Price Conduction Mechanism of China's Wheat Industry Chain Based on VECM

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Abstract With the aid of the VECM (vector error correction model), this paper studied dynamic effect of wheat price and flour price conduction mechanism in the wheat industry chain. Study results indicate that in a long term, wheat price and flour price have equilibrium relationship. Through threshold co-integration test, it found that there is no threshold co-integration relationship between wheat price and flour price. This can be adjusted using the linear error correction mode . In a short term, the wheat price and flour price have Granger causality relationship. When the price deviates from equilibrium state, the flour price can be adjusted and regressed to equilibrium state, but the speed of wheat price regressing to equilibrium state is slow. Finally, the impulse response function analysis indicates that fluctuation of the wheat price can bring huge and sustained impact to wheat and flour market.

Key words Wheat industry chain, Wheat price, Flour price, Price conduction, Threshold co-integration, VECM

1 Introduction

Wheat is an essential grain crop of China. Its industry chain includes the whole process of upstream and downstream closely related to wheat production, including production, circulation and sales sections. The structure of its industry chain is shown as Fig. 1. Participant subjects mainly include wheat producers, purchasers, wheat flour processing enterprises, feed processing enterprises, industrial processing enterprises, and sellers. At present, about 70% wheat is used for grain ration (calculated according to the consolidated balance sheet of China National Grain and Oils Information Center). Flour is primary product of wheat processing and also raw material of subsequent flour products, so flour production is an essential stage in the wheat industry chain. In this study, we take flour price as downstream product price of the wheat industry chain.

Since January 2000, the price of wheat and flour fluctuated and the rising trend is significant. Fluctuation of wheat and flour price not only influences stable income of farmers, but also influences profits of flour processing enterprises, and concerns sound and stable development of China's wheat industry. More important, the industry chain price conduction mechanism is an essential indicator for evaluating market efficiency. When a certain impact is acted on the conduction process, the price will be adjusted accordingly. As a result, it will lead to redistribution of benefits and welfare of members in the whole product supply chain. Study on price conduction mechanism of wheat and flour price can provide certain reference for making proper policies for China's wheat industry and for flour processing enterprises making proper decisions.

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Domestic and foreign scholars have made extensive researches on vertical conduction of agricultural product price fluctuation. Agricultural products they researches mainly include livestock products[7, 8, 15], poultry and egg products[12], grain products[2, 17], dairy products[10], fishes[3], and vegetable[9, 13]. Research methods include error correction model (ECM)[6] and asymmetrical threshold error correction model (ATECM)[4, 16]. However, there are few researches about vertical conduction of price of China's wheat industry chain, and the existing researches are mainly integration of wheat and flour market[13] and conduction of domestic and foreign price.

In view of this situation, the objective of this study is to test whether there is nonlinear relationship between wheat price and flour price in a long term, analyze short-term dynamic conduction effect of China's wheat price and flour price through building the VECM and impulse response function, and to provide certain theoretical reference for wheat industry formulating industry policies and flour processing enterprises making proper decisions.

2 Data selection and relevant tests

2.1 Data selection Since this study focuses on the conduction between wheat price and flour price of the whole country, the wheat price (PWW) adopted the monthly average price of white wheat reported by each price reporting station, and the flour price (PFL) adopted the monthly average price of special flour grade 1 reported by each price reporting station. (In China, wheat flour can be divided into grade flour, high and low gluten flour, and special purpose flour.) The data were selected from the Grain and Oil Wholesale Market Price Collection System of China Grain Website and Sinograin Price Monitoring System. And the data were supplied by 61 price reporting stations in Anhui, Beijing, Fujian, Gansu, Guangdong, Hebei, Henan, Hubei, Jilin, Jiangsu, Shandong, Shanxi, Shaanxi, Tianjin, and Xinjiang. The cal-

culation method adopted simple arithmetic mean.

