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Identifying Monetary Impacts on Food Prices in China: A VEC Model Approach

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Identifying Monetary Impacts on Food Prices in China: A VEC Model Approach

Xuehua Peng, Mary A. Marchant and Michael R. Reed *

Abstract

This research attempts to investigate the impacts of monetary variables (such as money supply and interest rates) on food prices in China using a vector error correction (VEC) model approach. Evidence indicates that monetary variables and the food price index (FPI) have a long-run equilibrium relationship in China. Furthermore, the direction of Granger-causality moves from the money supply to the FPI and then to interest rates, rather than the reverse. Monetary impacts on food prices in China mainly stem from the money supply rather than interest rates.

Keywords: food prices, monetary shocks, VEC model, China

Introduction

Food price fluctuations in China have great impacts on Chinese farmers' income and consumers' cost of living. Recently, China has seen strong upward pressure on food prices. Since 2003, Chinese food prices have increased dramatically for the first time in six years raising concerns over food security in China and the world. Historically, China experienced large food price fluctuations over the last two decades (Figure 1). The food price index's annual percentage change peaked at almost 20% in 1994 and then declined steadily to a low of about -5% in 1999. Traditional agricultural economics research examines reasons for these agricultural price fluctuations using supply and demand analysis. In contrast, recent agricultural economics literature indicates that macroeconomics, especially monetary and financial factors, impact agricultural prices (Orden, 2002, 1986a, 1986b; Orden and Fackler, 1989; Barnett, Bessler and

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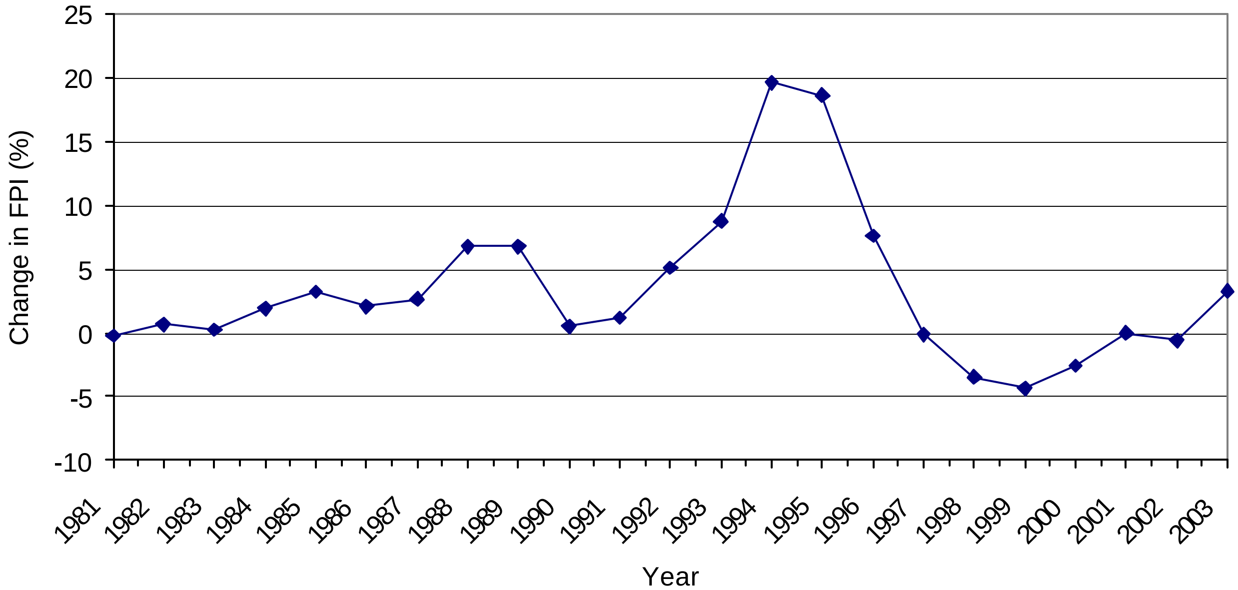
Figure 1. Annual Percent Change in Food Price Index (%)



Source: World Bank. *World Development Indicators Online Database*.

Thompson, 1983; Saghaian, Reed and Marchant, 2002; Shane and Liefert, 2000; McCalla, 1982; Schuh, 1974).

