The Spillover Effect between Futures and Spot Price of Agricultural Products: A Case Study of Soybean Products of China

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Abstract Taking soybean products as an example and using the daily price data of 2007 - 2015, this paper established the error correction model and BEKK-GARCH model, and made an empirical study on the spillover effect of futures and spot price of agricultural products of China. According to this study, there were mean spillover effect and two-way volatility spillover effect in futures and spot price of soybean, soybean oil, and soybean meal; soybean futures prices significantly guided the spot price; in the price linkage between the types, the price relationship between the soybean meal and soybean was closer than between the soybean oil and soybean.

Key words Futures price, Spot price, Soybean products, Volatility spillover, Price linkage

1 Introduction

With the significant improvement in people's dietary structure, residents have higher and higher demands for oil and protein products. In this situation, soybean products receive increasing attention. In the domestic market, China imported 8.1164 million tons of soybeans in 2015, accounting for 60.4% of total imports of agricultural products, making the soybean become the agricultural product with the largest import. At the same time, soybean oil is the main edible oil and soybean meal is the main protein feed in domestic and even the global breeding market, so the demands for raw soybean continue to rise. In the international market, China's soybean import accounted for 64% of the global import, which was 38% higher than that in 2014, showing high dependence on the global soybean market and certain hidden trouble of market risk. Since Dalian Commodity Exchange released the soybean, soybean meal, and soybean oil futures in the 1990s, China's futures market has established a complete soybean product system. Futures price has a certain price forecast and higher market transparency. Lean *et al.* [1] proved that the operation of the futures market is reasonable and effective for the price discovery and provides powerful guarantee for agricultural market hedging and stable income. Taking soybean, soybean oil, and soybean meal as samples, we analyzed the spillover effect of futures and spot price of China's agricultural products, to reveal the information generation and transmission process among different markets[2], show certain realistic significance and strategic value for stabilizing price, evading potential market risk, and ensuring reasonable dietary demands of residents.

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2 Literature review about the spillover effect between future and spot price of agricultural products

The existing literature focused on the spillover effect of stock, foreign exchange, bonds and other financial market and domestic and foreign commodity market, and the spillover effect between futures and spot market is to be further studied[9-12]. The spillover effect of futures and spot market includes mean spillover and volatility spillover. At present, the mean spillover study is relatively comprehensive. When studying the price transmission of main agricultural products (soybean, cotton, and refined white sugar), both domestic and foreign scholars found that there exists co-integration relationship between futures and spot markets, and the futures market takes the leading position in the price discovery[3-4, 13-14]. The study on volatility spillover is insufficient, So and Tse[5] studied the information transmission relationship between Hang Seng Index futures market and spot market using the information sharing model and multivariable GARCH model. Pang Zhenyan and Liu Lei[15] found that the listing of futures contracts of agricultural products reduces the volatility of the spot market, Yang Chenhui *et al.* [16] found that there is a two-way volatility spillover effect between futures and spot markets of corn and white sugar and futures spillover effect on the spot is greater than the spot spillover effect on the futures. Besides, due to different sample time and study methods for the futures and spot price transmission of agricultural products, there is certain dispute about conclusions of the transmission relationship. Taking soybeans as an example, Liu Qingfu and Wang Haimin[17] found that there is a two-way volatility spillover relationship between the spot prices of soybean, and with the development of futures market, the volatility degree between the two markets is gradually increasing, while Huang Taiyang, with the aid of VAR-MVGARCH-BEKK model, found that there is a significant one-way volatility spillover effect in the soybean spot market in China. In sum, the studies about futures and spot price spillover effect of China's agricultural products are to be further improved. (i) The existing researches on the transmission of the spot market of agricultural products are mainly limited to the mean spillover effect of the spot market, while the researches on the volatility spillover between the two markets are fewer. (ii) Sample time of some researches is shorter or the frequency of data is low, so the conclusions have some limitations and controversies. (iii) The existing literature generally studies the transmission relationship of the spot market of a single agricultural product, but ignores the linkage relationship between the related products to a certain extent. In view of these, taking the soybean products as an example, we used the error correction model and the BEKK-GARCH model to analyze the spillover effect of agricultural futures and spot price in China, and discussed the linkage relationship between types in the mean spillover effect.

3 Model building

In this study, we used the VAR model with co-integration constraints. Its coefficients reflect the interaction between the mean levels of the market, while the GARCH coefficients reflect the inter-market volatility level. We established the error correction model and the BEKK-GARCH model, combined with the Wald test, to verify the volatility spillover effect between variables. Since the error correction model is very common in the existing literature, we just built the BEKK-GARCH model as follows. Generally, the order of GARCH model is small, and the GARCH (1,1) model can describe a large number of time series. The BEKK-GARCH model was proposed by Engle and Kroner in 1995. It guarantees the positive variability of the conditional variance and covariance matrix in the optimization process and minimizes the number of parameters to be estimated. Because the model allows the dynamic dependence of volatility series, it is better than other multivariate GARCH models in describing the volatility relationship of different time series. We used BEKK-GARCH (1, 1) model to study the volatility spillover effect between futures and spot price of soybean, soybean oil, and soybean meal in China. The conditional mean equation was set as follows:

