

Integration of Major Agricultural Product Markets of China

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Abstract

China's accession to the World Trade Organisation (WTO) raises two key questions. One is whether China's local markets are integrated and the other is whether China's markets can coordinate with world markets. This paper uses 3-step methods to answer the above questions. In the study, co-integration analysis is applied to test market integration, Granger-causality test is used to analyse the direction of price spread between markets, and IMC (Index of Market Connection) method is employed to measure the connection degree between markets. The results show that long-run market integration exists among local markets. China's major agricultural product markets are also integrated with world markets in the long-run. However, except for two pairs of domestic hog markets, short-run integration is not found both between domestic markets and between domestic and world markets. Market connection degrees are different for different products. Finally some policy implications are suggested.

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1 Introduction

China's accession to the WTO raises two key questions. One is whether China's local markets are integrated and the other is whether China's markets can coordinate with and integrate into the world markets. These two aspects are closely related because only high integration of domestic markets can improve the integration of domestic and world markets. If domestic markets were segmented, it is difficult for them to integrate into world markets. This paper will select rice, wheat, corn, soybean, hog and peanut oil first to test market integration respectively, including domestic local market integration and the integration between domestic and world markets, and, if the markets are integrated, then to measure the degree of integration and to analyse the differences between products. The study will also analyse the reasons if the markets are not integrated.

Market integration can be classified into two kinds. Long-run and short-run integration. Long-run market integration refers to such a case that there exists long-run and stable price relationship between two markets, even if this long-run relationship "balance" was broken in short-run, it still will reach the balance finally. Short-run market integration shows that the price changes in one market in some period will be passed "immediately" into another market. This reflects the sensitivity of price response between markets.

2 Methodology

This paper mainly includes two parts. One is the integration and influences of domestic markets, and the other is the integration and influences between world and domestic markets. Each part is a three-step study, therefore, three kinds of methods will be used. In the first step, the market integration will be tested. This will show whether there exist stable relationships between markets. In the second step, if the markets are integrated, the Granger-causality test will be applied to show the influence direction between markets and to decide the leading markets of each product. Finally in the third step, IMC (Index of

Market Connection) method will be used to show the connection degree of markets. This can also reflect, at certain extent, the influence of one market on another.

2.1 Long-run Market Integration Test

Long-run market integration will be tested by co-integration model. This method requires that: (1) two variable series, P_{it} and P_{jt} , are each non-stationary in levels but stationary in first differences, i.e., $P_{it} \sim I(1)$ and $P_{jt} \sim I(1)$; (2) there exists a linear combination between these two series, which is stationary, i.e., $P_{it} - \alpha - \beta P_{jt} \sim I(0)$. So the first step of this method is to test whether each of the univariate series are stationary. If they are both $I(1)$, then going to the second step to test for co-integration. The Engle and Granger (1987) procedure is the common way to test for co-integration.

For stationary status, an ADF test is often applied. It tests the null hypothesis that P_t is non-stationary by calculating a t-statistic for $\beta = 0$ in:

$$\Delta P_t = a + bP_{t-1} + gt + \sum_{k=2}^n d_k \Delta P_{t-k} + x_t \quad (1)$$

where $\Delta P_t = P_t - P_{t-1}$, and $\Delta P_{t-k} = P_{t-k} - P_{t-k-1}$; $k = 2, 3, \dots, n$; P_t , P_{t-1} , P_{t-k} , and P_{t-k-1} are the prices at time t , $t-1$, $t-k$, and $t-k-1$, respectively. α , β , γ , and δ_k are parameters to be estimated in the last equation, t is a time trend and ξ_t is the error term.

If the value of ADF statistic is less (i.e. more negative because these values are always negative) than these critical values, it shows that P_t is stationary. If P_t is found to be non-stationary, it should be determined whether P_t is stationary in the first difference (i.e. to test $\Delta P_t - \Delta P_{t-1} \sim I(1)$) by repeating the above procedure. If the ADF test can be rejected for the null hypothesis, as is usually the case with commodity price series, it may be concluded that $P_t \sim I(1)$, then continue to the second step for co-integration.

To test for co-integration, Engle and Granger (1987) developed a two-step, residual based test, which is now commonly used:

The first step is the OLS regression of one $I(1)$ price series, say P_{it} on another $I(1)$ price

series, say P_{jt} plus a constant and a time trend. The regression equation is as follows (known as co-integrating regression):

$$P_{it} = \varphi + \omega P_{jt} + \eta t + e_t \quad (2)$$

where P_{it} is the price in market I at time t; P_{jt} is the price in market j at time t; φ , ω and η are parameters to be estimated; and e_t is the error term.

The second step involves testing whether the residuals, e_t , from the co-integrating regression are non-stationary by using the modified ADF test:

$$\Delta e_t = \lambda e_{t-1} + \sum_{k=2}^n \theta_k \Delta e_{t-k} + \mu_t \quad (3)$$

where $\Delta e_t = e_t - e_{t-1}$, $\Delta e_{t-k} = e_{t-k} - e_{t-k-1}$, e_t , e_{t-1} , e_{t-k} , e_{t-k-1} are, respectively, the residuals at time t, t-1, t-k, and t-k-1; λ and θ_k are parameters to be estimated; μ_t is the error term.

The constant and time trend are omitted from the ADF test because the residuals from the co-integrating regression will have a zero mean and be detrended. The null hypothesis that $\lambda=0$ is again tested, but this is a test of residual stationary rather than original time series. If the t-statistic value of the λ coefficient is less than the relevant critical value, the null hypothesis is rejected and two price series are said to be co-integrated of order (1, 1), so the two markets are co-integrated. This implies long-run market integration.

2.2 Short-run Market Integration Test

Short-run market integration means a price change on one market will “immediately” be passed onto another market. Short-run market integration is tested on following model by F-test. If null hypothesis: $\mu_{11}=\dots=\mu_{1n}=\mu_{21}=\dots=\mu_{2n}=0$, $\lambda=1$ and $\mu_{20}=\alpha$ are rejected, this shows that short-run integration doesn't exist, vice versa.

$$\begin{aligned} \Delta P_{it} = & m_{11} \Delta P_{it-1} + \dots m_{1n} \Delta P_{it-n} + m_{20} \Delta P_{jt} + m_{21} \Delta P_{jt-1} + \dots \\ & + m_{2n} \Delta P_{jn-1} - l (P_{it-1} - a P_{jt-1} - b T - d) + e_i \end{aligned} \quad (4)$$

where P refers to price, i and j refer to markets.

2.3 Granger-Causality Test

If a pair of series is co-integrated, then there must be Granger-Causality in at least one direction. This in turn can reflect the direction of price influences between markets. Theoretically, if the present or lagged terms of a time series variable, say X, decide another time series variable, say Y, there exists Granger-Causality relationship between X and Y, in which Y is Granger caused by X. In 1982, Bessler and Brandt firstly introduced this theory into the research of market integration to decide the main leading market. From above analysis, the model was built as follows:

$$\Delta P_{it} = q_{11} \Delta P_{it-1} + \dots + q_{1n} \Delta P_{it-n} + q_{21} \Delta P_{jt-1} + \dots + q_{2n} \Delta P_{jt-n} - g_1 (P_{it-1} - a P_{jt-1} - d) + e_{1t} \quad (5)$$

$$\Delta P_{jt} = q_{31} \Delta P_{jt-1} + \dots + q_{3n} \Delta P_{jt-n} + q_{41} \Delta P_{it-1} + \dots + q_{4n} \Delta P_{it-n} - g_2 (P_{it-1} - a P_{jt-1} - d) + e_{12} \quad (6)$$

The following two assumptions were tested respectively from the above two models so as to decide the Granger -Causality relation between prices:

$$\theta_{21} = \dots = \theta_{2n} = \gamma_1 = 0 \text{ (no causality from } P_j \text{ to } P_i \text{)}$$

$$\theta_{41} = \dots = \theta_{4n} = \gamma_2 = 0 \text{ (no causality from } P_i \text{ to } P_j \text{)}$$

2.4 Index of Market Connection (IMC) method

Index of Market Connection (IMC) method will be applied to measure the connection degree between markets. This method was based on Ravallion Model and built by Timmer in 1984. In 1990, Arshad used this method and did the research on the integration of palm oil market in Peninsular Malaysia.

From Ravallion Model¹ we can get the following formula:²

$$P_{it} = (1+b_1)P_{it-1} + b_2(\bar{P}_t - \bar{P}_{t-1}) + (b_3 - b_1)\bar{P}_{t-1} + b_4X + m_t \quad 7$$

where P_{it} is price in market I at time t; $\bar{P}_t$ is the reference price at time t; X is a vector of seasonal and other relevant variables in market I at time t.

From the above model, IMC can be calculated. Market Connection Index equals to the coefficient of lagged price in local markets divided by coefficient of lagged price in central/reference market. that is:

$$IMC = (1+b_1)/(b_3 - b_1) \quad (8)$$

From Ravallion model we know that: when markets are integrated, $b_1 = -1$, $IMC = 0$; when markets are completely isolated or integration degree equals to zero, $b_1 = b_3$, $IMC = \infty$. Generally IMC is greater than 0. When IMC is closer to 0, the integration degree between markets is higher, vice versa.