These studies showed that within an economy with a fixed-price manufacturing and service sector and a flex-price agricultural sector, agricultural prices respond relatively quickly to a monetary shock. The commodity arbitrage condition may then lead to the overshooting of flexible agricultural prices in the short run with a monetary shock. But the extent of the overshooting depends positively on the relative weight of fixed prices in the price index, interest response of money demand and the speed of adjustment (Karungu, Reed and Allen, 1995; Saghaian, Reed and Marchant, 2002).

Most of the existing empirical analyses regarding macroeconomic impacts on agricultural prices were conducted on well-developed market economies. Compared with these market economies, China may have four major differences. First, China's agricultural commodity markets and future markets are not well developed. Due to regional protectionism, poor infrastructure and other factors, China's agricultural markets are far from integrated and efficient. Second, China has used a fixed exchange rate system since 1994. China's currency, the Ren Min Bi (RMB), has been pegged to the U.S. dollar. Third, interest rates are dictated by the Chinese central bank rather than determined by market forces. Interest rate adjustments, which are dictated by the Chinese government, may not be consistent with money market forces. Fourth, the ratio of household savings with respect to total national saving accounts is very high. There are limited ways to direct Chinese households' savings into investment. Due to these characteristics and other inherent shortcomings within China's institutional framework, macroeconomic instruments such as monetary policy in China do not function as effectively as in well-developed market economies (Kumar et al., 2003).

Upon its accession into the WTO, China committed itself to further expedite and deepen its financial reforms, including allowing markets to determine interest rates. It is expected that further monetary policy manipulation will play a more active role in affecting food prices in China. Thus, it is necessary and important to identify monetary impacts on Chinese food prices through quantitative methods so that food price changes can be better understood.

The objective of this research is to investigate the impacts of monetary policy variables, such as the money supply and interest rates, on Chinese food prices using a vector error correction (VEC) model approach. Three specific objectives are included:

1. To test whether monetary variables and food prices in China are related through cointegration tests using a vector error correction (VEC) model framework.

2. To test the causal relationships between Chinese monetary policy variables and Chinese food prices;
3. To analyze how food prices respond to a monetary variable shock by estimating impulse response functions.

The remainder of this paper proceeds as follows: the next section discusses the research methodologies used in this research, including VEC models, cointegration tests, Granger-Causality tests and impulse response functions. Following the discussion of methodologies, we describe the data used in this research. Empirical modeling results are then reported for cointegration tests, Granger-Causality tests and impulse response functions. Finally, implications about China's food price variability and food security are drawn from our empirical results.

Research Methodology

The methodology used in this research is based on cointegration analysis of time series data. In this study, econometric analyses were conducted through four procedures. First, we performed unit root tests on each series to assess the stationarity of each variable. Second, we used the Johansen methodology to test the cointegration relationships between food prices and monetary variables (Johansen,1988; Johansen and Juselius, 1990). Third, we conducted Granger-causality tests on possible causal relationships between each series. Finally, we estimated the impulse response functions of food prices for a given monetary variable shock.

Unit Root Tests

Before applying empirical cointegration tests, the Augmented Dickey Fuller (ADF) method was used to test whether or not each variable was stationary. Most economic variables, such as prices that exhibit strong trends, are nonstationary. If a stationary process can be produced by taking a first difference on a nonstationary variable, then this variable is said to be integrated of order one, denoted as I(1) (Greene, 2000).

Consider an augmented vector autoregression (VAR) process of order *k* as given in equation (1)

$$Y_t = \sum_{i=1}^{k} \Phi_i Y_{t-i} + \Psi D_t + e_t \qquad t = 1, 2, \ldots, T \tag{1}$$

where Y_t is an $l \times 1$ vector of jointly determined non-stationary I(1) dependent variables (described below), and D_t is a $q \times 1$ vector comprised of q deterministic terms and/or exogenous variables, e_t is an $l \times 1$ vector of innovations, and Φ_j {j = 1, 2, ..., k} and Ψ are $l \times l$ and $l \times q$ coefficient matrices, respectively. In our case, $l = 3$ and $Y_t = \left[FPI_t, M2, IR\right]'$, where each variable denotes a food price index, money supply measured by M2 and interest rates, respectively. Equivalently, we can rewrite (1) in a vector error correction (VEC) form as

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \Delta Y_{t-j} + \Psi D_t + e_t \tag{2}$$

where $\Pi = \sum_{j=1}^{k} \Phi_j - I$; I is the identity matrix (3)

and $\Gamma_j = -\sum_{i=j+1}^{k} \Phi_i$ (4)

We can perform ADF tests on the Π parameter to determine whether or not each series is more closely identified as being either an I(1) or an I(0) process. If we cannot reject the null hypothesis that $\Pi = 0$, we infer that each series is more likely to be an I(1) instead of an I(0) process (Eviews4 User's Guide, 2000; Greene, 2002).

