

Food Price Differences and Market Integration in China^{*}

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By applying the co-integration approach, this paper tests the market integration for the main agricultural products in China. Both long-run market integration and short-run market integration for the main agricultural products are tested and analysed. The study also calculates the Index of Market Connection (IMC) to measure the degree of market integration of the main agricultural products. The study reveals that the major agricultural product markets in China are integrated in long-run, but the degree of short-run market integration is very low. Therefore, in agricultural product markets, the transmission of price information is very slow and price changes across regions are not responsive. Based on the research results, the study also discusses some policy implications to improve the degree of market integration of agricultural products in China.

1 Introduction

Since late 1979, China's market-oriented reform has drawn much attention both within China and abroad. What are the market conditions after about 20 years of reform? What is the connection among local food markets? Is the government's strategy of managing the economy through the market mechanism effective? This paper investigates and answers these questions by focusing on China's food market integration.

Most studies of agricultural product prices in China are mainly focused on vertical dynamic analysis with little attention on spatial market conditions (for example, the transmission of price fluctuations across the regional markets). However, the spatial market issues are very important in such a large country like China. At the end of 1993,

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the rise in major agricultural product prices in China originated from south-east coastal regions such as Guangzhou, then spread to central China and finally to the north of China. This kind of phenomenon might be understood more easily once it was over. However, if we know the rules of price fluctuation across China, the vast country-wide price fluctuation might be avoided. Furthermore, studies of price spreads across local markets can also help governments design price support policy in different local markets, and indirectly, to control agricultural products supply so as to ensure the balance of agricultural product supply across the country and to avoid too much instability in the rural economy.

There is a growing number of studies of China's agricultural market integration. Some researchers have studied the degree of integration in Chinese grain markets, for example Yu Wen (1997), Wan Guanghua (1997), Li Luping (1996), and Tian Weiming and Li Peng (1998). In addition, other researchers talked about the integration of agricultural product markets in China in different aspects as part of their study of agricultural produce markets, for example, Rozelle, Park, Jin Hehui and Huang Jikun (1998), Ke Bingsheng (1996), and Huang Jikun (1996).

These studies of China's agricultural product market integration show that the integration degree of China's rice market is not high. Ke Bingsheng found that the degree of corn market integration is not high either. For example, the corn price in north-east of China (the main producing region of corn) in July 1996 was 1200 yuan per tonne, but it was 1800 yuan per tonne in south-west region. The price difference was larger than the transport cost (150-200 yuan per tonne). It could be concluded that the price difference being larger than the transportation cost is caused by market separation (Ke Bingsheng, 1997).

This paper will extend the above studies in two aspects. First, studies so far are mainly focussed on single products, and they do not analyse the market integration of several products, especially on the comparison of different products. This study will compare the integration of different product markets. Second, all the studies above only test whether markets are integrated, but they did not measure the degree of integration. This paper will discuss these two issues.

Since wheat, corn and pork are respectively China's main grain crop, feed crop and animal husbandry products, this study will apply cointegration and the Index of Market Connection (IMC) methods to test market integration and measure the degree of integration of these selected products. The data used in cointegration and IMC methods are product prices. The price system of agricultural products in China is composed of the government procurement price, support price (negotiated price), market purchase price, wholesale price and consumption price. Those used in this study are monthly market purchase prices from 1987 to 1997 for wheat and corn products, and from June 1994 to June 1998 for pork.

Generally speaking, if the distance between markets is far, or for studies of long-run integration, the seasonal, monthly or two-week price data are appropriate. If the distance between markets is short, or for studies of short-run integration, the ten-day, weekly or even daily prices are appropriate, because the price information spreads fast between two markets near each other, and the price difference between markets can disappear quickly. For the study of integration between provincial markets, monthly prices are sufficient.

Although the price data of one province are collected from several rural markets in each province, this paper relies on the purchasing prices on one specific rural market in each province. If the average prices of several markets had been chosen, the characteristics of some markets may be smoothed. The results may then not reflect the real integration of provincial markets.

2 Theoretical background of market integration

2.1 Concept of market integration

Market integration can be understood from two aspects. First, it refers to vertical integration and horizontal integration. The former is in fact the industry integration which reflects the nature of agribusiness, while the latter mainly is spatial market integration. Second, the integration includes spatial market integration, temporal market integration, integration across price form and integration across product form.