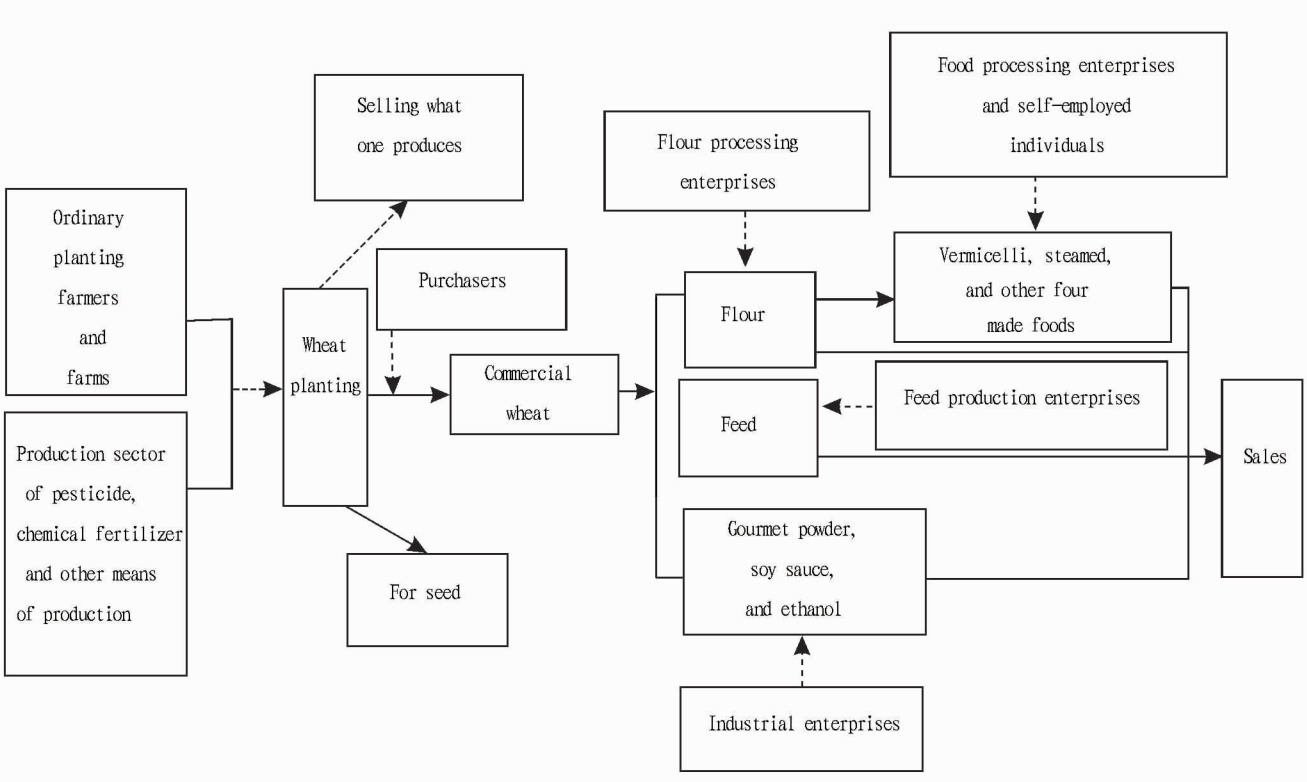

Fig. 1 Structure of wheat industry chain

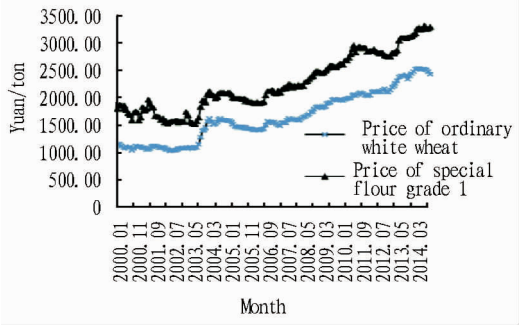

Fig. 2 Variation trend of wheat and flour price

Fig. 2 is the variation trend of wheat and flour price during January 2000 and June 2014. Fig. 2 shows that the variation trend of wheat and flour price is basically consistent, *i. e.* rising with fluctuation. From Table 1, we can see that the variation coefficient (standard deviation divided by average value) of wheat price and flour price is 0.27 and 0.23 respectively, and the fluctuation amplitude is basically same. The correlation coefficient of price series is 0.984, indicating highly positive correlation.

2.2 Data test To eliminate possible heteroscedastic variance in time series data, we first took natural logarithm for two price variables. lnPWW and lnPFL respectively denote natural logarithm of wheat price and flour price.