Cointegration Tests

Granger's representation theorem asserts that if the coefficient matrix Π in equation (2) has reduced rank $r < l$, then there exist $l \times r$ matrices a and b each with rank r such that $\Pi = ab'$, and $b'Y_t$ is stationary (Granger 1981; Engle and Granger 1987). In regards to definitions, r is the number of cointegrating relations (the rank), and l is the number of variables included in vector Y_t, in our case l equals 3. The elements of a are known as the adjustment parameters in the VEC model and each column of b is the cointegrating vector. The hypothesis of cointegration can then be formulated as a restriction on the Π matrix where the number of cointegration relationships is given by r. The trace test method is used to test for r (the maximum number of cointegration relationships) and the statistic is

$$l_{trace} = -T \sum_{i=r+1}^{k} \ln(1 - l_i) \qquad (5)$$

where T is number of time period observations and l_i is the i-th largest eigenvalue. The null hypothesis is that the cointegration rank is r and the alternative hypothesis is that the cointegration rank is k, the order of the VAR process.

Granger-causality Tests

In analyzing Granger causality relationships, our main interest is to find the lead/lag relationships between variables. The concept of Granger-causality is fundamentally different from economic causality. However, if *A* causes *B* according to economic theory, A must move before *B*. That is to say, the Granger-causality relationship is a necessary, but not a sufficient condition for an economic causality relationship between variables.

We partition Y_t into two subgroups, one for food prices Y_{1t}, and another subgroup for monetary variables Y_{2t} consisting of money supply and interest rates. The following two VAR equations can then be used to test whether a Granger-causality relationship exists between food prices and monetary variables.

$$\Delta Y_{1t} = a_0 + \sum_{i=1}^{k} a_{1i}\Delta Y_{1t-i} + \sum_{i=1}^{k} a_{2i}\Delta Y_{2t-i} + \Psi_1 D_t + u_{1t} \tag{6}$$

$$\Delta Y_{2t} = b_0 + \sum_{i=1}^{k} b_{1i}\Delta Y_{2t-i} + \sum_{i=1}^{k} b_{2i}\Delta Y_{1t-i} + \Psi_2 D_t + u_{2t} \tag{7}$$

In equation (6), if the a_{2i} parameters are statistically different from zero, we may reject the absence of Granger-causality and conclude that monetary variables Y_2 Granger-cause food prices Y_1. In equation (7), if the b_{2i} parameters are statistically significant from zero, we may conclude that the direction of Granger-causality relationship moves from food prices, Y_1 to monetary variables, Y_2. If both are statistically different from zero, we conclude that there exists bicausality between Y_1 and Y_2 (Granger, 1969).

Impulse Response Functions

We can express equation (1) in a vector moving average (MA) form (Pesaran and Shin, 1998) such as

$$Y_t = \sum_{i=0}^{\infty} A_i e_{t-i} + \sum_{i=0}^{\infty} G_i D_i, \text{ t = 1, 2, ..., T} \tag{8}$$

where the $l \times l$ coefficient matrices A_i can be obtained using the following recursive relationships:

$$A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + ... + \Phi_k A_{i-k}, \text{t = 1, 2, ...,} \tag{9}$$

with $A_0 = I_l$ and $A_i = 0$ for i <0, and $G_i = A_i \Psi$, where previous definitions hold and I_l is the identity matrix of dimension l.

An impulse response function traces the effect of shocks at a given time on the (expected) future values of variables in a dynamic system. In our case, the impulse response functions are estimated to depict effects of a monetary variable shock on Chinese food prices over time.