Spatial market integration reflects the effects of price change in one market on another market. Theoretically, under the assumption of full competition, when two regions trade, the product price in the import region equals to the price in the export region plus transportation cost. Therefore, the price change in the export region will induce a price change in the import region in the same direction and of the same degree. If this is the case, the two markets are completely integrated.

Spatial market integration includes long-run market integration and short-run market integration. The former refers to such cases in which there exists a long-run and stable price relationship between two markets. Even if this long-run relationship “balance” is broken in the short run, eventually the balance will be renewed. Short-run integration shows that the price change in one market in some period will bring “in the next period” (i.e., immediately) the price change in another market. This reflects the sensitivity of the spread of product prices between markets.

Integration across marketing stages reflects the effects of price change in one marketing stage on the price change in next stage. If the prices in different marketing stages meet the condition of “next stage price = this stage price + market charge”, there exists integration between market stages. The integration between wholesale and retail markets is one example of integration across marketing stages. This paper will not cover this case.

Temporal market integration reflects the effect of present price change on future prices. When prices meet the condition of “future price = present price + storage cost”, it is called temporal market integration. Studies of temporal market integration are still in the theoretical research stage, so this paper will not cover this case.

Integration across product form reflects the effect of price change of one product on price change of other related product, which usually refers to the price relationship between a primary product and a processed product. If the condition that “processed product price = primary product price + processing cost” is met, the markets are integrated. The research on the integration of related product markets will be very

important. Its results can indicate whether the price relations between two products are reasonable and whether these related product markets can coordinate effectively. For example, the research on the integration of corn and hog markets will reflect much more than just the price comparison between them.

This paper will only analyse the spatial market integration, though the other three types are also very important.

2.2 Factors affecting market integration

Market integration reflects price linkages when there is trade between two markets, so studies of market integration usually use the prices of two markets to test and measure its extent. Transportation is an important factor affecting market integration. In addition, the spread of price information, seasonal factors, inflation and intervention of governments are also factors affecting market integration.

As for policy intervention of government, many studies claim that government intervention has led to regional market blockades, so as to reduce the degree of market integration and, sometimes, to cut the price linkage among markets completely. But another case should be noted. Government intervention can force the same price changes in regional markets, so that the degree of market integration seems higher. In fact this is not real “market integration” in an economic sense, and it can be described as “planned” market integration.

Seasonal factors and inflation will affect market integration, especially in the long-run. Furthermore, the characteristics of different products, the presence of monopoly power and the presence of self-sufficient production are also important factors affecting market integration.

3 The data samples

As mentioned, since wheat, corn and pork are respectively China’s main food crop, feed crop and livestock products, this study chooses these three major agricultural products to measure the regional price differences and the integration of markets. The study

focus is to find laws of price fluctuation among regions and to test and measure the integration of regional markets.

Wheat is consumed as grain food mainly in north and as an input into food processing over the whole country. Wheat production is concentrated in the following three areas: the Huang-huaihai winter wheat production areas (including Shandong, Henan, Jiangsu and Anhui provinces), the north winter wheat region (including Hebei, Shanxi and Shanxi provinces) and the areas of up-middle reaches of Yangzi River (including Sichuan and Hubei provinces). This study chooses the ten major wheat production provinces of Shandong, Henan, Jiangsu, Anhui, Hebei, Shanxi, Shanxi, Sichuan, Gansu and Yunnan. The wheat output of these ten provinces accounted for 82 percent of the national total in 1997. Considering wheat consumption, this study also selects Beijing, Tianjin, Ningxia, Zhejiang and Guizhou as comparison areas.

As the main feed crop, corn is consumed in every province. But corn production areas are located in a corn belt from north-east to south-west of China, including north spring corn regions, Huang-huaihai summer corn regions and south-west mountain corn areas. The corn output of north-east three provinces (Heilongjiang, Jilin and Liaoning), Shandong, Hebei, Henan and Inner Mongolia accounts for 65 percent of the total corn output in 1997 in China. This study selects the above seven provinces and Sichuan, Yunnan, Shanxi, Shaanxi and Guizhou as the major corn production areas (the corn output of the above provinces accounts for 83.5 percent of the national total). Meanwhile, Beijing, Jiangsu and Gansu are chosen as the non-major corn production provinces to compare and analyse market integration.