3 Integration of Domestic Local Markets

In this study, we select rural free markets (*nongcun jimaoshichang*) and choose wheat, corn and hog as samples.³ The regions are selected based on the production of the three sample products. We choose 15, 15 and 16 provinces as sample areas for wheat, corn and hog respectively.⁴

¹ Ravallion, Martin (1986), "Testing Market Integration", *AJAE* 68:102-9.

² For the detailed procedure see: Paul J.H. (1986), "Testing Market Integration", *Food Research Institute Studies* 20(1) or Fatimah Mohd. Arshad (1990), "The Integration of Palm Oil Market in Peninsular Malaysia", *Indian Journal of Agricultural Economics* 45:21-30.

³ Wheat, corn and hog are respectively Chinese major grain crop, feed crop and animal product. In this research we don't study rice because there are many researches about Chinese domestic rice market integration, such as (Li Pen, 1999; Yu Wen & Huang Jikun, 1998; Wan Guanghua, 1997; Zhou Zhangyue etc., 1997 and Luping Li, 1996.)

⁴ For wheat, we choose Henan, Shandong, Hebei, Jiangsu, Sichuan, Anhui, Shaanxi, Gansu, Shanxi, Yunnan, Beijing, Tianjin, Ningxia, Zhejiang and Guizhou (These 15 province accounts for 83% of total wheat output of China in 1999); For corn, we select Jilin, Shandong, Heilongjiang, Hebei, Liaoning, Henan, Inner Mongolia, Sichuan, Yunnan, Shanxi, Shaanxi, Guizhou, Beijing, Jiangsu and Gansu (these 15 province accounts for 91% of total corn output in 1999); For hog, we select Sichuan, Hunan, Henan, Hubei, Hebei, Shandong, Guangdong, Guangxi, Jiangsu, Jiangxi, Anhui, Yunnan, Heilongjiang, Beijing, Shanghai and

The price data used in this research are the farm-gate prices from the Rural Survey Team of the Ministry of Agriculture (MOA) of China. These data were collected by the sub-teams which are scattered in 200 counties of 30 provinces. We selected the monthly farm-gate prices from 1987 to 1998. In each province, we select one county's price, not the average of several counties, to represent the price of that province because the average data can miss some important information so that to distort the market (Zhou Z.Y. and Wan G.H. 1999). However, in the data set of Rural Survey Team, there are no farm-gate prices of hog, therefore, we use the data from the Information Centre of MOA, which are the monthly price data covering the period of 1994 to 1998.

3.1 Integration Test of Domestic Markets

All price series of the sample products passed the stationary test $I(1)$ by ADF method. The results are presented in Table 1. Therefore, we go head to do the integration test. Table 2-1, 2-2 and 2-3 are the results of long-run integration tests for wheat, corn and hog respectively. The short-run integration test results are in Table 3-1, 3-2 and 3-3.

The long- run integration results show that all 105 pairs⁵ of wheat and corn markets are integrated, but in 120 pairs of hog markets, 23 pairs are not integrated at 5% significance level, and 10 pairs are not integrated at 10% significance level.

These are several reasons, firstly, the prices of wheat and corn have been under the government control and guidance in a long time. Though the agricultural product prices have been gradually relaxed since 1992, the effects of quota/procurement prices of government on the prices of rural markets are still very strong. Secondly, production of wheat and corn are more concentrated than hog production. The concentrated production can easily make prices move together in certain degree. Thirdly, for the hog markets, which are not integrated, are mainly around Hunan, Henan, Hubei and Yunnan. Except for Henan province, the transportation in these provinces is poor.

Tianjin (the pork output and number of slaughtered hog of the 16 provinces respectively reach 83% of total in 1999).

⁵ 15 sample provinces of wheat and corn can be matched to 105 pairs of markets, likely, 16 sample provinces

Table 1: I (1) Results of Wheat, Corn and Hog Price Series

I (1) Results of Wheat Price Series

	Henan	Shandong	Hebei	Jiangsu	Anhui	Sichuan	Shaanxi	Shanxi	Gansu	Yunnan	Guizhou	Beijing	Ningxia	Tianjin	Zhejiang	1%	5%	10%
Constant only	-7.17	-6.09	-6.27	-6.78	-7.03	-6.61	-6.58	-6.80	-7.66	-7.35	-7.72	-7.42	-7.28	-6.53	-7.08	-3.48	-2.88	-2.66
Constant and Trend	-7.19	-6.08	-6.27	-6.78	-7.01	-6.62	-6.55	-6.78	-7.64	-7.35	-7.74	-9.50	-7.25	-6.52	-7.05	-4.03	-3.45	-3.14
Neither	-7.19	-6.11	-6.28	-6.80	-7.04	-6.63	-6.60	-6.83	-7.69	-7.38	-7.74	-9.58	-7.31	-6.56	-7.11	-2.59	-1.94	-1.62

Note: The lagged period is 2 for “constant only” condition, 5 for “Constant and trend” and 3 for “neither”.

I (1) Results of Corn Price Series

	Jilin	HLJ	Shandong	Hebei	Henan	Sichuan	IM	Liaoning	Yunnan	Shanxi	Shaanxi	Guizhou	Jiangsu	Gansu	Beijing	1%	5%	10%
Constant only	-4.81	-6.85	-6.13	-6.30	-6.49	-6.03	-7.02	-6.55	-5.46	-6.18	-5.53	-6.27	-5.56	-7.14	-4.48	-3.48	-2.88	-2.58
Constant and Trend	-4.80	-6.83	-6.10	-6.28	-6.49	-6.05	-7.00	-6.57	-5.43	-6.16	-5.50	-6.26	-5.57	-7.11	-4.47	-4.03	-3.45	-3.14
Neither	-4.83	-6.87	-6.15	-6.33	-6.51	-6.01	-7.06	-6.56	-5.47	-6.20	-5.56	-6.28	-5.59	-7.16	-4.52	-2.58	-1.94	-1.62

Note: the lagged periods are 4 for all conditions. HLJ refers to Heilongjiang, IM refers to Inner Mongolia.

I (1) Results of Hog Price Series

	Sichuan	Hunan	Henan	Hubei	Hebei	Shandong	Guangxi	Guangdong	Jiangsu	Jiangxi	Anhui	Yunnan	HLJ	Beijing	Shanghai	Tianjin	1%	5%	10%
Constant only	-4.48	-3.83	-3.20	-4.34	-4.27	-3.92	-4.28	-5.36	-3.53	-4.71	-3.69	-3.98	-3.50	-3.59	-4.31	-3.94	-3.59	-2.92	-2.60
Constant and Trend	-4.33	-4.06	-4.35	-4.31	-4.20	-3.87	-4.27	-5.34	-3.44	-4.61	-3.61	-3.93	-3.45	-3.56	-4.25	-3.91	-4.18	-3.51	-3.19
Neither	-4.51	-3.44	-2.99	-4.11	-4.12	-3.73	-4.15	-5.05	-3.15	-4.60	-3.35	-3.72	-3.28	-3.45	-4.09	-3.81	-2.62	-1.95	-1.62

Note: the lagged periods are 4 for all conditions. HLJ refers to Heilongjiang.

Table 2-1 : Results of ADF test for long-run integration of wheat markets

	Henan	Shandong	Hebei	Jiangsu	Anhui	Sichuan	Shaanxi	Shanxi	Gansu	Yunnan	Guizhou	Beijing	Ningxia	Tianjin	Zhejiang
Henan		-3.09	-3.49	-3.65	-3.23	-3.74	-3.47	-3.27	-3.26	-3.24	-3.39	-3.09	-2.97	-3.34	-3.20
Shandong			-3.80	-2.91	-3.20	-2.83	-3.49	-3.75	-3.24	-3.85	-2.93	-2.69	-3.21	-4.16	-3.30
Hebei				-3.10	-3.82	-3.42	-4.16	-4.29	-4.74	-4.14	-3.21	-4.35	-3.73	-3.96	-3.98
Jiangsu					-3.30	-2.84	-2.92	-3.13	-2.56	-2.95	-3.29	-2.63	-2.51	-3.10	-2.66
Anhui						-2.69	-3.56	-3.76	-2.84	-3.02	-2.91	-2.59	-2.68	-3.48	-2.68
Sichuan							-3.02	-3.94	-2.81	-2.99	-4.10	-3.18	-2.95	-3.02	-3.01
Shaanxi								-4.67	-4.80	-3.90	-3.36	-4.04	-4.10	-4.32	-3.42
Shanxi									-3.65	-3.93	-3.00	-3.29	-3.04	-4.12	-3.37
Gansu										-3.51	-3.06	-4.06	-4.25	-3.68	-3.50
Yunnan											-3.99	-3.74	-3.89	-4.88	-3.88
Guizhou												-3.19	-2.68	-3.30	-3.01
Beijing													-3.23	-2.71	-3.30
Ningxia														-2.89	-4.05
Tianjin															-3.70

1 These are the t-statistics for λ in $\Delta e_t = l e_{t-1} + \sum_{k=2}^n q_k \Delta e_{t-k} + m_t$, where $\Delta e_t = e_t - e_{t-1}$, $\Delta e_{t-k} = e_{t-k} - e_{t-k-1}$, e_t , e_{t-1} , e_{t-k} , e_{t-k-1} are respectively the residuals when t , $t-1$, $t-k$

and $t-k-1$. λ and θ_k are parameters to be estimated, μ_t is error term.