Data Description

This empirical analysis was carried out using annual data from 1980 to 2002. Since the available monthly data series is not long enough to cover periods when FPI fluctuations were large, we used annual data. Data for money supply and interest rates were obtained from the *World Development Indicators Online Database* maintained by the World Bank. Data for the food price index came from *China's Statistics Yearbook*. All variables are expressed in nominal terms in order to test the neutrality of money. For the food price index series, the base year equals 1980. All variables took the form of natural logarithm for the estimation. Eviews 4.1 and SAS8.2 were used in this analysis.

Table 1 provides simple descriptive statistics for each variable. The coefficients of variation and ranges show that there are big fluctuations observed for food prices and monetary variables. Interest rate fluctuations have been great over the last two decades.

Table 1. Descriptive Statistics for FPI and Monetary Variables in China: 1980-2002

Variable	Mean	Standard Deviation	Minimum	Maximum	CoefVar
FPI	5.52	0.63	4.61	6.27	11.33
M2	6.86	1.34	4.74	8.89	19.48
IR	1.77	0.54	0.68	2.43	30.40

Sources: World Bank. *World Development Indicators Online Database.*
National Bureau of Statistics of China. *China's Statistics Yearbook*.

Empirical Results

Unit Root Tests

The Dickey-Fuller unit root test results are reported in Table 2. The results indicate that all of the variables are I(1) as expected. This means that it is appropriate to conduct the cointegration test on our time series data for food price index and monetary variables in China.

Table 2. ADF Unit Root Tests Results

Variable	Type	t-ADF	p-value[a]
FPI	Level	-1.4508	0.5369
	First Difference	-2.9374	0.0587*
M2	Level	-0.6396	0.8421
	First Difference	-3.4801	0.0193**
IR	Level	0.2028	0.9663
	First Difference	-2.8689	0.0660*

Note: a. MacKinnon (1996) one-sided p-values.
*** denotes 1% significance level,
** denotes 5% significance level and
* denotes 10% significance level

Cointegration Tests

Table 3 reports the cointegration test results for the food price index and monetary variables in China. The results reveal that there is one cointegrating equation at the 5% significance level. Thus, we can conclude that the food price index and monetary variables are cointegrated of order 1. This implies that there may exist a long-run equilibrium relationship between the food price index and monetary variables.

Table 3. Cointegration Rank Test Results

No. of Cointegrating Equations	Eigenvalue	Trace Statistics	5% Critical Value
None	0.6710	42.5415	34.91
At most 1	0.4337	19.1959	19.96
At most 2	0.2922	7.2564	9.24

Vector Error Correction Model Estimates

Table 4 summarizes parameter estimates and diagnostics for our VEC models. The results show that the food price index, money supply and interest rates in a lagged one-year period are statistically significant at the 10% significance level in the determination of a FPI change and are statistically significant at the 1% significance level in the determination of an interest rate change. The food price index change in a lagged one-year period is statistically significant at the 10% significance level in the determination of a money supply change.

Granger-Causality Tests

We conducted tests on some possible Granger-causality relationships between the food price index and monetary variables and report them in Table 5. The results reveal that there exists a bicausality relationship between the FPI and the monetary variables. This means that monetary policies Granger cause a FPI change; meanwhile a FPI change also Granger causes monetary policy changes.

Table 4. Vector Error Correction Model Parameter Estimates and Diagnostics

Variable	ΔFPI_t	$\Delta M2_t$	ΔIR_t
FPI_{t-1}	-0.37889*	-0.02141	-2.03115***
$M2_{t-1}$	0.17323*	0.00979	0.92863***
IR_{t-1}	0.07470*	0.00422	0.40046***
ΔFPI_{t-1}	0.70635***	-0.65903*	2.34493***
$\Delta M2_{t-1}$	0.25283	0.27782	-0.08941
ΔIR_{t-1}	-0.03817	0.03818	-0.43212*
ΔFPI_{t-2}	-0.16295	0.20505	-0.92027*
$\Delta M2_{t-2}$	-0.01320	0.23863	-1.47610**
ΔIR_{t-2}	-0.01529	0.15121	-0.45442**
R^2	0.8194	0.2961	0.7917
DW	1.86	2.08	2.65
Akaike AIC	-2.961623	-2.250082	-0.921578

Note: ***denotes 1% significance level, ** denotes 5% significance level and **denotes 10% significance level