Table 1 Basic statistics of wheat price and flour price

Variables	PWW	PFL
Mean value	1644.6950	2257.1020
Median	1580.6700	2117.7850
Max.	2529.7700	3311.3300
Min.	1037.6500	1518.5500
Standard deviation	449.6117	517.5196
Skewness	0.3159	0.3959
Kurtosis	2.0307	1.9692
Normality test	9.7054	12.2496
Probability of statistics	0.0078	0.0022

2.2.1 Unit root test. If conducting econometric analysis directly for non-stationary time series, it is easy to have the problem of spurious regression. Therefore, it is required to take stationary test firstly. In this study, we adopted ADF test. According to Akaike's Information Criterion (AIC) and the Schwartz Criterion (SC), we determined the specific lag order and carried out stationary test of variables lnPWW and lnPFL (as listed in Table 2). Test results indicated that ADF test value of lnPWW and lnPFL at 5% significance level is higher than the critical value, so both price series are non-stationary; with first order difference, ADF test value is lower than the critical value, indicating both price series are I(1) series.

Table 2 Stationary test of variables

Variables		$\ln PWW_t$	$\ln PFL_t$	$\Delta\ln PWW_t$	$\Delta\ln PFL_t$
ADF test	Test value	-2.84611	-3.09665	-6.197684	-6.796681
	5% Critical value	-3.436475	-3.436009	-2.878413	-2.878413
	P value	0.1831	0.1104	0.0000	0.0000
	Test type	(c,t,3)	(c,t,0)	(c,0,2)	(c,0,2)
	Test result	Non - stationary	Non - stationary	Stationary	Stationary

Note: test type (c,t,p) denotes constant term, time trend, and lag order (optimum lag order is determined according to AIC); denotes first difference of price variable.

2.2.2 Co-integration test. If two or more non-stationary economic variables have stationary linear combination, co-integration relationship will exist in these variables. From Table 1, it can be known that both variables are first order single co-integration variable. Since only the single co-integration variable in the same order can be tested for co-integration, we carried out co-integration relationship test for wheat price and flour price.

In this study, we used Johansen Maximum Likelihood Ratio (LR) to conduct co-integration test for wheat price and flour price, so as to judge whether there is a long-term equilibrium relationship between them. Before the Johansen co-integration test, it is required to firstly determine optimum lag order of the VAR model. Multi-criteria determination method, *i. e.* LR testing statistics, final prediction error (FPE), AIC, SC and HQ information criteria, was used to judge the two price series, to determine the optimum lag order. From comparison, we finally determined that the optimum lag order of the VAR model is 4. Thus, the lag order of Johansen test is 3. According to data characteristics of two price variables, we adopted test type that variables have linear trend and co-integration equation only has intercept, we obtained test results as listed in Table 3. Table 3 indicates that when the original hypothesis has no co-integration relationship, in other words, both calculated values of trace test and maximum Eigenvalue test are higher than critical value at 5% significance level; in the original hypothesis of at most 1 co-integration vector, both calculated values of trace test and maximum Eigenvalue test are lower than critical value at 5% significance level. Thus, there exists co-integration relationship and only one co-integration between wheat price and flour price, indicating there is long-term equilibrium relationship between wheat price and flour price.

Table 3 Johansen co-integration of wheat price and flour price

Original hypothesis	Trace test			Maximum Eigenvalue test		
	Statistics of test	5% Critical value	P value	Statistics of test	5% Critical value	P value
Zero co-integration vector *	17.6504	15.4947	0.0233	16.53598	14.2646	0.0215
At most one co-integration vector	1.1144	3.8415	0.2911	1.1144	3.8415	0.2911

Note: * means it rejects original hypothesis at 5% significance level.

The expression formula of normalized co-integration equation is as follows:

$$ECM_t = \ln PFL_t - 0.8610\ \ln PWW_t - 1.3515 \quad (1)$$
$$(-0.0494)$$

where ECM_t is error correction, and the data within brackets is standard deviation.

2.2.3 Non-linear co-integration test Johansen co-integration test indicated that there is long-term stable equilibrium relationship between wheat price and flour price. If the linear error correction model is directly obtained, it may neglect discontinuation and asymmetry of system adjustment. Thus, we tested if there is threshold co-integration relationship between wheat price and flour price with the aid of Matlab program designed by Hansen & Seo(2002).

