Is China's domestic agricultural market influenced by price fluctuations of the world agricultural commodities in the short-run?

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Abstract: After entry into the WTO, China's domestic agricultural market is more and more closely integrated into the world market. Recently, a significant price fluctuation of agricultural commodities in the global market has increased concerns over its impact on the economic stability in those developing countries such as China, which has a large import and export of agricultural commodities every year. This paper attempts to study the short-term impact from price fluctuations of the world agricultural commodities upon the China's domestic agricultural market by investigating the dynamic correlation between the price change in the world and Chinese market in the copula framework. Our findings suggest a weak but strengthening short-run impact with an asymmetric nature. At the same time, diversified short-run impacts are observed in four main agricultural commodity markets. Empirical results show that the world price fluctuation has a volatile but decreasing influence on the China's rice market. This volatility of price impact is also observed in the wheat market but it has an escalating trend. The corn market experiences an intensified price shock with a distinct stage characteristic and the soybean market is under the strongest influence from the international price fluctuation.

Key words: agriculture, copula, dynamic correlation, market integration, short-term impact

Since 2003, world prices of the major agricultural commodities, such as cereals, meat, oils and dairy products experienced a five years' rising. According to the Food and Agricultural Organization (FAO) of the United Nations, the FAO Food Price Index increased from 98 in 2003 to 200 in 2008. Especially between 2006 and 2008, the index was increased by 57.5% and the FAO Cereal Price Index was increased by 95.1% (FAO 2012). Surges of global agricultural commodity prices during this period are unprecedented since the World War II (Baffes and Haniotis 2010). After the upward trend reached to its peak in mid-2008, however, the agricultural commodity prices began to fall. By the end of 2008, the major agricultural commodity prices reached their early 2007 levels. After the great drop in 2008, the global prices of agricultural commodities experienced another two years' climbing and rebounded to their former high levels again at the end of 2010 before the continuous decreasing from the beginning of 2011 until now. The spiralling agricultural commodity prices with a sharp and frequent fluctuation have caused deep concerns all over the world because agricultural commodities play an extremely important role in the stability of economic development. Cereals such as rice and wheat are staple foods in many developing countries and soaring prices of food will increase poverty in these countries (Chen and Ravallion 2008; Dessus et al. 2008; Ivanic and Martin 2008). At the same time, some agricultural commodities, such as corn, are important feedstock for both stockbreeding and bio-fuel. Price fluctuation will impinge on the inflation rate in those countries that heavily depend on food import and consequently pose a threat on the economic stability (Azzam and Rettab 2012).

In the same period, the market of agricultural commodities in China also experienced an oscillatory price increasing. According to the Grain Network in China (GNC) (see www.cngrain.com), prices of rice, wheat and corn are increased by 52%, 46% and 87%, respectively, from the beginning of 2006 to the end of 2011. The soybean's price was almost doubled in early 2008 compared with the mid-2006, and it resumed a slow increase after a dive in the third season of 2008. In 2010, food contributed about 70% of the CPI's growth in China, which ignited many concerns on prices of food, especially agricultural commodities. Many factors can account for the price spike of agricultural commodities in China, including long-term factors such as the fast economic growth and the population increase, mid-term factors such as the ascending cost in agricultural production and the inflation expectation, as well as short-term factors such as the frequent natural disasters. After the entry into the WTO, China is more closely related to the international markets. Exports and imports of agricultural commodities increased dramatically in the last decade. It seems that the impact of the international price fluctuation cannot be ignored.

Do international agricultural commodity price fluctuations have a significant influence on the domestic market in China? If they do, what is the influence degree and are the impacts similar or diversified on different commodities? To answer the above questions, it is necessary to know the pattern of the co-movement between the global agricultural commodity price changes and the domestic price change in China. This paper aims to study the short-term impact of the price fluctuation in the world agricultural market on China's domestic agricultural market by investigating the dynamic correlation between the world and China cereal price index's monthly growth rate from January of 1999 to July of 2012. Another four main agricultural commodities (rice, corn, soybean and wheat) in the same period are also studied to give a comprehensive analysis of the short-term price impact.

LITERATURE REVIEW

The existing literature related to this paper is the research of market integration. According to the spatial equilibrium model, the price dispersion of an identical good in two locations should be lower than the arbitrage cost when there is no restriction on trade (Enke 1951; Samuelson 1952; Takyama and Judge 1971). And the price fluctuation of one commodity in one market will be quickly and smoothly transmitted to other spatially separated markets, if they are fully integrated. In this sense, the spatial market performance can be evaluated with the price co-movement and the spatial price behaviour in regional markets can be used to measure the overall market performance. Therefore, the analysis of market integration can help the government to judge whether some intervention policy is necessary and useful.