2 The lagged period is 4 in ADF test.

3 At the significance of 5% and 10%, the MacKinnon values are -1.94 and -1.62.

Table 2-2: Results of ADF test for long-run integration of Corn markets

	Jilin	HLJ	Shandong	Hebei	Henan	Sichuan	IM	Liaoning	Yunnan	Shanxi	Shaanxi	Guizhou	Jiangsu	Gansu	Beijing
Jilin		-3.69	-3.87	-3.77	-4.12	-4.24	-3.89	-4.02	-3.53	-3.45	-4.48	-4.28	-4.08	-4.15	-4.01
HLJ			-5.52	-5.25	-4.82	-4.68	-4.80	-4.54	-4.98	-4.73	-4.53	-4.60	-4.96	-4.79	-4.90
Shandong				-3.73	-3.74	-3.42	-3.06	-3.51	-2.92	-3.07	-2.90	-3.43	-3.25	-3.27	-3.71
Hebei					-3.32	-3.31	-2.81	-3.11	-3.99	-3.54	-2.68	-2.92	-3.33	-2.72	-3.09
Henan						-4.23	-3.28	-3.38	-3.29	-3.48	-3.89	-4.72	-3.34	-3.76	-3.49
Sichuan							-2.92	-2.78	-2.81	-2.96	-2.75	-3.80	-2.86	-2.45	-2.89
IM								-4.04	-5.20	-4.00	-3.84	-3.86	-4.19	-3.98	-4.33
Liaoning									-3.72	-3.85	-4.12	-3.93	-4.24	-4.10	-3.67
Yunnan										-3.07	-3.26	-3.26	-4.07	-3.19	-2.73
Shanxi											-3.57	-3.64	-4.07	-3.78	-4.10
Shaanxi												-2.59	-2.76	-2.92	-2.86
Guizhou													-2.95	-2.96	-3.27
Jiangsu														-2.67	-2.80
Gansu															-3.51
Beijing															

Note: as table 2-1. HLJ refers to Heilongjiang, IM refers to Inner Mongolia.

Table 2-3: Results of ADF test for long-run integration of Hog markets

	Sichuan	Hunan	Henan	Hubei	Hebei	Shandong	Guangxi	Guangdong	Jiangsu	Jiangxi	Anhui	Yunnan	HLJ	Beijing	Shanghai	Tianjin
Sichuan		-4.04	-3.27	-3.02	-3.11	-3.10	-3.69	-3.00	-3.02	-2.96	-3.20	-2.90	-3.64	-2.95	-3.33	-3.18
Hunan			-1.78	-2.47	-1.51	-1.63	-2.71	-4.01	-1.67	-1.56	-1.64	-1.06	-2.10	-1.32	-0.92	-1.55
Henan				-1.88	-1.45	-1.80	-2.65	-2.09	-3.95	-2.38	-2.12	-1.15	-2.90	-1.49	-2.12	-2.46
Hubei					-1.77	-1.95	-3.96	-3.81	-2.35	-1.85	-1.83	-1.48	-3.14	-1.85	-2.37	-2.74
Hebei						-3.97	-3.41	-2.64	-3.05	-2.44	-2.37	-2.77	-4.21	-3.84	-4.00	-3.77
Shandong							-2.69	-2.19	-2.87	-3.36	-2.07	-2.19	-3.35	-2.62	-3.11	-4.00
Guangxi								-3.60	-3.12	-2.90	-3.03	-2.55	-3.59	-2.82	-2.61	-3.03
Guangdong									-2.31	-2.00	-2.65	-1.84	-2.69	-2.04	-2.05	-2.48
Jiangsu										-3.29	-1.83	-1.73	-2.52	-2.01	-2.40	-3.47
Jiangxi											-2.26	-2.31	-3.22	-2.03	-3.18	-3.75
Anhui												-1.97	-2.55	-1.96	-2.25	-2.44
Yunnan													-2.43	-2.23	-3.62	-2.20
HLJ														-2.83	-2.64	-3.72
Beijing															-4.37	-2.76
Shanghai																-2.99
Tianjin																

Notes: as table 2-1. HLJ refers to Heilongjiang.

Table 3-1: Results of F-test for short-run integration of wheat markets

	Henan	Shandong	Hebei	Jiangsu	Anhui	Sichuan	Shaanxi	Shanxi	Gansu	Yunnan	Guizhou	Beijing	Ningxia	Tianjin	Zhejiang
Henan		15.81	22.93	17.18	18.10	14.77	21.60	21.65	20.17	20.37	22.33	23.10	25.67	17.96	22.56
Shandong			22.95	17.65	12.88	13.84	19.18	22.62	18.40	25.48	37.87	26.46	36.57	7.79	27.10
Hebei				27.93	23.50	26.03	26.44	23.20	19.01	31.70	41.71	25.64	34.10	16.83	30.81
Jiangsu					9.28	10.88	13.86	27.74	18.87	21.18	23.42	22.24	30.07	13.92	23.71
Anhui						13.16	14.88	26.61	18.91	20.31	27.56	23.79	30.02	13.40	22.06
Sichuan							16.09	20.94	15.87	14.53	19.37	20.16	27.09	6.51	21.74
Shaanxi								20.77	12.98	13.83	21.43	17.54	18.54	12.50	15.86
Shanxi									10.14	18.42	24.07	19.71	16.43	12.46	16.06
Gansu										14.84	18.56	12.51	16.00	10.07	12.70
Yunnan											20.73	22.19	21.63	14.74	20.27
Guizhou												22.34	22.06	16.31	22.27
Beijing													26.28	19.54	24.65
Ningxia														15.17	12.14
Tianjin															23.25
Zhejiang															

Note: N=132 V1=11 V2=121 the critical value for F-test at the 5% significant level is 1.83.

Table3-2: Results of F-test for short-run integration of wheat markets

	Jilin	HLJ	Shandong	Hebei	Henan	Sichuan	IM	Liaoning	Yunnan	Shanxi	Shaanxi	Guizhou	Jiangsu	Gansu	Beijing
Jilin		20.88	21.45	21.87	22.16	22.38	16.77	17.41	20.75	22.69	25.16	22.52	23.69	22.76	19.45
HLJ			22.37	23.35	21.05	22.00	24.94	21.17	21.06	19.17	22.63	20.38	22.67	20.89	21.09
Shandong				18.14	15.24	20.30	15.66	10.80	14.07	23.77	13.78	9.12	20.54	16.83	20.66
Hebei					22.43	23.32	23.55	25.26	22.42	17.18	31.78	18.22	15.49	27.10	23.44
Henan						27.18	31.79	31.19	27.75	22.37	32.12	13.20	23.19	21.80	23.70
Sichuan							56.58	55.14	42.95	42.36	57.18	5.43	36.87	26.14	41.52
IM								13.40	26.05	19.67	22.00	21.80	23.19	25.06	22.57
Liaoning									24.84	23.47	25.38	25.39	27.98	27.54	26.84
Yunnan										18.44	32.90	26.77	22.10	28.38	16.77
Shanxi											25.41	18.63	17.45	22.85	13.20
Shaanxi												24.91	24.33	20.51	22.78
Guizhou													37.16	18.60	36.68
Jiangsu														22.35	23.97
Gansu															19.14
Beijing															

Note: N=132 V1=11 V2=121 the critical value for F-test at the 5% significant level is 1.83. HLJ refers to Heilongjiang, IM refers to Inner Mongolia.

Table 3-3: Results of F-test for short-run integration of hog markets

	Sichuan	Hunan	Henan	Hubei	Hebei	Shandong	Guangxi	Guangdong	Jiangsu	Jiangxi	Anhui	Yunnan	HLJ	Beijing	Shanghai	Tianjin
Sichuan		4.12	8.85	5.79	5.95	7.94	4.84	6.03	9.22	7.49	8.57	8.66	8.92	5.71	8.58	9.54
Hunan			12.08	9.50	13.17	16.25	7.26	17.27	9.51	14.40	7.88	12.53	7.81	11.88	8.64	12.73
Henan				3.47	4.21	6.86	9.05	8.80	1.68	4.95	6.16	4.37	2.77	4.48	6.67	2.40
Hubei					5.94	8.76	10.68	7.51	3.76	6.77	9.16	10.17	5.89	6.74	11.23	7.92
Hebei						4.88	10.89	10.07	3.77	4.20	10.25	6.35	4.13	4.09	7.11	3.87
Shandong							13.03	10.87	4.95	2.75	10.91	7.37	4.87	5.89	7.32	3.72
Guangxi								11.97	8.05	11.24	6.22	11.52	9.17	8.20	11.56	12.57
Guangdong									16.84	23.29	15.75	30.53	23.14	20.66	34.12	26.45
Jiangsu										10.50	8.37	6.67	6.44	8.60	8.65	5.78
Jiangxi											14.43	9.42	6.99	11.72	8.07	3.84
Anhui												8.16	7.00	7.27	10.09	9.81
Yunnan													4.85	5.61	5.91	4.15
HLJ														5.11	5.52	4.02
Beijing															4.03	2.49
Shanghai																1.89
Tianjin																

Note: N=132 V1=11 V2=38 the critical value for F-test at the 5% significant level is 2.00. HLJ refers to Heilongjiang.