As Chinese traditional meat product, pork is consumed by most Chinese people all over the country. But hog production is concentrated in the central regions. The pork output and the number of slaughtered hogs in Sichuan, Hunan, Henan, Hubei, Hebei and Shandong account for 50 percent of the national total. This study will choose the above six provinces and Guangdong, Guangxi, Jiangsu, Jiangxi, Anhui, Yunnan, Heilongjiang, Beijing, Shanghai and Tianjin (the pork output and the number of slaughtered hogs of the above sixteen provinces accounted for 83 percent of the national total in 1997) to analyse the integration of China's hog markets.

This study mainly analyses the integration of purchase markets so the rural free market purchase prices are used. The prices of wheat and corn are monthly provincial data from the Research Centre for the Rural Economy, covering 1987 to 1997. Hog prices are monthly provincial data from the Information Centre of the Ministry of Agriculture of China, covering 1994 to 1998.

4 The integration of main agricultural product markets

This study first applies the cointegration approach to test whether markets of main agricultural products are integrated. It then calculates the Index of Market Connection (IMC) to measure the degree of market integration. The price series are deflated by an index of purchase prices of agricultural products. EVIEWS software is used to deal with the data and model.

4.1 Integration (cointegration) test

Long-run market integration

The long-run market integration is tested by using the Engle and Granger (1987) approach of a two-step residual based test.

The first step is the OLS regression of one price series, say P_{it} , on another price series, say P_{jt} , plus a constant and a time trend.

$$P_{it} = \varphi + \omega P_{jt} + \eta t + e_t$$

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 cointegrating regression are nonstationary by using modified ADF test.

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

$$\Delta e_t = e_t - e_{t-1}; \Delta e_{t-k} = e_{t-k} - e_{t-k-1};$$

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

The null hypothesis is $\lambda = 0$. This is a test of residual stationary rather than original time series. If the t statistical value is less than the reference value, the null hypothesis is rejected and two price series are integrated to order 1, so the two markets are integrated in the long-run.

The results are presented in Table 1-3. The tables show that long-run integration exists between every pair of provincial wheat markets. The same applies in corn markets. In provincial hog markets, integration, at the 95% significance level, is not observed in 20 percent of cases.

In summary, grain markets appear to be integrated but hog markets are less integrated.

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

No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Province	Shandong	Hebei	Jiangsu	Anhui	Sichuan	Shaanxi	Shanxi	Gansu	Yunnan	Guizhou	Beijing	Ningxia	Tianjin	Zhejiang
1	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
2	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
3	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
4	Jiangsu				-3.30	-2.84	-2.92	-3.13	-2.56	-2.95	-3.29	-2.63	-2.51	-3.10	-2.66
5	Anhui					-2.69	-3.56	-3.76	-2.84	-3.02	-2.91	-2.59	-2.68	-3.48	-2.68
6	Sichuan						-3.02	-3.94	-2.81	-2.99	-4.10	-3.18	-2.95	-3.02	-3.01
7	Shaanxi							-4.67	-4.80	-3.90	-3.36	-4.04	-4.10	-4.32	-3.42
8	Shanxi								-3.65	-3.93	-3.00	-3.29	-3.04	-4.12	-3.37
9	Gansu									-3.51	-3.06	-4.06	-4.25	-3.68	-3.50
10	Yunnan										-3.99	-3.74	-3.89	-4.88	-3.88
11	Guizhou											-3.19	-2.68	-3.30	-3.01
12	Beijing												-3.23	-2.71	-3.30
13	Ningxia													-2.89	-4.05
14	Tianjin														-3.70

Notes: 1. The figures in the table are the t statistical value of λ ;
2. The lagged period is 4 in ADF test;
3. The MacKinnon values at the 5% and 10% significance level are -1.94 and -1.62 respectively.

