.66
Money Supply	1.50	1.49
Thailand		
Agricultural Prices	4.30	0.14
Manufacturing Prices	88.20	94.62
Exchange Rate	4.14	5.18
Money Supply	3.36	0.06
Indonesia		
Agricultural Prices	57.40	0.82
Manufacturing Prices	1.45	81.28
Exchange Rate	28.91	1.09
Money Supply	12.24	16.81

through manufacturing prices. Thailand's manufacturing prices see monetary influences coming strongly through manufacturing prices, which is consistent with the finding for their agricultural prices. Monetary policy has a strong indirect linkage through the exchange rate for manufacturing prices in the Philippines.

Summary and Conclusions

This paper examined the impacts of monetary policy on agricultural prices in four Asian countries using well-established econometric time series analysis along with graph theory. The estimations clearly show that agricultural prices overshoot their long-run equilibrium values for Korea, Philippines, and Thailand, and that this overshooting for agricultural prices is larger than for manufactured prices. The impulse response functions based on directed graphs and causal approach in the data show that this departure from equilibrium takes quite a while before it disappears in many instances, especially for agricultural prices in Indonesia and Korea.

The variance-decomposition analysis highlights the complex interplay among the variables in the model and how those relationships differ by country. Thailand has very strong linkages between the agricultural and manufacturing sectors, whereas those linkages are minor in Indonesia and Philippines. Monetary policy works through the exchange rate for agricultural prices in Indonesia and manufacturing prices in Philippines, but not for agricultural or manufacturing prices in Thailand and Korea. More analysis beyond this study, however, is required to fully understand these relationships.

The results show that money is not neutral in three of the four countries analyzed, which is rather surprising. Specifically, the results indicate that there is no relationship between the money supply and prices in Indonesia, whereas only about 20 percent and 40 percent of the change in money supply is passed forward to agricultural and manufacturing prices in Thailand and Korea, respectively. This might partially explain the fast per-capita growth rates in Indonesia, Korea, and Thailand during the late 1980s and early 1990s, and could be a partial explanation of the financial crisis for the same countries in the late 1990s.

The analysis clearly lends insights into how monetary policy impacts the agricultural and manufacturing sectors of these East Asian economies. Money supply changes clearly affect real variables and relative prices, at least in the short-run, for all countries either through overshooting or the non-neutrality of money. Future studies of price relationships in less-developed countries need to be cognizant of the findings that overshooting occurs and can distort economic decision making in the short and long run. More detailed sector or commodity studies should incorporate these monetary linkages if they are to fully reflect the integration of these markets with the macro economy. The findings strengthen the call for stable monetary policy that results in smooth price changes and less disruptive price changes in the agricultural and manufacturing sectors.

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