Because of the agriculture's extreme important role in both developed and developing economies, many scholars have made great contributions to the empirical testing of market integration for different agricultural commodities in different countries since 1960s. The methodology of empirical work kept on evolving from the early stage of using the bivariate price correlation to measure the degree of the spatial market integration (Lele 1967; Jones 1968; Thakur 1974; Stigler and Sherwin 1985) to more recent advanced techniques which can take account of the non-stationarity, common trend, heteroskedasticity and endogeneity of the price data. Ravallion (1986) proposed a radial model and applied the error correction mechanism to overcome the autocorrelation and seasonality problems and to allow for the short-run and long-run dynamics. Inspired by the influential work of Ravallion (1986), more researchers attempted to solve the non-stationarity problems within the cointegration framework. The related literature included Engle-Granger's two step cointegration method (Palaskas and Harriss-White 1993; Alexander and Wyeth 1994, 1995; Dercon 1995), Johansen's cointegration framework (Goodwin 1992; Asche et al. 1999; Gosh 2003) and the Threshold Autoregressive (TAR) cointegration method (Abdulai 2000; Goodwin and Piggott 2001; Meyer 2004). Due to the different methodology and the varied market status in different countries, conclusions from the existing literature are quite diversified. Generally speaking, the integration degree of the agricultural commodity market is relatively high in developed countries (Goodwin 1992; Asche et al. 1999; Goodwin and Piggott 2001) and relatively low in developing countries (Ravallion 1986; Alexander and Wyeth 1994; Gonzalez-Riviera and Helfand 2001).

Being a large developing and transition economy, China provides an excellent case for the market integration research. Research works indicate that the market liberalization policies do increase the inter-regional agricultural market integration in China and the agricultural market policy reforms in 1990s are relatively effective (Rozelle et al. 1997; Park et al. 2002; Huang et al. 2004; Awokuse 2007). After the China's entry to the WTO, Chinese economy benefited greatly from the increasing trend of globalization and trade liberalization. However, external shocks from the international market fluctuation have become a significant source of the domestic economic instability. Therefore, the research on integration between the international and domestic market should also focus on the impacts and risks from globalization besides the market structure and efficiency, which is the foundation for the appropriate evaluation of trade policy.

A thorough and comprehensive study of the dependence structure, especially dynamic changes of such dependence as time goes, between the international and domestic markets can facilitate our understanding of the impacts of the international market on domestic market. Among the existing literature on dependence structures between various markets, the correlation-based models are mostly applied to measure the dependence between markets. Since the traditional measurement of dependence, that is the mostly used Pearson correlation, has been proven to have both theoretical and empirical limitations (Embrechts et al. 2002), the copula techniques were introduced to model the dependence structure and they have become increasingly popular and very active for the econometric research recently. A copula function connects marginal distributions of variables together to form the joint distribution and correlations between the variables, which are therefore completely determined by the copula, which allows us to study the dynamic correlation by constructing the copula models of the time-varying parameters. Patton (2006) develops copula models using the time-varying normal and the Student's *t* copula functions and empirically studies the dynamic correlations between the Euro-US dollar and Japanese yen-US dollar exchange rates. Roboredo (2012) applies the models of Patton (2006) and studies the dynamic correlation between food and oil prices.

Summing up, the existing research literature pays little attention to the market integration between the global and China agricultural markets, especially the short-term impact of the international price fluctuation is not clear. This paper attempts an alternate empirical methodology within the framework of copula to shed some light on dynamic characteristics of the external price shock on the China domestic agricultural market

DATA AND METHODOLOGY

In this section, we provide the methodology of evaluating correlation, especially the dynamic correlation, between the growth rates of the world and China agricultural commodity prices. Generally speaking, the correlation between two random variables is completely determined by their joint distribution. If the joint distribution of variables can be estimated using the sample data, then it is straightforward to derive the correlation between them from the estimated joint distribution. Following this idea, we first describe the data used in this paper and then introduce the copula techniques that are used to estimate the joint distribution of variables, from which the correlation or the dynamic correlation can be derived.

Data

The sample data of our study contains the monthly the growth rates of the world and China cereals price indices and the prices of four major agricultural commodities, which are rice, corn, soybean and wheat. The monthly world real cereals price indices are obtained from the FAO and the monthly world agricultural commodity prices are obtained from the World Bank database. The monthly China cereals price indices are obtained from the GNC database, while the monthly China agricultural commodity