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

No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Province	Heilongjiang	Shandon	Hebei	Henan	Sichuan	Inner Mongolia	Liaoning	Yunnan	Shanxi	Shaanxi	Guizhou	Jiangsu	Gansu	Beijing
		g													
1	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
2	Heilongjiang		-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
3	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
4	Hebei				-3.32	-3.31	-2.81	-3.11	-3.99	-3.54	-2.68	-2.92	-3.33	-2.72	-3.09
5	Henan					-4.23	-3.28	-3.38	-3.29	-3.48	-3.89	-4.72	-3.34	-3.76	-3.49
6	Sichuan						-2.92	-2.78	-2.81	-2.96	-2.75	-3.80	-2.86	-2.45	-2.89
7	Inner Mongolia							-4.04	-5.20	-4.00	-3.84	-3.86	-4.19	-3.98	-4.33
8	Liaoning								-3.72	-3.85	-4.12	-3.93	-4.24	-4.10	-3.67
9	Yunnan									-3.07	-3.26	-3.26	-4.07	-3.19	-2.73
10	Shanxi										-3.57	-3.64	-4.07	-3.78	-4.10
11	Shaanxi											-2.59	-2.76	-2.92	-2.86
12	Guizhou												-2.95	-2.96	-3.27
13	Jiangsu													-2.67	-2.80
14	Gansu														-3.51

Notes: 1. The figures in the table are the t statistical value of λ ;
 2. The lagged period is 4 in ADF test;
 3. The MacKinnon values at the 5% and 10% significance level are -1.94 and -1.62 respectively.

Table 3 Results of ADF test for long-run integration of hog markets

No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Province	Hunan	Henan	Hubei	Hebei	Shandong	Guangxi	Guangdong	Jiangsu	Jiangxi	Anhui	Yunna n	Heilongjiang	Beijing	Shanghai	Tianjin
1	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
2	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
3	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
4	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
5	Hebei					-3.97	-3.41	-2.64	-3.05	-2.44	-2.37	-2.77	-4.21	-3.84	-4.00	-3.77
6	Shandong						-2.69	-2.19	-2.87	-3.36	-2.07	-2.19	-3.35	-2.62	-3.11	-4.00
7	Guangxi							-3.60	-3.12	-2.90	-3.03	-2.55	-3.59	-2.82	-2.61	-3.03
8	Guangdong								-2.31	-2.00	-2.65	-1.84	-2.69	-2.04	-2.05	-2.48
9	Jiangsu									-3.29	-1.83	-1.73	-2.52	-2.01	-2.40	-3.47
10	Jiangxi										-2.26	-2.31	-3.22	-2.03	-3.18	-3.75
11	Anhui											-1.97	-2.55	-1.96	-2.25	-2.44
12	Yunnan												-2.43	-2.23	-3.62	-2.20
13	Heilongjiang													-2.83	-2.64	-3.72
14	Beijing														-4.37	-2.76
15	Shanghai															-2.99

Notes: 1. The figures in the table are the t statistical value of λ ;
 2. The lagged period is 4 in ADF test;
 3. The MacKinnon values at the 5% and 10% significance level are -1.94 and -1.62 respectively.

There may be several reasons for these different results. First, 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 procurement prices of government on the prices of free markets are still very strong. Meanwhile when setting the regional procurement prices, government will consider the regional equilibrium, so this makes the integration degree higher. Second, production of wheat and corn is more concentrated than hog production. The concentrated production causes much attention by traders and consumers on production and marketing, and this makes the prices in other regional markets move with the prices of production areas to a greater degree. Third, the above analyses show that the change and spread of hog prices are more irregular, leading to a lower degree of integration. Furthermore, hog markets with low a low degree of integration are concentrated in Hunan, Henan, Hubei and Yunnan.¹

Hunan is China's second largest hog and pork production province. But because hogs are mainly produced by farmers and middle or small scale enterprises, there is a lack of large scale hog enterprises, so the scattered production and poor transportation in Hunan lead to the low degree of market integration between Hunan and other ten provinces.

Henan is the third largest hog and pork production province. It is also a very large demander of pork meat because of many processing industries, so the hog production in Henan mainly meets its own demand, and there is little trade with other provinces. This is the main reason that hog market of Henan is not integrated with other six provinces.