In the hog market:

- Hunan is not integrated with other 10 markets, including Henan, Hebei, Shandong, Jiangsu, Jiangxi, Anhui, Yunnan, Beijing, Shanghai and Tianjin.
- Henan is not integrated with Hunan, Hubei, Hebei, Shandong, Yunnan and Beijing (6 markets).
- Hubei is not integrated with Henan, Hebei, Jiangxi, Anhui, Yunnan and Beijing (6 markets).
- Yunnan is not integrated with those of Hunan, Henan, Hebei, Guangdong and Jiangsu.

Hunan is the second largest hog and pork production province, but the hog are mainly produced by scattered and middle/small-scale farms. The scattered production and poor transportation in Hunan lead to the low degree of market integration with other 10 provinces. The cases of Hubei and Yunnan are just like Hunan. Henan province is the third biggest hog and pork production province, meanwhile it is also a big demander for meat. The production in Henan mainly meets its own demand so there is little trade with other provinces, which is the main reason that hog market of Henan is not integrated with other 6 provinces.

The short-run integration of wheat and corn markets is not found at all in any pairs markets. But two pairs of hog markets, Henan-Jiangsu and Tianjin-Shanghai, are found to be integrated in the short-run. The reasons mainly include following aspects. First is the poor transportation conditions, which are the main reason that lead to lower market integration. In China, it usually will take long time to transport commodities from one province to another because of the limitation of transportation capacity. This prevents the traders from responding immediately to the price changes of one market. Secondly, government intervention and policy are also important factors that lead to lower short-run market integration. For example, Governor Responsibility System of grain enhanced the local governments' interventions to grain production, and the protectionism to local trade usually sets the obstacles and prevents price changes. Thirdly, the short-run hog markets integration of Henan-Jiangsu and Tianjin-Shanghai mainly lies in the closely geographical location, good transportation and less government interventions to hog production and market. Especially in Shanghai, Tianjin and Jiangsu, there are very important ports so their transportation is much better than other provinces. Meanwhile there are big pork markets in Shanghai, which play very important roles in east China.

3.2 Granger-Causality Analysis on Domestic Markets

In price causality test of wheat, corn and hog, the lagged period is 5. The results are presented in Table 4-1, 4-2 and 4-3. They show that:

- Price information of wheat, corn and hog markets flows respectively from other provinces to their main production areas --- Henan, Jilin and Sichuan provinces, so these three provinces can be as the representative markets (reference markets) of the three products.
- The wheat prices in Shandong, Ningxia, Tianjin and Zhejiang lead other provinces. The corn price changes mainly start in Beijing and Gansu. The hog price changes across regions are irregular, but compared with other provinces, Hebei and Shandong can be seen as the start points of price changes.
- The causality test results also show that wheat price influences between two markets are mainly in two directions, indicating that most pairs of wheat markets are influenced by each other. However, in corn and hog markets the Granger causality of prices is in one direction. This is especially for hog markets, the price influence pattern is irregular compared with corn and wheat.

Table 4-1 Patterns of wheat price causality among local markets

	Henan	Shandong	Hebei	Jiangsu	Anhui	Sichuan	Shaanxi	Shanxi	Gansu	Yunnan	Guizhou	Beijing	Ningxia	Tianjin	Zhejiang
Henan		<=	<=	<=	<=	<=	<=	<=	<=	<=	<=	<=>	<=	<=	<=
Shandong			<=>	<=>	<=>	<=>	=>	=>	<=>	<=>	<=	<=>	<=>	<=>	<=>
Hebei				<=>	<=>	<=	<=>	<=>	<=>	<=>	<=	<=>	<=>	<=	<=>
Jiangsu					<=>	<=	<=	<=	<=>	<=	<=	<=	<=	<=	<=
Anhui						<=	<=>	<=	<=>	<=>	<=	<=	<=	<=	<=
Sichuan							<=	<=>	<=>	<=	<=>	<=	<=	<=	<=
Shaanxi								<=	<=>	<=	<=	<=	<=>	<=	<=>
Shanxi									<=>	<=>	<=	<=	<=>	<=	<=>
Gansu										<=	<=	<=>	<=>	<=	<=>
Yunnan											<=>	<=	<=	<=	<=
Guizhou												<=	<=	<=	<=>
Beijing													<=>	<=	<=>
Ningxia														<=	<=>
Tianjin															<=>
Zhejiang															

Note: "<=" refers to the direction from column provinces to row provinces, ">=" means from row provinces to column provinces, "<=>" means column and row provinces cause each other. This table is based on the Appendix table 1.

Table 4-2 Patterns of corn price causality among local markets

	Jilin	HLJ	Shandong	Hebei	Henan	Sichuan	IM	Liaoning	Yunnan	Shanxi	Shaanxi	Guizhou	Jiangsu	Gansu	Beijing
Jilin		<=	<=	<=	<=	<=	<=>	<=	<=	<=	<=>	<=	<=	<=	<=
HLJ			<=	<=	<=	<=	<=>	<=>	<=	<=	<=	<=	<=	<=	<=
Shandong				<=	<=	<=	<=	<=	<=	<=	<=	<=	<=	<=	<=>
Hebei					<=	<=	<=>	<=	<=	<=	<=	<=	<=	<=	<=
Henan						<=>	<=	<=	<=	<=	<=>	<=>	<=	<=>	<=>
Sichuan							<=	<=	<=	<=	<=>	<=>	<=>	<=>	<=>
IM								<=	<=	<=	<=	<=	<=	<=	<=>
Liaoning									<=	<=	<=	<=	<=	<=	<=>
Yunnan										<=>	<=>	<=	<=	<=	<=>
Shanxi											<=	<=	<=	<=	<=>
Shaanxi												<=	<=	<=	<=
Guizhou													<=	<=>	<=>
Jiangsu														<=	<=
Gansu															<=
Beijing															

Note: "<=" refers to the direction from column provinces to row provinces, ">=" means from row provinces to column provinces, "<=>" means column and row provinces cause each other. HLJ refers to Heilongjiang, IM refers to Inner Mongolia. This table is based on the Appendix table 2.

Table 4-3 Patterns of hog price causality among local markets

	Sichuan	Hunan	Henan	Hubei	Hebei	Shandong	Guangxi	Guangdong	Jiangsu	Jiangxi	Anhui	Yunnan	HLJ	Beijing	Shanghai	Tianjin
Sichuan		<=	<=	<=	<=	<=	<=	<=	<=	<=	<=	<=	<=	<=	<=	<=
Hunan			×	<=	×	<=>	<=	<=	×	×	×	×	<=>	×	<=>	×
Henan				×	×	×	=×	=×	<=	<=	=>	×	=>	×	=>	=>
Hubei					×	<=	<=>	<=	<=	×	×	×	=×	×	=×	=×
Hebei						<=>	=×	=×	=>	<=	<=>	<=>	=>	=>	=>	=>
Shandong							=>	=×	=>	=×	=>	=×	=>	=>	=>	=>
Guangxi								<=	<=	<=	<=	<=	<=	<=	<=	<=
Guangdong									=×	=×	=>	×	=×	=×	=×	=×
Jiangsu										<=>	×	×	<=>	=>	=>	×
Jiangxi											<=>	=>	=>	<=>	=>	=>
Anhui												<=	<=	<=	<=	<=
Yunnan													=>	<=	=>	<=>
HLJ														<=	<=	<=
Beijing															<=>	<=
Shanghai																<=>
Tianjin																

Note: "<=" refers to the direction from column provinces to row provinces, ">=" means from row provinces to column provinces, "<=>" means column and row provinces cause each other, "=×" refers to that pairs of markets in these two provinces are integrated in long run but not integrated in short sun. HLJ refers to Heilongjiang.

This table is based on the Appendix table 3.

3.3 Index of Market Connection (IMC) analysis on Domestic Markets

Based on the conclusions of above causality analysis, the following will take Henan, Jilin and Sichuan as representatives of wheat, corn and hog markets respectively to calculate IMC and measure the integration degree between reference markets and other markets.