Since different lag period will influence statistical results, we selected lag period of 1, 2 and 3 to conduct the threshold co-integration test, and the results are as shown in Table 3. When the lag period is 1, the statistical value of Sup LM is 13.18, lower than the critical value at 5% significance level, the corresponding P value is 0.06, in other words, it rejects non-linear model hypothesis; when the lag period is 2, the ECM coefficient fails to pass Wald statistical test at 5% significance level; when the lag period is 3, the statistical value of Sup LM is 28.95, higher than 5% critical value of fixed regression, and the corresponding P value is 0.045, in other words, it accepts linear model hypothesis. Therefore, there is no threshold effect but linear adjustment relationship between wheat price and flour price, and it is able to analyze short-term dynamic adjustment with the aid of linear error correction model.

3 Model building and result analysis

3.1 The VECM and estimation results The Granger representation theorem states that if a set of non-stationary variables are co-integrated then they can be characterized as generated by an error correction mechanism. According to this theorem, co-integrated variables have long-term equilibrium relationship in a long term; in a short term, it may deviate from equilibrium, and their short-term non-equilibrium relationship can be expressed with the VECM (advantages of the VECM: use of first-order difference eliminates possible trend factor of variables, avoids spurious regression, and also eliminates possible multicollinearity; introduction of error correction item guarantees that information of variable level value not neglected). In this study, taking monthly data of

wheat price and flour price in January 2000 to June 2014 as samples, we built the VECM and analyzed short-term dynamic relationship between wheat price and flour price with the aid of Eviews 6.0 software. The VECM is as follows:

$$\Delta \ln PFL_t = \gamma_1 + \alpha_1 ECM_{t-1} + \mu_{11}\Delta \ln PFL_{t-1} + L + \mu_{1k}\Delta \ln PFL_{t-k} + \mu_{21}\Delta \ln PWW_{t-1} + L\mu_{2k}\Delta \ln PWW_{t-k} + e_{1t} \quad (1)$$

$$\Delta \ln PFL_t = \gamma_1 + \alpha_1 ECM_{t-1} + \mu_{11}\Delta \ln PFL_{t-1} + L + \mu_{1k}\Delta \ln PFL_{t-k} + \mu_{21}\Delta \ln PWW_{t-1} + L\mu_{2k}\Delta \ln PWW_{t-k} + e_{1t} \quad (2)$$

where γ, α, and μ are parameters to be estimated, k denotes number of lag period, and e_{it} refers to independently and identically distributed random error items with 0 mean value and constant variance. ECM_{t-1} is error correction item, *i. e.* non-equilibrium degree of $t-1$ period. The coefficient α reflects the response to deviation of price in $t-1$ period from the long-term equilibrium relationship. If the absolute value of this value is closer to 1, the speed of correcting deviation will be higher; if the absolute value of this value is closer to 0, the correction speed will be lower. The parameter μ reflects characteristics of short-term dynamic adjustment.

According to AIC and SC, the optimum lag order of the VECM is 2, we selected variables with linear trend and co-integration equation with only intercept item, and estimation results of the VECM are listed in Table 4.

Table 4 Estimation results of the VECM for wheat price and flour price

Equation	ΔlnPFL			Explanatory variables		
	Coefficient	Standard deviation	P value	Coefficient	Standard deviation	P value
ECM_{t-1}	−0.1449***	0.0448	0.0013	−0.0049	0.0300	0.8702
ΔlnPFL(−1)	−0.0325	0.0843	0.7001	0.1528***	0.0564	0.0071
ΔlnPFL(−2)	−0.1715**	0.0843	0.0427	−0.0495	0.0564	0.3806
ΔlnPWW(−1)	0.3382***	0.1306	0.0100	0.3154***	0.0874	0.0004
ΔlnPWW(−2)	−0.0749	0.1231	0.5434	−0.0582	0.0824	0.4802
Constant term C	0.0028	0.0022	0.1923	0.0030**	0.0015	0.0405

Note: *** and ** denote significance at 1% and 5% significance level respectively.