¹ For example:

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

In Hubei, another large production province of hog and pork products, hogs are also produced mainly by scattered small-scale farmers or enterprises though there have emerged some large-scale hog farms in recent years. But constrained by transport problems and geographical conditions, the integration degree is very low. The reason that there is a lack of integration between the hog markets of Yunnan and other provinces is also the poor transportation and the scattered small-scale production.

Short-run market integration

Short-run market integration means that a price change of one market will “immediately” be passed onto another market. Short-run market integration is tested on the following model (Bessler and Brandt, 1982), using the F-test.

$$\Delta P_{it} = \mu_{11}\Delta P_{it-1} + \dots + \mu_{1n}\Delta P_{it-n} + \mu_{21}\Delta P_{jt-1} + \dots + \mu_{2n}\Delta P_{jt-n} - \lambda(P_{it-1} - \alpha P_{jt-1} - \delta) + \varepsilon_{1t}$$

The null hypotheses are $\mu_{11}=\dots=\mu_{1n}=\mu_{21}=\dots=\mu_{2n}=0$ and $\lambda=1$. If the calculated F value is greater than the reference F value, then the null hypotheses are rejected. Therefore, we may conclude that there does not exist short-run integration between the two markets.

The results are reported in Table 4-6 and show that there does not exist short-run integration for wheat and corn markets. Apart from two pairs of markets “Henan-Jiangsu” and “Tianjin-Shanghai”, no hog markets are integrated in short-run. This probably has following several reasons.

The first reason is the frequency of the data used in the study. This research uses monthly prices, which probably could not reflect the price changes in a rather short time period, especially between two provinces which are close to each other. Usually the agricultural products are transported between two markets in one or two weeks. Unfortunately, high frequency purchase price data are not available in China.

The second reason is the transportation conditions, which might be the main reason for lower market integration. In China, it usually will take a 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 in other markets.

The third reason is the government intervention and policy factors. These are also important factors that lead to lower short-run market integration. For example, the Governors Responsibility System of grain production has enhanced local governments' interventions in grain production, and the protectionism in local trade usually sets obstacles and prevents price changes in one provincial market from spreading immediately onto other markets.

Fourth, the reason for the short-run integration of Henan-Jiangsu hog markets mainly lies in the close geographical location, good transportation conditions and lower level of government intervention in hog production and marketing. The reason for the short-run integration of Tianjin-Shanghai hog markets, apart from good transportation conditions and less government intervention, is mainly that Shanghai plays an important role in China's hog marketing and trade. Shanghai's pork wholesale market connects directly with the Sichuan hog wholesale market, and there is speedy and convenient transportation between Shanghai and Tianjin.

Table 4 Results of F-test for short-run integration of wheat markets

No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Province	Shandong	Hebei	Jiangsu	Anhui	Sichuan	Shaanxi	Shanxi	Gansu	Yunnan	Guizhou	Beijing	Ningxia	Tianjin	Zhejiang
1	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
2	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
3	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
4	Jiangsu				9.28	10.88	13.86	27.74	18.87	21.18	23.42	22.24	30.07	13.92	23.71
5	Anhui					13.16	14.88	26.61	18.91	20.31	27.56	23.79	30.02	13.40	22.06
6	Sichuan						16.09	20.94	15.87	14.53	19.37	20.16	27.09	6.51	21.74
7	Shaanxi							20.77	12.98	13.83	21.43	17.54	18.54	12.50	15.86
8	Shanxi								10.14	18.42	24.07	19.71	16.43	12.46	16.06
9	Gansu									14.84	18.56	12.51	16.00	10.07	12.70
10	Yunnan										20.73	22.19	21.63	14.74	20.27
11	Guizhou											22.34	22.06	16.31	22.27
12	Beijing												26.28	19.54	24.65
13	Ningxia													15.17	12.14
14	Tianjin														23.25

Note: The critical value for F-test with $N_1=11$ and $N_2=121$ at the 95% significance level is 1.83.