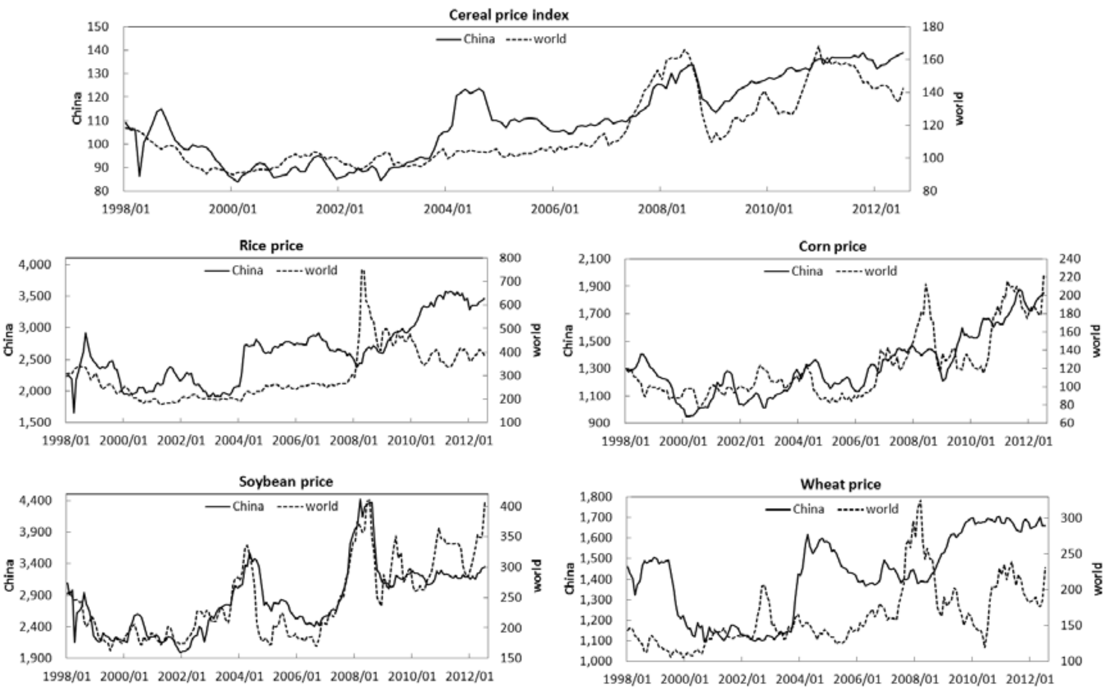

Figure 1. Sample paths of the China and world agricultural commodity prices

Table 1. Descriptive statistics of growth rates of China and world agricultural commodity prices

	China					World				
	index	rice	corn	soybean	wheat	index	rice	corn	soybean	wheat
Mean	0.046	0.036	0.030	0.032	0.018	0.051	0.051	0.070	0.055	0.063
Std. Dev.	0.093	0.138	0.125	0.200	0.122	0.218	0.331	0.247	0.253	0.281
Max	0.339	0.449	0.284	0.655	0.431	0.741	1.891	0.827	0.678	1.027
Min	–0.138	–0.199	–0.233	–0.302	–0.248	–0.304	–0.427	–0.392	–0.404	–0.451
Skewness	0.819	0.830	–0.144	0.911	1.054	0.965	3.159	0.939	0.515	0.880
Kurtosis	4.763	4.091	2.377	3.737	5.198	3.695	15.851	3.599	2.913	3.801
Q(10)	814.44*	537.46*	545.93*	549.61*	711.47*	478.15*	442.03*	410.73*	428.98*	403.44*
Jarque-Bera	20.18*	17.20*	5.20	17.77*	27.51*	18.87*	24.67*	17.86*	6.67*	17.33*
ADF	–4.350*	–4.759*	–3.941	–3.468*	–3.624*	–3.207*	–3.549*	–3.737*	–3.523	–3.699*

Q(10) is the Ljung-Box statistic for serial correlation with 10 lags. Jarque-Bera is the χ^2 statistic for the test of normality. ADF denotes the augmented Dickey-Fuller test of unit root. An asterisk (*) indicates the rejection of null hypothesis at 5% level

prices are obtained from the National Bureau of Statistics of China. The availability of data for the Chinese agricultural commodity prices determines the start of the sample period that is January 1998, and the end of sample period is July 2012. Figure 1 shows the sample paths of the China and world agricultural commodity prices. In order to remove seasonal effects on agricultural commodity prices, we adopt the year-on-year growth rates which are the percentage price changes expressed over the corresponding month of the previous year. For all growth rate series, the sample period is between January 1999 and July 2012. Table 1 provides descriptive statistics of each growth rate series. In practice, the transmission of price change between different markets takes some time to work, and the length of time lag depends on the spatial distance, trade policy and so on. For example, the soybean price rose sharply in October, 2003, but the price increase of soybean in China was not observed until November, 2003. Actually the short-term impacts within three month are all studied in this paper, but the results of two-month and three-month delay are ignorable. So in the remaining part of this paper, our study will focus on the results of the same month and one-month delay.

Average growth rates of all agricultural commodity prices are positive, indicating upward trends of the China and world agricultural commodity prices in general. Sample paths of the China and world agricultural commodity prices shown in Figure 1 also indicate this fact. Positive values of skewness, except for the growth rates of China corn prices, indicate a greater probability of larger increases in growth rates. High values of kurtosis for some growth rate series suggest the existence of fat tails in distributions of these series. The Ljung-Box tests show the presence of serial correlation, and the Jarque-Bera tests reject the null hypothesis of normality except for the growth rates of China corn prices. The augmented Dickey-Fuller tests reject the null hypothesis of unit root and therefore all growth rate series are stationary.

Copula theory

Let X_1 and X_2 be the growth rate of the world and China agricultural commodity prices, respectively. Denote the cumulative distribution function (cdf) of X_1 by $H(x_1)$, the cdf of X_2 by $G(x_2)$, and the joint distribution of X_1 and X_2 by $F(x_1, x_2)$, where all distribution functions are continuous. According to the theorem of Sklar (1959), there must exist a bivariate function $C(u,v)$ on $[0,1]\times[0,1]$ such that

$$f(x_1, x_2) = C(H(x_1), G(x_2)) \tag{1}$$

where the function C is called the copula function of X_1 and X_2. Differentiating both sides of (1) with respect to x_1 and x_2 gives

$$f(x_1, x_2) = h(x_1)g(x_2)c(H(x_1), G(x_2)) \tag{2}$$

where $f(x_1, x_2)$ is the joint density function of X_1 and X_2, $h(x_1)$ is the probability density function (pdf) of X_1, $g(x_1)$ is the probability density function (pdf) of X_2 and $c(u,v)=\dfrac{\partial^2 C(u,v)}{\partial u \partial v}$ is the copula density of X_1 and