In the flour price short-term fluctuation (ΔlnPFL) equation, the error correction coefficient is negative and significant at 1% significance level, indicating that after deviating from the equilibrium state, the flour price can adjust the error correction item, to return to the equilibrium state at the adjustment speed of 14.49%. At the same time, the fluctuation of flour price at the present period is significantly influenced by wheat price fluctuation at the first lag period and flour price fluctuation at the second lag period. The influence of wheat price fluctuation at the first lag period is positive, while the influence of flour price at the second lag period is negative, and the influence of wheat price fluctuation is higher than the influence of flour price fluctuation.

In short-term fluctuation (ΔlnPWW) equation of wheat price, the error correction coefficient is negative (−0.0049) but fails to pass the significance test, indicating that the speed of returning to equilibrium state after deviating from the equilibrium state is slow. In addition, the wheat price fluctuation at the first lag period and the flour price fluctuation at the first lag period significantly influence the wheat price fluctuation at the present period, and the influence of wheat price fluctuation is higher than the influence of flour price fluctuation.

3.2 Granger causality test With introduction of VAR, the co-integrated vector can be expanded into VECM, thus the VECM belongs to VAR model. Granger causality test is based on VAR model, so it is able to test long-term and short-term Granger causality according to significance of α and μ. From Table 4, it can be known that the error correction coefficient α_1 ofΔlnPFL equation is significant at 1% significance level, while the error correction coefficient α_2 of ΔlnPWW equation is not significant. This reflects that the wheat price is Granger cause of change of the flour price, while the flour price is not Granger cause of change of the wheat price. Short-term Granger causality reflected statistical significance of μ in Table 5 indicates that the wheat price and flour price has mutual Granger causality in short term.

Since variables in the error correction mode are stationary time series variables, we tested the Granger causality between the wheat price and the flour price based on the VECM. The test results are listed in Table 5. From Table 5, we can see the wheat price and flour price has mutual Granger causality in short term. This is consistent with the statistical significance of μ reflected in the VECM.

Table 5 VEC based Granger causality test of the wheat price and the flour price

Original hypothesis	x^2 Statistics	Degree of freedom	P value
ΔlnPWW is not Granger cause for ΔlnPFL	6.7535	2	0.0342**
ΔlnPFL is not Granger cause for ΔlnPWW	9.5153	2	0.0086***

Note: ** and *** denote rejecting original hypothesis at 5% and 1% significance level respectively.

3.3 Analysis of the impulse response function The impulse response function (IRF) is used to analyze dynamic influence on system when the VAR model is under certain impact. Specifically, it describes influence of applying a standard deviation impact in

the random error of a certain endogenous variable on present value and future value of all endogenous variables[11]. Based on the VEC mode, we used the impulse response function to analyze dynamic response path of mutual impact between the wheat price and the flour price (setting the impact period as 10).

Fig. 3 and Fig. 4 is an impulse response function for a standard deviation impact of wheat price and flour price respectively. In Fig. 3, when the flour price exerts a standard deviation impact, the wheat price generate a positive response in the second period, later, the response degree declines and is close to 0; the flour price makes decreasing positive response for consecutive 10 period. In Fig. 4, when the wheat price exerts a standard deviation impact, the flour price exerts a positive response in the second period, later, the response degree is increasing; the wheat price makes positive response in the first period, the response degree ri-

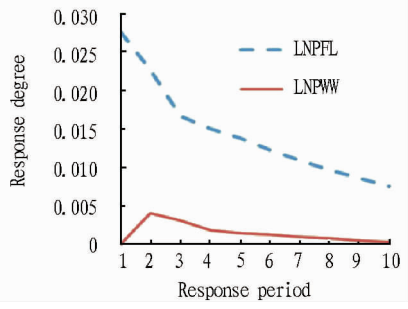

Fig. 3 Impulse response of a standard deviation impact to lnPFL

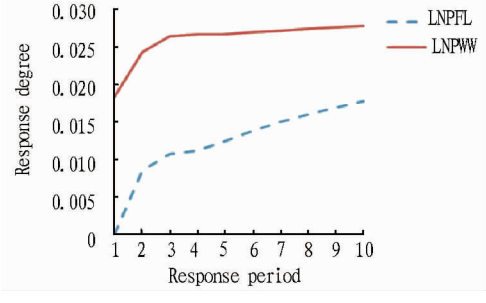

Fig. 4 Impulse response of a standard deviation impact to lnPWW

ses in the second and third period, and then keeps stable trend.