When calculating IMC of wheat, corn and hog markets, this paper does not introduce the transportation, policy, inflation, time trend variables into the model, that is, in formula (7) there are not X. This is based on the following reasons. Firstly, it is very difficult to collect the detailed transportation data between regional markets and central markets, meanwhile, if cargo turnover, instead of transportation cost, is introduced into the model, the coefficients are not significant. Secondly, policy factor is one of the important factors that influence market integration. During the research, policies were ever divided into three stages: 1987-92 (before market reform), 1993-95 (market reform), 1996-97 (Governor Responsibility System) and 1998 (new agricultural policy) and were introduced into the model, but the coefficients are also not significant. Finally, The prices are deflated, therefore, the inflation factors are not introduced into the model. Because of the insignificance, time trend is also not included into the model. The specified model of this research is as following:

$$P_{it} = (1 + b_1)P_{it-1} + b_2(\bar{P}_t - \bar{P}_{t-1}) + (b_3 - b_1)\bar{P}_{t-1} + m_i \quad (9)$$

The results are presented in Table 5. Generally speaking, IMCs of corn market are higher, which shows that Jilin market (Jilin as reference market) is not connected and integrated closely with other provinces. Meanwhile, the big differences among IMC values of corn markets also show that corn markets are connected only among several provinces such as Jilin, Inner Mongolia and Heilongjiang. However, the IMC values of wheat markets and the differences among them are small, this shows that there are closer and broader connection between Henan and other wheat markets.

Table 5 Domestic IMCs of wheat, corn and hog markets

	IMCs of wheat markets (Henan as reference market)														
Region	Shandong	Beijing	Zhejiang	Shanxi	Guizhou	Gansu	Tianjin	Jiangsu	Sichuan	Shaanxi	Yunnan	Anhui	Ningxia	Hebei	
IMCs	1.56	2.89	3.09	3.39	3.50	4.06	4.59	4.68	5.17	5.49	5.80	5.94	7.23	9.14	
	IMCs of corn markets (Jilin as reference market)														
Region	IM	HLJ	Gansu	Shanxi	Liaoning	Beijing	Shandong	Henan	Jiangsu	Hebei	Shaanxi	Yunnan	Guizhou	Sichuan	
IMCs	1.19	1.71	5.40	5.61	6.74	7.47	9.22	9.23	9.43	11.15	13.84	14.38	20.06	22.98	
	IMCs of hog markets (Sichuan as reference market)														
Region	Guangxi	Shanghai	Beijing	Huna n	Tianjin	Anhui	HLJ	Guangdong	Hebei	Hubei	Jiangsu	Yunnan	Jiangxi	Hena n	Shandong
IMCs	1.60	1.63	2.22	2.42	3.70	3.76	4.19	7.24	7.48	7.90	9.17	9.85	10.26	11.38	14.45

Note: IM refers to Inner Mongolia, HLJ refers to Heilongjiang Province

- **IMC of wheat market:** The provinces, which have close relationship with Henan, include Shandong, Beijing, Zhejiang, Shanxi, the prices of Yunnan, Anhui, Ningxia, Hebei are not closely connected to wheat price of Henan. This is mainly because that Shandong, Beijing and Shanxi all are important consumption regions of wheat flour, the transportation between Henan and these provinces are not too bad. Henan is far from Yunnan and Ningxia, Anhui is close to Henan, but the transportation between Henan and these three provinces are not convenient, the trade of wheat and wheat flour is small. Zhejiang and Hebei are two provinces that should pay special attentions. Hebei and Henan are neighbours and both are main producers of wheat, their price connection of wheat is the smallest. The main reason is that the trade between them is very small, their wheat is mainly transported to Beijing, Tianjin and other regions. The values of IMC of Zhejiang are relative small, possibly because trade of wheat or flour between the two regions is large. This needs further research.
- **IMC of corn markets:** The corn prices of Inner Mongolia, Heilongjiang, Gansu and Shanxi are closely connected with the prices in Jilin, especially Inner Mongolia and Heilongjiang, their IMC values are respectively 1.19 and 1.71, which are much lower than those of other provinces. Such close price linkages between neighbour provinces coincide with the common sense. Heilongjiang and Jilin both are the largest corn producers. It was reported that in past several years they cooperated in corn production and trade, therefore, the price changes can be passed to each other so fast that price linkages are relative close. In contrast, Shanxi, Yunnan, Guizhou and Sichuan are far from Jilin so the price linkages are not close. The cases of Hebei are different. Hebei is not far from Jilin and the transportation between them is also convenient, but because these two provinces are both important corn production regions and corn trade between them is small so that the market connection is not close.
- **IMC of hog markets:** There exists close relationship between Sichuan and other markets, including Guangxi, Shanghai, Beijing and Hebei. Though trade of hog and pork is less among Sichuan, Guangxi and Hunan, as main hog production areas, the much attentions of these provinces on hog production and the short distances among them make price relationship among them rather close. As motioned above, Shanghai plays an important role in pork and hog trade in the east areas of China, it has close relationship with Sichuan. The hog prices in Beijing and Tianjin are connected to Sichuan markets by Shanghai. Henan and Shandong are main hog production regions in north China, but because the hog mainly meet their local demands, there have little hog trade between Henan/Shandong with other provinces, so the markets are not linked closely.

4 Integration of Domestic and World Major Agricultural Product Markets

In this section, we still use the 3-step methods to study the price linkages and market integration of major agricultural products between domestic and world markets. The sample includes rice, wheat, corn, soybean, peanut oil and hog. As for market types, we select wholesale market because it is more suitable than rural free market or retail market. China is so large and so the regional differences are. Therefore, we choose two wholesale markets for every sample products, which are located far from each other. Considering the difference of economic and market development, we select one from northern part of China, and the other from the south.

From the above Granger-Causality analysis, Henan and Jilin are respectively the centres of wheat and corn markets. Therefore, we will choose Zhengzhou Grain Wholesale Market in Henan province and Jilin Grain and Oil Wholesale Markets as the representatives of domestic wheat and corn wholesale markets. Henan and Jilin are also the main producers of wheat and corn in China. As for rice, soybean, peanut oil and hog, we select respectively Hunan Grain Wholesale Market, Heilongjiang Grain and Oil Wholesale Market, Shandong Grain Wholesale Market and Sichuan Hog Markets as representatives. As mentioned before, in order to reflect the regional differences we also select another wholesale market for every sample products to compare between them. The domestic samples are as follows.

Domestic Sample Markets

	South China	North China
Rice	Hunan Grain Wholesale Market	Heilongjiang Grain and Oil Wholesale Market
Wheat	Hubei Grain Wholesale Market	Zhengzhou Grain Wholesale Market
Corn	Hubei Grain Wholesale Market	Heilongjiang Grain and Oil Wholesale Market
Soybean	Fujian Grain Wholesale Market	Heilongjiang Grain and Oil Wholesale Market
Peanut Oil	Zhengzhou Grain Wholesale Market	Shandong Grain Wholesale Market
Hog	Shanghai Hog Market	Sichuan Hog Market

Note: In fact, Sichuan is located in West of China, Henan in central China. Because in China there are still not perfect hog wholesale markets we use the rural free markets instead.

In our 3-step research, we mainly use the price data. Domestic prices are mainly taken from the Ministry of Agriculture, the Ministry of Internal Trade, Chinese Grain and Oil Information Network and the field survey.

The world representative markets and price data are selected as follows. For wheat, corn, soybeans and hog, we will use the Chicago Commodity Exchange prices. For rice, Bangkok FOB prices will be applied. For peanut oil, the Rotterdam CIF price will be used. These data is collected from *Information of International Economy and Trade* and other related newspapers and yearbooks. All these are biweekly data from 1996 to 1999.

4.1 Integration between Domestic and World Markets

Table 6 is the results of price stationary test I(1) by ADF method, this results show that all price series passed the stationary test so we continue to do the integration analysis. The results of integration test are presented in Table 7 and 8, which show that all pairs of markets are integrated in long-run, but short-run integration is not found at all.

Table 6 Results of Price stationary test of China and world markets by products, I (1)

Prices	Intercept only	Intercept and Trend	None
<u>Wheat</u>			
Hubei Grain Wholesale Market	-4.58	-4.58	-4.46
Zhengzhou Grain Wholesale Market	-3.71	-3.68	-3.38
World market	-5.27	-5.28	-5.05
<u>Rice</u>			
Hubei Grain Wholesale Market	-5.08	-5.13	-5.10
Zhengzhou Grain Wholesale Market	-5.02	-5.10	-4.95
World market	-5.24	-5.21	-4.89
<u>Corn</u>			
Heilongjiang Grain and Oil Wholesale Market	-5.14	-5.18	-4.84
Hubei Grain Wholesale Market	-5.35	-4.35	-4.14
World market	-3.67	-3.66	-3.58
<u>Soybean</u>			
Heilongjiang Grain and Oil Wholesale Market	-4.26	-4.65	-4.28
Fujian Grain Wholesale Market	-5.64	-5.83	-5.49
World market	-5.33	-5.38	-5.21
<u>Peanut Oil</u>			
Zhengzhou Grain Wholesale Market	-5.15	-5.48	-5.18
Shandong Grain Wholesale Market	-4.25	-4.32	-4.27
World market	-8.01	-7.97	-8.04
<u>Hog</u>			
Shanghai Hog Market	-4.03	-4.01	-4.09
Sichuan Hog Market	-4.86	-5.03	-4.93
World market	-3.56	-3.59	-3.59
<u>Significant levels</u>		<u>Critical Values</u>	
1%	-3.5031	-4.0613	-2.5886
5%	-2.8932	-3.4591	-1.9437
10%	-2.5834	-3.1554	-1.6176

Note: This test is Dickey-Fuller t test, the null hypothesis is non-stationary, at the significances of 5% and 10%, the t-statistics are all bigger (in absolute value) than the reported critical values so the hypothesis are rejected, all prices series are stationary.