Table 5. Granger-Causality Relationship Tests Results

Null Hypothesis	F-Statistics	Probability
M2 and IR does not Granger Cause FPI	17.24	0.0084***
FPI does not Granger Cause M2 and IR	18.26	0.0056***
M2 does not Granger Cause FPI	7.8564	0.0042***
FPI does not Granger Cause M2	0.2962	0.7476
IR does not Granger Cause FPI	0.6510	0.5348
FPI does not Granger Cause IR	3.5250	0.0539*
IR does not Granger Cause M2	0.3601	0.7031
M2 does not Granger Cause IR	6.9068	0.0069***

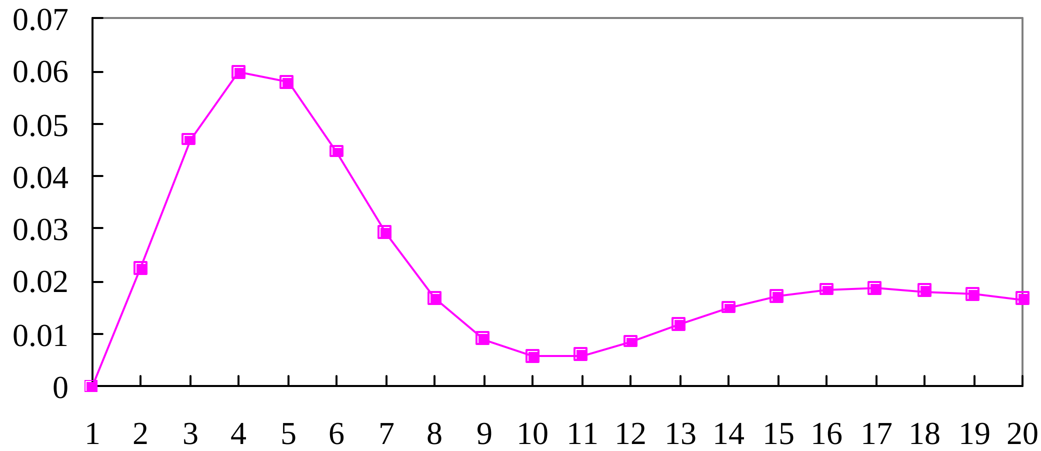
Note: *** denotes 1% significance level,
** denotes 5% significance level and
* denotes 10% significance level

We also conducted tests on the Granger-causality relationship between each individual monetary variable and the food price index. Results indicate that the money supply (measured by M2) Granger-causes the food price index at the 1% significance level and the food price index Granger-causes interest rates at the 10% significance level. Consistent with transitivity, a change in the money supply Granger-causes a change in interest rates at the 1% significance level. However, the opposite direction of this Granger-causality relationship does not exist. A change in interest rates does not Granger-causes a change in money supply.

Impulse Response Functions

Since the money supply is the main policy variable that contributes to the Granger-causality relationship that a change in monetary policy affects food prices, we estimated impulse response functions for the food price index in response to money supply shocks. Figure 2 reports our results and suggests that positive money supply shocks raise food prices. The neutrality assumption of the money supply is rejected and food prices are found to overshoot in the short run.

Figure 2. FPI Response to a Shock of Money Supply (M2)



Concluding Remarks

This research found that food prices in China have a long-run equilibrium relationship with monetary variables, such as the money supply and interest rates. China's monetary policies significantly influence its long-term food prices. Granger-causality tests reveal that there exists a Granger-bicausality relationship between food price and monetary variables in China. Specifically, a change in the money supply Granger-causes a change in food prices and a change in food prices Granger-cause a change in interest rates. The opposite direction of this Granger-causality relationship does not exit. A possible reason is that interest rates in China are not determined by financial market forces. Given this financial environment, China's monetary policy might be inconsistent with its objectives and expectations. As a macroeconomic policy instrument, interest rates play a very limited role in affecting food price fluctuations. Impulse response functions demonstrate that the money supply is not neutral in determining China's food prices. Thus, the dominant monetary policy instrument which can be used by the Chinese government to control food price fluctuations is the money supply instead of interest rates.

This research illustrates that monetary policy matters in the determination of food prices in China. The Chinese government should give great care and attention to macroeconomic policy adjustments to smooth out the variability and fluctuations in food prices and their impacts on Chinese farmers' real income and consumers' living expenditures.

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