In sum, changes of the wheat price will bring great and sustained impact to wheat market and flour market. It means that the wheat market lacks rapid adjustment mechanism and the price impact may bring sustained effect.

4 Conclusions and policy recommendations

In order to study the conduction effect between downstream and upstream price of the wheat industry chain, we analyzed monthly data of wheat price and flour price in January 2000 to June 2014 with the aid of VECM, and studied the characteristics of the price conduction mechanism. In a long term, there is a linear equilibrium relationship between wheat price and flour price. In a short term, the wheat price and flour price have Granger causality relationship. When the price deviates from equilibrium state, the flour price can be adjusted and regressed to equilibrium state, but the speed of wheat price regressing to equilibrium state is slow. Finally, the pulse response function analysis indicates that fluctuation of the wheat price can bring huge and sustained impact to wheat and flour market.

Based on the above conclusions, full consideration should be given to price conduction characteristics of the wheat price industry chain when relevant departments making wheat industry policies and flour processing enterprises making decisions. Firstly, when making wheat industry policies, apart from guaranteeing farmers' benefits, relevant departments should consider development of downstream flour processing enterprises. China launched the price subsidy pilot projects for soybeans in northeast and Inner Mongolia and cotton in Xinjiang. The objective of this policy is to bring into full play decisive role of market in resource allocation in the precondition of safeguarding benefits of farmers, to promote coordinated development of upstream and downstream industries. Therefore, the reform direction of China's grain price formation mechanism is also the target price policy. Besides, at the same time of ensuring the wheat yield, government should also take proper measures to expand planting area of fine seed, to provide stable and high quality wheat for downstream processing enterprises. Secondly, when making production and operation decisions, flour processing enterprises should consider price conduction characteristics of wheat price and flour price, make forecast for the flour price based on the fluctuation of wheat price, so as to determine change of production scale. Thirdly, in line with problems of repetitive construction, low technological level and backward management of flour processing enterprises, China should optimize the merger and reorganization and adjust product structure promptly, to strengthen ability of responding to impact of fluctuation of wheat price.

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ment theory. The establishment of *Good Agricultural Practice for Tobacco* (*GAP*) is an effective way for the tobacco industry to strengthen management[9]. In early 2005, some tobacco-growing areas in Yunnan introduced the PMI global "GAP" management model, and promoted GAP in the flue-cured tobacco production, which was acclaimed by the international tobacco industry[10]. GAP involves the tobacco quality process control and requirements of environmental protection and safe production. On the one hand, it places demands on the resources, technology, management processes and product quality of tobacco production enterprises; on the other hand, it also provides code of conduct for the industry management. It can simplify operating procedures, reduce labor intensity, reduce production costs, optimize the allocation of tobacco production resources, and ensure ecological safety, so as to effectively solve the drawbacks of traditional production and achieve sustainable development in the tobacco-growing area.

3.5 Establishing the tobacco production security system

Tobacco production is greatly influenced by natural conditions, and a variety of disasters directly affect the income level of farmers. Especially for the major tobacco growers, the impact of disasters can be devastating. With the increase in the number of major tobacco growers, in order to make the tobacco-growing area in South Anhui embark on a road of sustainable development, it is necessary to establish the tobacco production security system. Government, business and farmers should jointly offer funds to implement joint disaster insurance for tobacco production or establish the tobacco production guarantee fund, with the purpose of reducing economic losses due to natural disasters, enhancing farmers' ability to withstand natural disasters, and effectively protecting the economic interests of farmers, thereby ensuring the sustainable development of tobacco production.

4 Conclusions

The sustainable development is a national strategy, and in terms of ecological protection, agricultural infrastructure construction and production technical services, the sustainable development of tobacco industry can be directly integrated into the overall national strategy for sustainable development. In the course of promoting sustainable development of the tobacco-growing area in South Anhui, there is a need to continue to stick to the tobacco brand building in accordance with the local conditions, and find a suitable development path for the tobacco-growing area.

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