Table 2. Moments and test statistics of residuals of AR models

	China					World				
	index	rice	corn	soybean	wheat	index	rice	corn	soybean	wheat
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Std. Dev.	0.012	0.037	0.029	0.053	0.025	0.061	0.104	0.090	0.082	0.099
Jarque-Bera	59.71*	62.02*	1.48	12.11*	11.68*	6.32*	61.85*	4.53	2.85	5.23
ARCH-LM(10)	3.63	4.83	9.75	11.46	37.05*	22.80*	16.60	14.52	18.59	9.80
Q(10)	2.79	2.93	3.63	3.09	0.64	5.02	1.41	3.16	2.31	3.93

Q(10) = Ljung-Box statistic for serial correlation with 10 lags; Jarque-Bera = χ^2 statistic for the test of normality; ARCH-LM(10) = Engel's LM test for conditional heteroskedasticity with 10 lags; asterisk (*) indicates the rejection of null hypothesis at 5% level

X_2[1]. Equation (1) indicates that a copula function connects marginal distributions of two variables together to construct the joint distribution, and therefore the correlation between these two variables is completely determined by the copula function.

There are several advantages of applying the copula techniques here. First, the estimation of correlation is separated into two steps, the estimation of marginal distributions followed by the estimation of the copula function that contains the information of correlation, which is much more convenient and simplified than the direct estimation of correlation or joint distribution. Second, the copula function can capture the nonlinearity existing in the correlation between variables, where the dynamic characteristic of correlation can be described by using the copula functions of time-varying parameters. Third, certain copula functions can be used to examine the tail dependency of two variables, a measure for co-movements of extreme changes, where the upper tail dependency is defined as $\tau^U = \lim_{\varepsilon \to 1_-} Pr(H(Y_1) > \varepsilon | G(Y_2) > \varepsilon$ and the lower tail dependency is defined as $\tau^L = \lim_{\varepsilon \to 0+} Pr(H(Y_1) > \varepsilon | G(Y_2) > \varepsilon$. Finally, the copula techniques allow us to separately select optimal models for marginal distributions and the copula function, which provides a great flexibility in the issues of model selection.

Patton (2006) provides a multi-stage maximum likelihood estimation (MLE) of the copula-based models. The procedure of evaluating correlations between the growth rates of the world and China agricultural commodity prices using the copula techniques, which can be described by the following three steps.

(1) Estimate the marginal distributions of growth rates using the MLE.
(2) Estimate the copula function using marginal distributions obtained in step 1 using the MLE.
(3) Derive correlation between variables according to the copula function obtained in step (2).

Marginal distributions

The Ljung-Box statistics in Table 1 suggest strong serial correlations for all growth rate series. We first estimate the growth rate series using the benchmark auto-regression (AR) models and then test the normality, serial correlation and conditional heteroskedasticity of the residuals of the AR models.

Table 2 lists the moments and the test the results of residuals. These diagnostic tests of residuals of the AR models provide evidences to select the appropriate models for marginal distributions of the growth rate series. We find that the AR models fit well for the growth rates of the China corn price, the world corn price, the world soybean price and the world wheat price. For the growth rates of the China wheat price and the world cereals price index, the ARCH-LM statistics imply the ARCH effects in the residuals and suggest to adopt the GARCH (1,1) model for the variances of error terms for these two growth rate series. Due to the high values of kurtosis and the rejections of normality in the residuals, we adopt the Student's t distribution to fit the error terms of the AR models for the growth rates of China cereals price index, the China rice price, the China soybean price and the world rice price. Table 3 gives the selected models for marginal distributions of each growth rate series, where the lagged order of the AR models is chosen according to the AIC.

[1]The copula theory can be applied to multivariate random variables. In this paper, we only focus on the bivariate case. See Nelsen (2006) for details of copulas.

Table 3. Estimations of marginal distribution models and goodness-of-fit tests

	China					World				
	index	rice	corn	soybean	wheat	index	rice	corn	soybean	wheat
Mean term	AR(3)	AR(2)	AR(3)	AR(2)	AR(2)	AR(1)	AR(2)	AR(3)	AR(2)	AR(2)
Error term	t	t	normal	t	GARCH (1,1)	GARCH (1,1)	t	normal	normal	nornal
ϕ_0	0.028	0.822	−0.007	−0.292	−0.041*	−0.073	0.014	0.007	0.072	0.023
ϕ_1	1.344*	1.062*	1.551*	1.144*	1.253*	0.970*	1.117*	1.073*	1.257*	1.196*
ϕ_2	−0.341*	−0.095*	−0.734*	−0.145*	−0.351*	–	−0.229*	0.018	−0.331*	−0.305*
ϕ_3	−0.013	–	0.127	–	–	–	–	−0.207*	–	–
σ^2	0.709	0.122	0.001*	0.011	–	–	23.734	0.010*	0.008*	0.012*
ν	2.005*	2.008*	–	2.252*	–	–	2.011*	–	–	–
ARCH	–	–	–	–	0.283*	0.123*	–	–	–	–
GARCH	–	–	–	–	0.700*	0.870*	–	–	–	–
Q(10)	0.392	0.913	0.974	0.959	0.781	0.696	0.648	0.657	0.900	0.937
K-S test	0.300	0.491	0.202	0.894	0.567	0.696	0.918	0.574	0.810	0.870

Asterisk (*) indicates that the parameter is significantly different from 0 at 5% level, except for the degree of freedom, for which the inverse of the parameter is significantly different from 0 at 5% level

Parameter estimations for the specified marginal distribution models are given in Table 3. Let $u_t = H(x_t | I_{t-1}, \hat{\Theta})$, where x_t (t = 1, 2, ...,T) are the sample of the growth rate series, H is the marginal distribution of the corresponding model specified in Table 3 for the growth rate series, I_{t-1} is the set containing the past information until time t – 1 and $\hat{\Theta}$ is the estimations of the distribution parameter vector θ given in Table 3. If the marginal distribution is appropriately selected, then u_t(1, 2, ..., T) should be independent and identically distributed (i.i.d.) as uniform (0,1), which can be tested as follows. The independence of u_t (1 = 1, 2, ..., T) is tested using the Ljung-Box test and the distribution of uniform (0,1) is tested using the Kolmogorov-Smirnov test. P-values of statistics for both tests are given in the last two rows of Table 3 and the results show that the null hypothesis of being i.i.d. uniform (0,1) cannot be rejected at 5% significance level, which indicates that the marginal distributions for the growth rate series are correctly specified.