Table 7 Results of long-run integration between China and world markets (t test)

Commodities	Markets	t statistics
Wheat	Hubei Grain Wholesale Market -- World Market	-2.40*
	Zhengzhou Grain Wholesale Market -- World Market	-2.50*
Rice	Heilongjiang Grain and Oil Wholesale Market -- World Market	-2.89
	Hunan Grain Wholesale Market -- World Market	-3.62
Corn	Heilongjiang Grain and Oil Wholesale Market -- World Market	-2.25*
	Hubei Grain Wholesale Market -- World Market	-2.34*
Soybean	Heilongjiang Grain and Oil Wholesale Market -- World Market	-3.64
	Fujian Grain Wholesale Market -- World Market	-4.31
Peanut Oil	Shandong Grain Wholesale Market -- World Market	-2.18*
	Shandong Grain Wholesale Market -- World Market	-3.59
Hog	Shanghai Hog Rural Market -- World Market	-3.91
	Sichuan Hog Rural Market -- World Market	-3.61

1. The values in table are t test statistics based on the model $\Delta e_t = l e_{t-1} + \sum_{k=2}^n q_k \Delta e_{t-k} + m_t$.
2. During the test on coefficient λ , lagged period is 3.
3. The MacKinnon critical values are -2.59, -1.94 and -1.62 respectively at the significance levels of 1%, 5% and 10%.

Table 8 Results of short-run integration between China and world markets (F test)

Commodities	Markets	F statistics
Wheat	Hubei Grain Wholesale Market -- World Market	17
	Zhengzhou Grain Wholesale Market -- World Market	13
Rice	Heilongjiang Grain and Oil Wholesale Market -- World Market	29
	Hunan Grain Wholesale Market -- World Market	49
Corn	Heilongjiang Grain and Oil Wholesale Market -- World Market	18
	Hubei Grain Wholesale Market -- World Market	17
Soybean	Heilongjiang Grain and Oil Wholesale Market -- World Market	16
	Fujian Grain Wholesale Market -- World Market	17
Peanut Oil	Shandong Grain Wholesale Market -- World Market	250
	Shandong Grain Wholesale Market -- World Market	344
Hog	Shanghai Hog Rural Market -- World Market	32
	Sichuan Hog Rural Market -- World Market	30

Note: the critical value of hog market test is 2.22 and the critical value of other markets test is 2.78.

Long-run integration shows that there exist stable relationships between domestic and world markets for every sample product. This reflects that China's market and trade reform has made great progress. Especially after the mid of 1990s, China has improved greatly the grain trade system, the traditional "import only wheat and export only rice" pattern was changed. In terms of import, it was changed from only wheat to wheat, corn and rice etc. As for export, the corn export increases greatly. The trade was changed to consider the comparative advantages and economic efficiency. The relationship between domestic and world markets was gradually decided by economic rules.

However, the short-run integration results show that domestic and world prices can not respond "immediately" to each other. There are many reasons. The first is trade system. Because of the importance of grain to China, a country with huge population, considering the food security, the central government has controlled and monopolised the grain trade for a long time. In grain trade decisions there are many non-economic factors, which distorted the trade prices and lowered the market efficiency. Therefore, China and world markets cannot respond immediately to each other. The second reason is that we select wholesale markets as sample, but China's traded agricultural products have not been through the wholesale market totally and directly. The third reason is the market infrastructure and information systems. China's wholesale markets were established at the beginning of 1990s so market infrastructure and information systems are still not completed and cannot meet the demand of trader, which, of course, will influence the trade. Further more, the transportation is also an important reason.

4.2 Granger-Causality between Domestic and World Markets

The results of Granger-causality test shows that domestic corn prices on wholesale markets cause world prices, wheat prices on Zhengzhou Grain Wholesale Market in central China lead world prices, but wheat prices on Hunan Grain Wholesale Market in south China are caused by world market. As for rice, soybean peanut oil and hog, their domestic prices are all Granger caused by world prices. The results are presented in Table 9.

Table 9 Granger-Causality Test Results

Null Hypothesis	Observations	F value	Lags
Wheat			
Hubei Grain Wholesale Market $\neq$ World Market	94	1.739	2
*World Market $\neq$ Hubei Grain Wholesale Market	94	3.706	2
*Zhengzhou Grain Wholesale Market $\neq$ World Market	94	2.786	2
World Market $\neq$ Zhengzhou Grain Wholesale Market	94	0.145	2
Rice			
Hunan Grain Wholesale Market $\neq$ World Market	94	0.179	2
*World Market $\neq$ Hunan Grain Wholesale Market	94	7.119	2
Heilongjiang Grain and Oil Wholesale Market $\neq$ World Market	94	0.048	2
* World Market $\neq$ Heilongjiang Grain and Oil Wholesale Market	94	2.868	2
Corn			
*Heilongjiang Grain and Oil Wholesale Market $\neq$ World Market	93	2.712	3
World Market $\neq$ Heilongjiang Grain and Oil Wholesale Market	93	1.098	3
*Hubei Grain Wholesale Market $\neq$ World Market	93	3.067	3
World Market $\neq$ Hubei Grain Wholesale Market	93	0.215	3
Soybean			
Heilongjiang Grain and Oil Wholesale Market $\neq$ World Market	94	0.802	2
* World Market $\neq$ Heilongjiang Grain and Oil Wholesale Market	94	7.289	2
Fujian Grain Wholesale Market $\neq$ World Market	94	0.919	2
* World Market $\neq$ Fujian Grain Wholesale Market	94	5.324	2
Peanut oil			
Shandong Grain Wholesale Market $\neq$ World Market	95	0.057	1
* World Market $\neq$ Shandong Grain Wholesale Market	95	2.010	1
Zhengzhou Grain Wholesale Market $\neq$ World Market	95	2.863	1
*World Market $\neq$ Zhengzhou Grain Wholesale Market	95	4.258	1
Hog			
Sichuan Hog Rural Market $\neq$ World Market	58	1.255	2
* World Market $\neq$ Sichuan Hog Rural Market	58	4.151	2
Shanghai Hog Rural Market $\neq$ World Market	58	1.291	2
* World Market $\neq$ Shanghai Hog Rural Market	58	2.389	2

Note: " $\neq$ " means "does not Granger cause ". The hypothesis with * are rejected.

The reasons of above results include two aspects. On the one hand, China's huge grain trade and big yearly fluctuation catch many attentions of world traders, this makes world markets follow Chinese changes. Since the 1990s after the grain trade system reform, grain trade has presented great fluctuations each year. Corn trade is the most unstable one. In 1990 China exported 2.887 million tonnes of corn, in 1993 corn export reached 11.78 million tonnes, however, in 1995 and 1996, corn export dropped sharply to 113 and 159 thousand tonnes respectively. In 1998, it reached 4.69 million tonnes. Such big changes shocked the world markets. The whole grain trade also fluctuates greatly in the 1990s. In 1993, China's net grain export was 8.79 million tonnes, but it was changed to net import of 19 million tonnes in 1995. In 1997, China's net export of grain was 4.2 million tonnes.

However, the different conditions of Chinese grain trading partners make the market connection of wheat, corn and rice different. China exports corn to only several countries. In 1998 China exported 3.75 millions tonnes of corn, which was about 80 percent of its total corn export that year, to only two countries, Malaysia and Korea. Likewise, the imported wheat was also mainly from only several countries. In 1998, China imported 1.48 million tonnes of wheat from three countries, Canada (64.5 percent), the United States (21.4 percent) and Australia (13.6 percent). However, the case of rice is different. China exports rice to many countries. Still taking year 1998 as an example, China exported rice to about 47 countries, Philippines was the biggest buyer that year, but only accounting for 36.7 percent. Meanwhile the fluctuation of rice trade is very small compared with wheat and corn.

On the other hand, China's trade of soybean, peanut oil and hog is only a little portion of the world trade, so it does not affect the world markets. China basically keeps 2 million tonnes of soybean deficit annually in recent years. The good soybean harvests of the United States, Brazil and Argentina, the main soybean producers, in recent years pull down the world soybean prices. The cheaper imported soybean also pull down the domestic prices so that many Chinese farmers reduced soybean production. This makes China more and more rely on soybean import (Chang Xiuliang, 2000). China's peanut oil trade is very small, only several thousand tonnes or less. China's hog is mainly exported to Hong Kong and Macao. However, the quantity of hog exported is small, only several million heads were exported each year. Therefore, China's small amount of hog trade cannot influence the world markets.