Table 5 Results of F-test for short-run integration of corn markets

No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Province	Heilongjiang	Shandon	Hebei	Henan	Sichuan	Inner Mongolia	Liaoning	Yunnan	Shanxi	Shaanxi	Guizhou	Jiangsu	Gansu	Beijing
		g													
1	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
2	Heilongjiang		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
3	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
4	Hebei				22.43	23.32	23.55	25.26	22.42	17.18	31.78	18.22	15.49	27.10	23.44
5	Henan					27.18	31.79	31.19	27.75	22.37	32.12	13.20	23.19	21.80	23.70
6	Sichuan						56.58	55.14	42.95	42.36	57.18	5.43	36.87	26.14	41.52
7	Inner Mongolia							13.40	26.05	19.67	22.00	21.80	23.19	25.06	22.57
8	Liaoning								24.84	23.47	25.38	25.39	27.98	27.54	26.84
9	Yunnan									18.44	32.90	26.77	22.10	28.38	16.77
10	Shanxi										25.41	18.63	17.45	22.85	13.20
11	Shaanxi											24.91	24.33	20.51	22.78
12	Guizhou												37.16	18.60	36.68
13	Jiangsu													22.35	23.97
14	Gansu														19.14

Note: The critical value for F-test with $N_1=11$ and $N_2=121$ at the 95% significance level is 1.83.

Table 6 Results of F-test for short-run integration of hog markets

No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Province	Hunan	Henan	Hubei	Hebei	Shandong	Guangxi	Guangdong	Jiangsu	Jiangxi	Anhui	Yunnan	Heilongjiang	Beijing	Shanghai	Tianjin
1	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
2	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
3	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
4	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
5	Hebei					4.88	10.89	10.07	3.77	4.20	10.25	6.35	4.13	4.09	7.11	3.87
6	Shandong						13.03	10.87	4.95	2.75	10.91	7.37	4.87	5.89	7.23	3.72
7	Guangxi							11.97	8.05	11.24	6.22	11.52	9.17	8.20	11.56	12.57
8	Guangdong								16.84	23.29	15.75	30.53	23.14	20.66	34.12	26.45
9	Jiangsu									10.50	8.37	6.67	6.44	8.60	8.65	5.78
10	Jiangxi										14.43	9.42	6.99	11.72	8.07	3.84
11	Anhui											8.16	7.00	7.27	10.09	9.81
12	Yunnan												4.85	5.61	5.91	4.15
13	Heilongjiang													5.11	5.52	4.02
14	Beijing														4.03	2.49
15	Shanghai															1.89

Note: The critical value for F-test with $N_1=11$ and $N_2=38$ at the 95% significance level is 2.00.

4.2 Index of market connection (IMC) analysis

Index of market connection (IMC) is used to measure price relationship between integrated markets. Timmer (1984) established the following formula to calculate the IMC.²

$$P_{it} = (1 + b_1) P_{it-1} + b_2 (\bar{P}_t - \bar{P}_{t-1}) + (b_3 - b_1) \bar{P}_{t-1} + b_4 X + \mu_{it}$$

$$IMC = (1 + b_1) / (b_3 - b_1)$$

According to the model, IMC equals to the coefficient of lagged price in local markets divided by coefficient of lagged price in reference market. From the model we can see that when markets are full integrated, $b_1 = -1$ and $IMC = 0$; when markets are completely isolated, $b_1 = b_3$ and $IMC = \infty$. IMC is generally greater than 0. When IMC is closer to 0, the degree of integration between markets is higher, vice versa.

We take Henan, Jilin and Sichuan as reference markets of wheat, corn and hogs respectively to calculate IMC and to measure the degree of integration between reference markets and provincial markets.

In the calculation of IMC, this study does not include the variables of transportation, policy, season and time trend. Therefore, there is no X in the model. The omission of those variables is based on the following reasons. First, it is difficult to get detailed and accurate data on transportation costs between regional markets and reference markets. Second, policy factors are important influence on market integration. During the study,

² This formula can be derived from the Ravallion model (1986):

$$(P_{it} - P_{it-1}) = (\alpha_i - 1)(P_{it} - \bar{P}_{t-1}) + \beta_{i0} (\bar{P}_t - \bar{P}_{t-1}) + (\alpha_i + \beta_{i0} + \beta_{i1} - 1) \bar{P}_{t-1} + \gamma_i X + \mu_{it}$$

Let:

$$\alpha_i - 1 = b_1; \beta_{i0} = b_2; \alpha_i + \beta_{i0} + \beta_{i1} - 1 = b_3; \gamma_i = b_4$$