Copula functions

We consider two copula functions, the normal copula and the Student's t copula, to capture the correlation and tail dependence between the growth rates of world and China agricultural commodity prices. The normal copula is associated with the bivariate normal distribution and the function and its density are given Equation (3),where Φ_ρ is the cdf of the bivariate standard normal random variables with correlation ρ and Φ^{-1} is the inverse cdf of a standard normal random variable. The parameter ρ of the normal copula function represents the constant correlation between two variables. The normal copula has zero tail dependence, that is $\tau^U = \tau^L = 0$.

The Student's t copula is associated with the bivariate Student's t distribution and the function and its density are given in Equation (4), where $T_{\rho,\nu}$ is the cdf of the bivariate Student's t random variables with correlation ρ and ν degrees of freedom, T_ν^{-1} is the inverse cdf of Student's t random variables with ν

$$C_N(u,v|\rho) = \Phi_\rho(\Phi^{-1}(u), \Phi^{-1}(v))$$

$$c_N(u,v|\rho) = \frac{1}{\sqrt{1-\rho^2}} \exp\left[-\frac{\rho^2(\Phi^{-1}(u)^2 + \Phi^{-1}(v)^2) - 2\rho\Phi^{-1}(u)\Phi^{-1}(v)}{2(1-\rho^2)}\right] \tag{3}$$

$$C_T(u,v|\rho,\nu) = T_{\rho,\nu}(T_\nu^{-1}(u), T_\nu^{-1}(v))$$

$$c_T(u,v|\rho,\nu) = \frac{\Gamma((\nu+2)/2)\Gamma(\nu/2)}{\Gamma((\nu+1)/2)^2\sqrt{1-\rho^2}}\left[\left(1+\frac{x^2}{\nu}\right)\left(1+\frac{y^2}{\nu}\right)\right]^{-(\nu+1)/2}\left[1+\frac{x^2+y^2-2\rho xy}{\nu(1-\rho^2)}\right]^{-(\nu+2)/2} \tag{4}$$

Table 4. Parameter estimations for the constant and time-varying normal copula functions

	Same month					One-month delay				
	index	rice	corn	soybean	wheat	index	rice	corn	soybean	wheat
ρ	0.068	–0.009	–0.047	0.171	–0.012	0.083	0.169	0.176	0.372	0.009
ω_N	0.041	–0.034	–0.048	0.001	0.016	–0.006	0.694	0.647	1.433	0.231
α_N	1.111	–0.905	0.999	2.214	1.134	2.174	–0.560	–1.552	–0.719	–2.170
β_N	0.121	–0.104	0.047	–0.102	0.377	–0.073	–1.056	0.797	–0.964	1.011

degree of freedom, $x = T_\nu^{-1}(u)$ and $y = T_\nu^{-1}(v)$. Similar to the normal copula, the parameter ρ of the Student's *t* copula function represents the constant correlation between two variables. Unlike the normal copula, the Student's *t* copula function allows for non-zero tail dependence with

$$\tau^U = \tau^L = 2T_{\nu+1}\left(-\sqrt{\nu+1}\sqrt{\frac{1-\rho}{1+\rho}}\right) \tag{5}$$

In order to study the dynamic correlation between two variables, we further assume that the parameter ρ of the normal or Student's *t* copula is time-varying and can be described similar to an ARMA(1,q) process as below (see Patton 2006 for details):

normal copula:

$$\rho_t = \Lambda\left(\omega_N + \alpha_N \rho_{t-1} + \beta_N \frac{1}{q}\sum_{j=1}^{q} \Phi^{-1}(u_{t-j})\Phi^{-1}(v_{t-j})\right) \tag{6}$$

Student's *t* copula:

$$\rho_t = \Lambda\left(\omega_T + \alpha_T \rho_{t-1} + \beta_T \frac{1}{q}\sum_{j=1}^{q} T_\nu^{-1}(u_{t-j})T_\nu^{-1}(v_{t-j})\right) \tag{7}$$

where $\Lambda(x) = (1 - e^{-x})/(1 + e^{-x})$ is the modified logistic function to make $\rho_t \in (1,1)$, ω_N, α_N, β_N and ω_T, α_T, β_T are the parameters that can be estimated by maximizing the following log-likelihood functions:[2]

normal copula:

$$l_N(\omega_N, \alpha_N, \beta_N) = \sum_{t=1}^{T} \ln c_N(u_t, v_t \mid \rho_t) \tag{8}$$

Student's *t* copula:

$$l_T(\omega_T, \alpha_T, \beta_T, \nu) = \sum_{t=1}^{T} \ln c_T(u_t, v_t \mid \rho_t, \nu) \tag{9}$$