4.3 The Connection between Domestic and World Markets (IMC)

As mentioned before, IMC is calculated based on the estimation of following model.⁶

$$P_{it} = (1 + b_1)P_{it-1} + b_2(\bar{P}_t - \bar{P}_{t-1}) + (b_3 - b_1)\bar{P}_{t-1} + b_4X + m_t$$

IMC equals to $(1 + b_1)/(b_3 - b_1)$, the calculation and results are in Table 10.

Table10 The Index of Market Connection between China and World

	P_{it}	$\bar{P}_t$	$1+b_1$	b_3-b_1	IMC
Wheat	Hubei	World	0.91605 (20.89)	0.05114 (1.87)	17.91
	*World	Zhengzhou	0.75389 (11.89)	0.13136 (3.25)	5.74
Rice	Heilongjiang	World	0.86203 (17.37)	0.12244 (2.87)	7.04
	Hunan	World	0.79968 (17.78)	0.16450 (3.52)	4.86
Corn	*World	Heilongjiang	0.80385 (13.69)	0.18848 (3.16)	4.26
	*World	Hubei	0.77138 (12.29)	0.18805 (3.48)	4.10
Soybean	Heilongjiang	World	0.86966 (21.04)	0.14356 (3.35)	6.06
	Fujian	World	0.81424 (15.21)	0.23965 (3.51)	3.40
Peanut Oil	Zhengzhou	World	0.89508 (19.93)	0.12006 (2.51)	7.46
	Shandong	World	0.92589 (22.06)	0.09824 (2.00)	9.42
Hog	Shanghai	World	0.91760 (19.31)	0.06495 (1.70)	14.13
	Sichuan	World	0.89601 (21.24)	0.06487 (2.46)	13.81

Note: Hubei refers to *Hubei Grain Wholesale Market*, so are the others. World means World Market

The row with * means price relationship from domestic to world markets.

The values in brackets are t statistics, at the 95% significance level, with 91degrees of freedom, t value is 1.66.

⁶ When estimating here, X only refers to time trend but in the estimation of Hubei and world markets, X was omitted but we introduce the intercept.

The results show that corn market connection is the largest, but the connection of hog and peanut oil market is small. The other products are in the middle. There are three IMC values that are much larger than others. It is obvious that two large IMC values of hog markets are mainly due to the data because we use rural free market prices instead of wholesale market prices. As for the large IMC value of wheat between Hubei and world markets, it is because only a little wheat is traded.

Considering the regional differences, corn markets, no matter in north or south, are all connected to the world market closely and have influence on the world market greatly. The influence coefficients (b_3-b_1) of north and south markets are all 0.188. Wheat market in central China (Zhengzhou, Henan Province) has close relationship with world markets, its influence coefficient is 0.131. Rice markets in south China are closely related to world market, its IMC is 4.86, but IMC between northern part and world market is obviously bigger. The reason is that wheat is the main grain crop in north China but rice is mainly produced in southern areas. As for soybean, peanut oil and hog, except for the soybean connection index between northern market and world market, they are all very small. Soybean IMC between northern area and world markets is also the smallest in all products so the connection is also the closest. The reason is that world market mainly affects the consumption areas of China because China's soybean supply cannot meet its demand for a long time. China's main soybean producers are in northeast area so they cannot be affected greatly like the south area.

In all, China's rice and soybean markets, especially in southern areas, should be paid special attentions since they are connected to world markets and the price causality is from world market to southern markets. In the long-run, government should focus on southern rice and soybean markets to supervise and adjust so as to keep the markets go smoothly. As for wheat, it seems not urgent as rice and soybean markets. Its markets are not connected as closely as rice and soybean in south. Meanwhile, it is Zhengzhou wheat market that affects world market. Though Hubei wholesale market is affected by world, the connection is not close so the influence from world market would not be large.

5 Conclusions and Policy Implications

Domestically, wheat and corn markets are respectively integrated in long-run, but short-run integration does not exist. This shows that wheat and corn markets are not active so the

efficiency is low. However, on hog markets, there are two pairs of markets which are integrated in short-run, but several pairs are not integrated in long-run. This means that governments should improve their plans of hog market development so as to make hog markets stable, meanwhile continue to make more and more active.

Generally speaking, China's domestic market connection is not close, the values of IMC lower than 2 are only 5, which are Henan-Shandong (wheat IMC, 1.56), Jilin-Inner Mongolia (corn IMC, 1.19), Jilin-Heilongjiang (corn IMC, 1.71), Sichuan-Guangxi (Hog IMC, 1.60) and Sichuan-Shanghai (hog IMC, 1.63). If it is seen as close connection when IMC lower than 2, the above finding means that China's agricultural marketisation still has a long way to go.

In terms of domestic and world market integration, there exists long-run integration of all sample markets, but no one pair of markets presents short-run integration. Therefore, China's markets cannot coordinate with the world markets, they cannot respond to each other effectively and efficiently.

However, in terms of the influences of world markets on China, southern markets should be the focus to be considered. In terms of product types, rice and soybean markets in southern areas should be put in the important position.

In all, the following suggestions are provided. (1) Under the background of stimulating aggregate demand, governments should also emphasise the construction of market infrastructure, information system, and construction of transportation. (2) From the point of stabilising markets, government should put efforts of market regulation on the start regions of price fluctuation. For wheat, they are Shandong, Ningxia, Tianjin and Zhejiang. For corn, Beijing and Gansu are the start province, Hebei and Shandong are the start regions of hog. Meanwhile, the rice and soybean markets in southern China should also be the focus. (3) Government should change trade strategy from “production decides trade” to “trade decides production”. Production should be based on trade, not the opposite. This can put China's comparative advantages into play. (4) The current trade system reform should be improved greatly, government should gradually break trade monopoly and implement the active trade policies to reduce trade tariffs to minimal level and to increase import quota. Of course, these should be based on the comparative advantages and structural adjustments. (5) Finally, governments should make the quality standards of agricultural products. How farmers can produce the high quality products if they even do not know the quality standards? This will influence Chinese domestic and international trade greatly so as to

prevent the market integration.

Reference

- [01] Barry K. Goodwin, Thomas J. Grennes and Christine McCurdy (1996), "Spatial Price Dynamics and Integration in Russian Food Markets", unpublished report.
- [02] Bob Baulch (1997), "Transfer Costs, Spatial Arbitrage, and Testing for Food Market Integration", *American Journal of Agricultural Economics* 79:477-487.
- [03] Chan Xiuliang (2000), "Analysis of Slow-down of China's Soybean Production", *China Rural Economy*, Vol.4, 2000.
- [04] Daniel Berkowitz etc (1996), "Transition in Russia: It's Happening", unpublished report.
- [05] Fatimah Mohd. Arshad (1990), "The Integration of Palm Oil Market in Peninsular Malaysia", *Indian Journal of Agricultural Economics* 45:21-30.
- [06] Frank Asche, Daniel V. Gordon and Rognvaldur Hannesson (1998), "Price Founded Test for Market Integration: Fish Markets in France", Paper presented at the annual meeting of the American Agricultural Economics Association, Salt Lake City, 1998.
- [07] Francesco Goletti and Suresh Babu (1994), "Market Liberalization and Integration of Maize Markets in Malawi", *Agricultural Economics* 11:311-324.
- [08] Gardner, B. and K. Brooks (1994), "Food Price and Market Integration in Russia:1992-1993", *American Journal of Agricultural Economics* 76:641-66.
- [09] Goodwin, B.K., J.G. Thomas and Christine McCurdy (1996), "Spatial Price Dynamics and Integration in Russian Food Markets", *JEL. F15, R10, C22*.
- [10] Goodwin, B.K. and T.C. Schroeder (1991) "Cointegration Tests and spatial Linkages in Regional Cattle Markets", *American Journal of Agricultural Economics* 73:452-64.
- [11] Hector O. Zapata and Jose M. Gil (1999), "Cointegration and Causality in International Agricultural Economics Research", *Agricultural Economics* 20:1-9.
- [12] Li Peng (1998), "Study on China's Rice Market Integration", master dissertation, China Agricultural University, 1998.
- [13] Monke, Eric, and Todd Petzel (1984), "Market Integration: An Application to International Trade in Cotton", *American Journal of Agricultural Economics* 66:481-87.
- [14] Paul J.H. (1986), "Testing Market Integration", *Food Research Institute Studies* 20(1).
- [15] Ravallion, Martin (1986), "Testing Market Integration", *AJ AE* 68:102-9.
- [16] S. B. Delpachitra and R. L. St Hill (1994), "The Law of One Price: a Test Based on Prices for Selected Inputs in New Zealand Agriculture", *Agricultural Economics* 10:297-305.
- [17] Silvapulle, P. and S. Jayasuriya (1994), "Test for Phikippines Rice Market Integration: A Multiple Cointegration Approach", *Journal of Agricultural Economics*, 45:369-380.
- [18] Tian Weiming (1998), "Price Linkages in the Chinese Grain Market", Paper presented at the 10th Annual Conference of the Chinese Economic Studies Association of Australia, the University of Sydney, Orange, Australia, July 1998.
- [19] Wan Guanghua (1997), "China's Rice Market Integration", *China Rural Economy*, Vol.8, 1997

- [20] Yu Wen and Jikun Huang (1998), "China's Grain Market Reform Based on Market Integration Analysis", *Economic Research*, 3: 50-57.
- [21] Zhou Z. Y., Wan G. H. and Chen L. B. (1997), "Integration of Rice Markets: the Case of Northern China", *Asian Journal of Agricultural Economics*, Vol. 2: 158-76.
- [22] Zhou Z.Y. and Wan G.H. (1999), "The Methods of Market Integration Study", *Economic Research*, 3: 50-57.