Then we have:

$$P_{it} = (1 + b_1) P_{it-1} + b_2 (\bar{P}_t - \bar{P}_{t-1}) + (b_3 - b_1) \bar{P}_{t-1} + b_4 X + \mu_{it}$$

Therefore:

$$IMC = (1 + b_1) / (b_3 - b_1)$$

policy was divided into three stages: 1987-92 (before market reform), 1993-95 (market reform), 1996-97 (Governors Responsibility System). A dummy variable to reflect policy was introduced into the model, but the coefficients were not significant. Third, because the prices have been deflated, the inflation factors are not introduced into model. Seasonal factors and a time trend were not retained in the model because that their coefficients were not significant.

The calculated results of IMC of wheat, corn and hog markets are reported in Table 7. Comparing the three products, the results show that the IMCs in corn markets generally are higher than those in wheat and hog markets, which indicates that corn markets (Jilin as reference market) are less integrated compared with wheat and hog markets. To a certain extent, there exists integration in hog markets (Sichuan as the reference market) and wheat markets (Henan as the reference market).

Table 7 IMCs of wheat, corn and hog markets**IMCs in 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 in corn markets (Jilin as reference market)

Region	Inner Mongolia	Heilongjiang	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 in hog markets (Sichuan as reference market)

Region	Guangxi	Shanghai	Beijing	Hunan	Tianjin	Anhui	Heilongjiang	Guangdong	Hebei	Hubei	Jiangsu	Yunnan	Jiangxi	Henan	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

5 Conclusions and Policy Implications

Through this analysis of wheat, corn and hog market integration, this paper provides the following conclusions and policy implications.

Basic conclusions

First, in general, the regional price differences in wheat, corn and hog purchase markets are low. However, among the three agricultural products, the regional price differences of corn markets are the largest.

Second, the purchase markets of wheat and corn are integrated in long-run, but short-run integration does not exist. The hog purchase markets are integrated to a low degree in long-run, but the short-run integration degree is higher than that of wheat and corn markets.

Third, most scholars think that government intervention will decrease the degree of market integration (Wang Guanghua, 1997; Zhou Zhangyue, 1998). However, this study shows that this is not accurate. It is known that prices of wheat and corn have been under the control or guidance of government for a long time. Though since 1992 the agricultural product prices have become free step by step, governments' pricing behaviour still influence purchase prices in free markets greatly. The central government will consider the balance of regional prices when it sets the prices so as to make wheat and corn markets integrated in long-run. Therefore, government intervention should be treated differently. If government intervention makes one pair of market prices move together, integration degree between two markets will appear to be high.

Policy implications

The results of this study show that major agricultural product markets in China are integrated in the long-run, but the degree of short-run market integration is rather low. Therefore, in agricultural product markets, the transmission of price information is not

speedy, and price changes across regions are not responsive to each other. In order to make China's agricultural product markets more efficient, some suggestions are provided.

(1) Continuing to develop transportation infrastructure

Transportation is an important factor that affects market integration. Governments should enhance the construction of transportation and basic facilities of rural markets. Thus to develop transportation and market facilities will be of practical significance and far-reaching strategic significance. In recent years, China has greatly improved in building of railways, highways and waterways, such as "Jing-Jiu" railways (from Beijing to Jiulong) and regional highways. All of these are examples of the progress in China's transportation system.

(2) Improving market information systems

Governments should pay much attention to the building of price information system and the transparency of markets. Transparent markets can ensure traders to have complete and timely knowledge of quality, quantity and price information of commodities. The following several aspects could be enhanced. Under the leadership of MOA and SSB, the government should establish institutions to collect and publish statistics data about agricultural products. The monitoring and forecasting results of the Information Centre of MOA and relative units on agricultural products supply, demand and price should be passed timely and accurately to producers and traders through various channels. This can help farmers and traders understand the trends of production and market so as to make better decisions.

(3) Changing governments' behaviours towards markets

Government should let agricultural markets adjust through imports, exports and storage and avoid direct intervention. Government intervention in markets generally exists in almost every country, but the means are different. From the view of guaranteeing high

efficient market, the best way is through imports, exports and storage to adjust commodity supply so as to adjust indirectly market prices.

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