The dynamic correlation is then represented as a series of ρ_t ($t = q + 1, \ldots, T$). According to Equation (5) and Equation (6), the dynamic tail dependence derived from the Student's *t* copula is

$$\tau_t^U = \tau_t^L = 2T_{\nu+1}\left(-\sqrt{\nu+1}\sqrt{\frac{1-\rho_t}{1+\rho_t}}\right)(t = q+1,\ldots,T) \tag{10}$$

MLE of parameters for the constant and time-varying normal copula functions, given in Equation (3) and Equation (8) respectively, are listed in Table 4.[3] The patterns of dynamic correlations for each pair of the growth rate series are plotted in Figure 2 through Figure 7, and Table 6 gives the descriptive statistics of the dynamic correlations. For the pair of growth rates of soybean prices, Table 5 shows the estimating results for the constant and time-varying Student's *t* copula functions and Figure 6 plots the dynamic tail dependence[4].

RESULTS AND DISCUSSION

Cereal price index

Figure 2 and Table 2 show that the constant correlation of the cereal price index's growth rates between the world and China in the same month is only 0.067, and the dynamic correlations fluctuate in the interval between 0.15 to –0.05 in most time with the

Table 5. Parameter estimations for the constant and time-varying Student's copula functions for soybean prices

	Constant		Time varying			
	ρ	ν	ω_T	α_T	β_T	ν
Same month	0.117	7.109	0.010	1.803*	0.042	7.766
One-month delay	0.388	10.10	1.481	–0.900	–0.677	12.225

[2]The value of q is determined using the AIC in the empirical study.

[3]Except for the case of soybean, we do not find any evidence of the joint fat tails, i.e. the estimations of parameter ν in the constant or time-varying Student's *t* copula functions are very large, which means that the Student's *t* copula functions are almost the same as the normal copula functions. Thus, we only list the results of the normal copula functions in Table 4.

[4]The constant and dynamic correlations derived from the Student's *t* copula are similar to those of the normal copula.

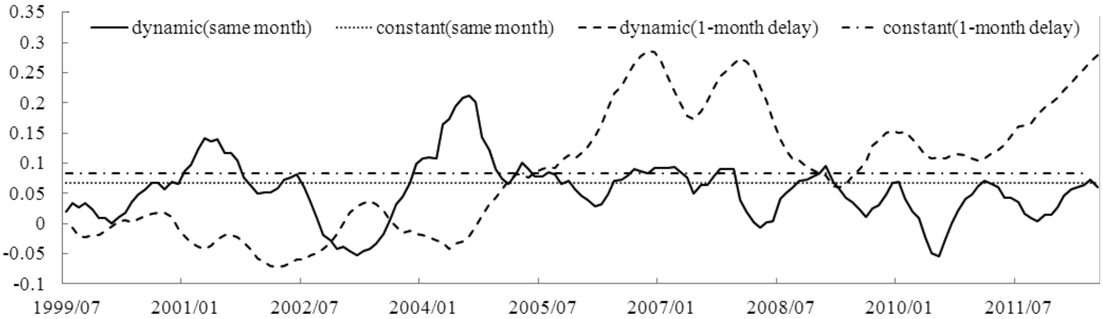

Figure 2. Correlations between the growth rates of the world and China cereals price indices

exception in mid-2004 when relatively higher correlations (around 0.2) appear. It is also observed that the fluctuation amplitude is decreased since 2005. Generally, there is no significant immediate impact from the world agricultural market as a whole, which is quite predictable because the agricultural futures market in China is quite immature and the instant price difference between the international and domestic market cannot quickly disappear by arbitrage.

At the same time, it can be seen that the constant correlation of the cereal price index between the world and China with one month delay is only 0.083, slightly higher than the immediate impact but still low. Compared with the case of the immediate impact, dynamic correlations tell a completely different story when considering one-month delay, as shown in Figure 2. Dynamic correlations are negative or close to zero in most months before 2005, which means that the price change in the world agricultural market had an insignificant impact on China. However, dynamic correlations increased and approached 0.3 with the accelerated rise of the world price between mid-2005 to early 2008. Then the dynamic correlations continue declining close to zero in the following one year period, accompanied by the growth rate of world price decreasing from 0.8 to –0.3 approximately. We observe a similar case again between 2010 and 2011. In summary, dynamic correlations and growth rates of the world price exhibit a quite similar fluctuation pattern between 2005 and 2010, which indicates an asymmetric effect from the international price fluctuation on the China's domestic market. That is, the price increase of world agricultural commodities may be relatively easily transmitted into China. One possible explanation for this asymmetric effect is the implementation of the minimum grain purchase price policy since 2004. Under this policy, a state-owned food enterprise will purchase rice and wheat at a predetermined price from farmers when the market price is lower to stabilize grain production. However, dynamic correlations keep increasing from 0 till 0.27 recently since 2011, while the growth rates of world price are both inclining and declining. This change can be viewed as a signal that a short-term impact from the price fluctuation in the world agricultural market may become more significant in the future.

In summary, a short-term impact from the international agricultural market's price fluctuation has the following characteristics: the general influence is weak and has a strengthening trend; the immediate impact was dominant before 2005 but the short run influence with one month delay became dominant since then and exhibits an asymmetric pattern.