Appendix Table 1 Results of Granger-Causality test for wheat prices, F-statistics

	Henan	Shandong	Hebei	Jiangsu	Anhui	Sichuan	Shaanxi	Shanxi	Gansu	Yunnan	Guizhou	Beijing	Ningxia	Tianjin	Zhejiang
Henan		7.08	6.70	5.87	4.76	6.42	5.09	6.60	5.69	5.96	8.52	11.51	6.23	6.42	5.52
Shandong	1.03		5.58	2.66	2.52	5.41	2.05	2.05	3.02	5.67	3.38	5.85	3.53	6.32	4.31
Hebei	1.51	2.21		4.16	2.15	2.69	3.63	2.62	2.62	3.26	2.28	3.63	4.16	2.42	3.26
Jiangsu	0.51	3.30	3.87		5.25	5.79	3.76	10.53	6.07	5.79	5.12	6.07	5.79	8.04	4.36
Anhui	0.42	5.43	4.66	3.14		6.11	6.25	13.22	8.73	7.91	6.11	7.59	8.90	11.51	6.69
Sichuan	0.91	3.52	1.99	1.17	1.08		2.58	4.65	2.68	3.19	5.52	6.86	3.96	5.52	4.54
Shaanxi	0.42	4.70	6.03	1.90	3.31	1.49		14.35	13.95	8.32	7.51	13.37	13.37	13.18	9.62
Shanxi	1.88	3.22	4.67	1.94	1.23	4.22	1.46		8.57	10.66	10.66	9.75	12.68	10.31	9.42
Gansu	1.05	5.18	9.82	2.65	2.83	2.38	5.18	4.63		10.14	7.37	17.27	14.54	12.19	9.36
Yunnan	0.71	4.85	4.39	2.03	3.51	2.12	0.96	3.94	1.66		7.60	11.03	9.63	15.91	9.63
Guizhou	2.13	0.72	0.80	1.85	0.31	2.32	0.23	1.22	0.80	2.61		12.25	9.35	9.52	12.05
Beijing	3.69	2.45	3.06	0.78	0.71	1.69	1.67	0.61	2.30	1.30	1.06		4.86	5.91	5.61
Ningxia	0.60	3.06	4.58	0.42	1.42	1.14	3.06	4.96	3.62	0.78	0.96	2.01		9.35	8.16
Tianjin	0.66	3.76	1.67	0.42	0.85	1.00	0.70	0.51	1.25	1.20	1.41	1.78	1.72		3.51
Zhejiang	0.64	3.87	6.02	2.11	1.54	2.05	2.90	3.34	2.90	1.71	2.71	3.21	2.77	4.01	

Note: N=132, V1=6, V2=121, at the 5% significance level, critical value is 2.17.

Appendix Table 2 Results of Granger-Causality test for corn prices, F-statistics

	Jilin	HLJ	Shandong	Hebei	Henan	Sichuan	IM	Liaoning	Yunnan	Shanxi	Shaanxi	Guizhou	Jiangsu	Gansu	Beijing
Jilin		10.82	10.14	11.63	12.10	11.72	13.08	9.56	14.55	12.68	13.38	12.39	11.72	12.68	10.14
HLJ	1.48		33.79	36.88	29.55	32.06	37.64	34.36	39.77	27.11	29.55	28.99	31.13	28.44	34.94
Shandong	0.28	0.65		10.22	9.23	10.02	6.29	7.77	9.04	8.85	8.30	8.30	9.62	9.62	11.96
Hebei	0.91	1.19	0.91		5.16	7.76	4.03	5.97	10.95	3.68	5.76	4.21	7.06	5.97	6.61
Henan	1.69	0.38	1.05	0.32		27.04	8.53	8.78	8.91	7.20	8.91	14.12	8.03	9.58	8.66
Sichuan	0.95	0.57	0.65	0.50	3.24		4.53	4.32	3.05	3.33	4.42	4.42	5.17	3.43	5.06
IM	4.49	5.30	0.78	4.38	1.32	0.78		25.42	51.21	32.00	28.49	28.27	33.28	32.76	36.05
Liaoning	0.87	2.28	0.71	2.00	1.12	0.39	0.87		21.74	17.61	18.15	16.58	22.07	19.57	22.75
Yunnan	0.95	1.98	0.46	1.63	1.63	0.62	0.62	0.46		5.57	5.33	3.75	5.09	3.96	6.07
Shanxi	0.98	0.73	1.42	1.79	1.97	1.60	0.65	0.90	5.34		13.40	11.75	12.97	13.19	14.52
Shaanxi	2.57	0.69	1.99	1.28	2.57	2.83	1.13	1.51	2.23	1.36		15.54	14.52	12.65	13.00
Guizhou	1.50	0.24	1.32	0.56	3.45	5.41	0.48	0.48	1.96	1.77	0.64		4.33	1.15	3.89
Jiangsu	0.32	0.77	0.77	1.60	0.65	2.63	0.77	1.23	1.97	0.11	0.21	0.32		4.52	5.34
Gansu	1.91	0.24	0.99	0.20	2.92	4.27	1.10	1.44	1.06	1.59	1.25	3.60	0.34		18.31
Beijing	1.04	1.74	2.30	1.21	2.11	2.49	3.08	4.03	4.83	3.50	1.21	5.19	1.74	2.11	

Note: N=132, V1=6, V2=121, at the 5% significance level, critical value is 2.17.

Appendix Table 3 Results of Granger-Causality test for hog prices, F-statistics

	Sichuan	Hunan	Henan	Hubei	Hebei	Shandong	Guangxi	Guangdong	Jiangsu	Jiangxi	Anhui	Yunnan	HLJ	Beijing	Shanghai	Tianjin
Sichuan		4.66	6.17	6.61	5.94	5.97	5.69	11.15	7.60	5.94	7.32	5.28	6.72	5.03	4.97	7.28
Hunan	1.34		6.57	8.64	7.52	8.25	5.28	20.24	8.00	7.34	6.13	6.47	3.98	6.67	3.04	6.55
Henan	0.60	0.90		1.89	2.95	6.56	0.90	1.94	2.72	5.75	1.26	2.03	1.70	1.12	1.61	2.75
Hubei	0.41	1.43	1.02		2.30	3.00	2.72	2.61	3.10	2.44	4.29	2.42	2.14	1.14	1.44	1.85
Hebei	0.42	1.51	0.84	0.36		2.49	1.41	1.71	2.13	3.25	2.93	3.08	2.13	0.26	2.07	1.71
Shandong	0.86	3.18	1.37	0.24	0.72		1.05	0.89	2.12	2.20	1.44	1.60	1.07	0.57	0.77	1.48
Guangxi	2.30	2.01	0.78	6.81	1.57	2.39		22.10	7.64	6.24	6.49	4.92	5.57	4.22	4.55	5.66
Guangdong	0.32	1.78	0.41	0.68	0.66	0.75	1.33		1.61	1.20	1.42	1.13	1.47	0.69	1.93	0.83
Jiangsu	1.20	0.87	2.07	1.10	2.38	4.14	0.87	0.89		4.03	1.49	1.65	2.73	1.49	1.01	1.57
Jiangxi	0.89	2.74	1.43	0.43	1.35	2.20	1.28	0.78	2.47		2.43	1.77	1.03	2.92	0.60	0.41
Anhui	1.84	1.54	4.76	7.92	6.40	6.46	2.29	5.00	5.34	6.81		5.09	4.73	3.72	5.63	4.79
Yunnan	1.60	0.50	0.25	0.74	2.25	1.97	0.51	0.77	0.59	2.33	0.54		1.59	2.03	1.04	2.43
HLJ	0.44	0.59	3.93	1.78	6.44	5.97	0.44	0.81	5.39	5.62	1.92	3.18		3.42	3.10	5.30
Beijing	0.43	2.62	1.53	1.04	3.74	4.84	0.75	1.66	2.19	6.91	1.70	2.15	0.86		4.42	3.77
Shanghai	0.27	0.23	2.61	0.97	5.36	5.90	0.69	0.86	2.82	5.76	0.84	3.42	1.48	2.98		2.39
Tianjin	0.41	1.55	2.45	0.44	3.88	5.08	0.65	0.09	1.02	3.22	0.64	2.91	0.90	0.84	2.57	

Note: N=49, V1=6, V2=38, at the 5% significance level, critical value is 2.34.