Four main agricultural commodities (rice, wheat, corn and soybean)

The constant correlation of the rice market is extremely close to zero (–0.009) and the fluctuation of dynamic correlations is negligible in the same month,

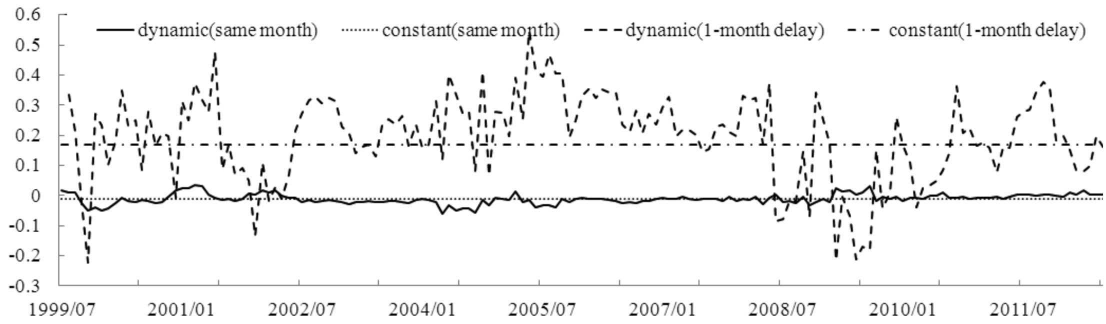

Figure 3. Correlations between the growth rates of the world and China rice prices

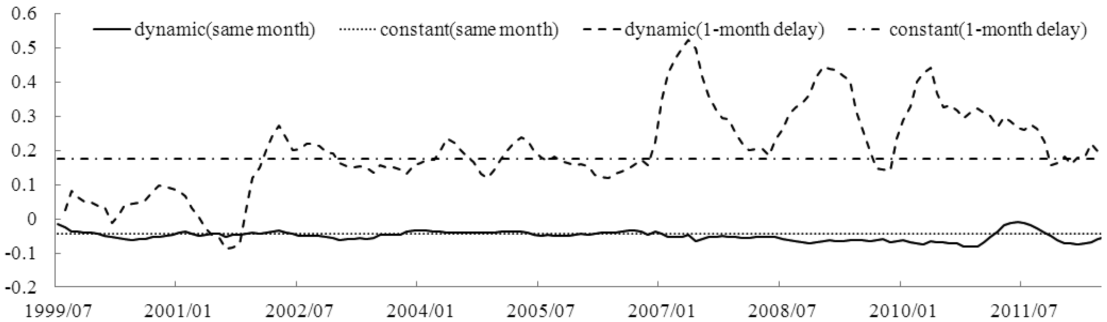

Figure 4. Correlations between the growth rates of the world and China corn prices

which clearly implies that there is no significant immediate impact from the international price change in rice market. After allowing one month delay, the constant correlation of price change between the world and China rice market is increased to near 0.2 and dynamic correlations basically fluctuated around 0.2 with varied amplitude in different time, as shown in Figure 3. It means that the price fluctuation in the world rice market has weak but unstable short-term influence on China after one month delay. Between early 2005 and late 2007, both the world and China rice market experienced a steady price increase and relatively higher correlations are observed in this period. Between the early-2008 and late 2010, dynamic correlations fluctuated around zero, while the international rice price experienced a drastic roller coaster in the same period, which implies that the international price volatility is mitigated.

The corn market has a similar technically ignorable immediate impact from the international price fluctuation as rice. A small increase of the constant correlation is also observed with one month delay. However, dynamic correlations of the corn market have obvious stage characteristics. The correlations fluctuate between 0 and 0.1 before 2002, and they increased to 0.2 from 2002 till 2007. Since 2007, dynamic correlations begin to fluctuate between an upper bound of 0.52 and a lower bound of 0.16. The increasing trend of both the dynamic correlation and its fluctuation amplitude means that the short-term impact may be strengthened in the future but this influence is quite volatile.

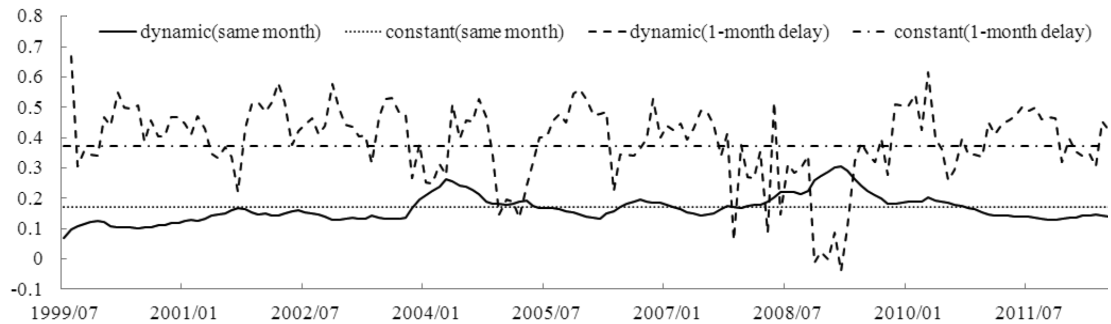

Figure 5. Correlations between the growth rates of the world and China soybean prices

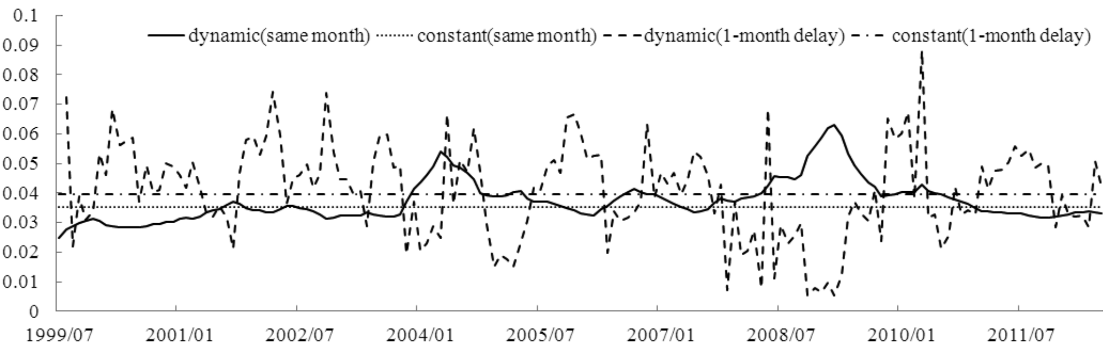

Figure 6. Tail dependence between the growth rates of the world and China soybean prices

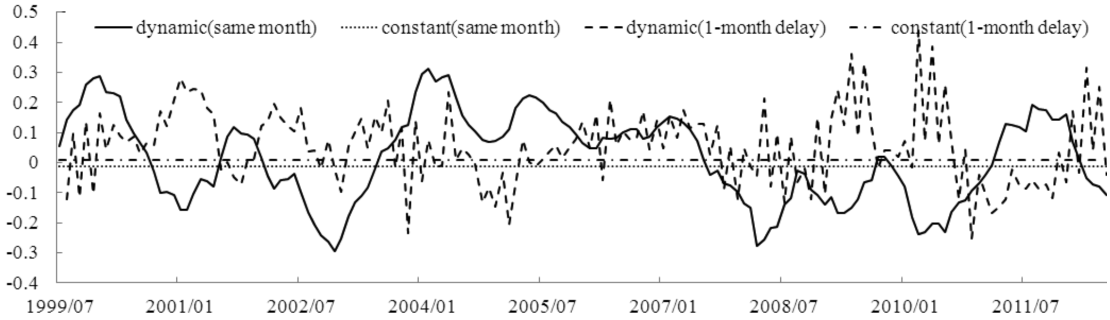

Figure 7. Correlations between the growth rates of the world and China wheat prices

In the same month, the constant correlation of the soybean price's growth rate between the world and domestic market is about 0.2 and dynamic correlations fluctuate around that value within a small neighbourhood. However, the constant correlation of one-month delay is almost doubled and the fluctuation of dynamic correlation is also amplified. Generally speaking, the price fluctuation in the world soybean market has a significant short-term influence on China and the price change can be smoothly transmitted into the domestic market. At the same time, the immediate and short-run (one month delay) impacts are both significant but the latter is stronger. One possible explanation is the existence of a highly mature and active soybean future market in China and a great demand for both import and export for soybean. It is noticed that there exists a significant tail dependence between the China and world soybean price changes for both immediate and short-run cases, that is, it is of a high probability that if the world soybean price experiences extreme changes, then the similar extreme price changes will occur in China in the same month or one month later.

In the wheat market, the constant correlation is quite close to zero in both the same month and one month delay, which means no significant impact in general. Meanwhile, dynamic correlations exhibit a high volatility with high amplitude in both cases. One-month-delay influence seems to be more dominant since the mid-2009 but it also has a high fluctuation frequency compared with an immediate impact.

CONCLUSIONS

In this paper, we studied the short-term dynamic impact of the price fluctuation in the global market on the China's agricultural commodity market. Generally speaking, the short-term impact of the price fluctuation in the world agricultural market is weak. However, it does show a clear strengthening trend. When China is more integrated into the world economy, the continuing liberation of the domestic agricultural market and the foreign trade will make the global price fluctuation more smoothly transmitted into China. In this sense, the imported inflation from the agricultural market does exist even in the short-term. Empirical findings also imply that the shock of the price change may be mainly passed through the international trade because of the dominance of the one-month delay impact in the short-term, which has an obvious characteristic of asymmetry.

As for the four main agricultural commodities, the short-term impact exhibits a quite diversified pattern. In the rice market, the immediate price shock is ignorable but the influence with one-month delay becomes more significant even though it is

Table 6. Descriptive statistics of dynamic correlations using normal copula functions

	Same month					One-month delay				
	index	rice	corn	soybean	wheat	index	rice	corn	soybean	wheat
Mean	0.056	−0.011	−0.050	0.166	0.016	0.086	0.193	0.202	0.389	0.053
Std. Dev.	0.050	0.017	0.014	0.043	0.146	0.102	0.145	0.123	0.125	0.122
Max	0.213	0.034	−0.009	0.306	0.311	0.286	0.546	0.524	0.668	0.439
Min	−0.054	−0.061	−0.082	0.070	−0.296	−0.071	−0.224	−0.088	−0.039	−0.251
Median	0.060	−0.011	−0.049	0.158	0.035	0.089	0.208	0.185	0.409	0.050

volatile. However, this impact has a weakening trend. The China's corn market has a similar situation in the immediate shock from the international price change, but the one-month delay impact has an obvious stage nature and an increasing tendency, which indicate a higher integration as well as a higher vulnerability in the domestic corn market. Soybean is under a significant impact from the world market in the same month and even a higher influence one month later, which is due to both the well-developed soybean future market and the large-volume import and export in China.

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