$$y_t = \begin{bmatrix} y_1, t \\ y_2, t \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_1, t \\ \varepsilon_2, t \end{bmatrix} \quad (1)$$

where the variable $I(1)$ is series and there exists co-integration relationship. y_t signifies the future and spot price at time t, stochastic disturbance term is the market impact at time t, ε_t submits to mean value 0, and variance is normal distribution. Variance equation was set as follows:

$$H_t = CC' + A(\varepsilon_{t-1}\varepsilon'_{t-1})A' + BH_{t-1}B' \quad (2)$$

It is conditional variance-covariance matrix, C is lower triangular matrix, A is conditional residual term coefficient matrix, including α_{11}, α_{12}, α_{21}, and α_{22}; B is conditional covariance term coefficient matrix, including symmetrical parameterization of β_{11}, β_{12}, β_{21}, and β_{22} based on the model. If CC' is positive definite, nearly all are positive definite[6]. The conditional variance-covariance matrix of BEKK-GARCH model is:

$$\begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix} = \begin{bmatrix} c_{11} & O \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} c_{11} & O \\ c_{21} & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{1,t-1} \\ \varepsilon_{2,t-1} \end{bmatrix} (\varepsilon_{1,t-1} \quad \varepsilon_{2,t-1}) \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \quad (3)$$

In this study, we did not expand the conditional variance-covariance matrix one by one. $h_{11,t}$ denotes the conditional variance of spot price, $h_{22,t}$ denotes the conditional variance of futures price, and $h_{12,t}$ and $h_{21,t}$ denote the conditional covariance of spot price and futures price. In this study, α_{11} and β_{11} denote ARCH and GARCH effect influenced by volatility of spot price; α_{22} and β_{22} denote ARCH and GARCH effect influenced by volatility of futures price; α_{12} and β_{12} denote volatility spillover of spot price to futures price, and α_{21} and β_{21} denote the volatility spillover of futures price to spot price. ARCH volatility spillover effect showed variance time-varying characteristic, while GARCH-type volatility spillover effect had volatility persistence characteristic. In order to further survey the volatility spillover effect between the spot market and the futures market, we carried out the Wald test for the inter-market matrix elements. Hypothesis testing:

Original H_1: there is no two-way volatility spillover effect between spot and futures market, namely $\alpha_{12} = \beta_{12} = \alpha_{21} = \beta_{21} = 0$.

Original H_2: the spot price does not have volatility spillover effect on the futures price, namely, $\alpha_{12} = \beta_{12} = 0$.

Original H_3: the futures price does not have volatility spillover effect on the spot price, namely, $\alpha_{21} = \beta_{21} = 0$.

4 Data selection and processing for futures and spot price of agricultural products

4.1 Data selection We selected the daily price of futures and spot of soybean products (soybean, soybean oil, and soybean meal) in January 2007 to December 2015, with the sample interval up to 2290 days, covering two violent fluctuations (2008 and 2012 respectively). The data of futures and spot price came from Dalian Commodity Exchange and China National Grain and Oils Information Center. In the future market, the contract months for soybean are January, March, May, July, September, and November; the contract months for soybean oil and soybean meal are January, March, May, July, August, September, November, and December. We adopted the last contract month construction method to make the futures price have the continuous price series consistent with the spot price. Specifically, the daily price adopted the last month contract settlement price, to form the continuous future contract price. When the last month enters the contract month, the future contract settlement price of the next contract month would be selected, to form continuous price series[21]. In the spot market, the production areas of domestic soybean are mainly the three northeastern provinces. We selected the soybean purchase price of Heilongjiang Jiamusi soybean oil, Liaoning Dalian grade IV soybean oil price and Heilongjiang Jiamusi soybean meal price. We rejected the holiday data that could not match the future and spot price. Through arrangement, we obtained 2175 pairs of price data.

4.2 Descriptive statistical analysis We processed descriptive statistical results of all data used in this study. According to Table 1, the spot price of soybean, soybean oil and soybean meal in China fluctuated sharply in 2007 – 2015, among which the standard deviation of soybean oil price was the most significant and the fluctuation was the most significant, indicating that compared with soybean and soybean meal market, soybean oil market had higher risk. According to the Jarque-bara statistic of Table 1, all the series were non-normal distribution, showing left or right skewed distribution, soybean and soybean oil kurtosis values were greater than 3, indicating that the series distribution was steep, taking on the distribution characteristic of sharp peak but thick tail. From the Ljung-box Q statistic of the variables, the significance level of all variables was below 5%, the lag period 5th order and 10th order of series and series square had significant autocorrelation and heteroscedasticity, showing volatility aggregation and obvious ARCH effect.

Table 1 Descriptive statistics of future and spot price of soybean, soybean oil, and soybean meal

	Spot soybean	Future soybean	Spot soybean oil	Future soybean oil	Spot soybean meal	Future soybean meal
Mean	3824.64	4195.28	8047.07	7875.32	3326.45	3235.11
Max.	5700.00	5821.00	16400.00	14614.0	4650.00	4799.00
Min.	2420.00	2697.00	5500.00	4950.00	1900.00	2236.00
Standard deviation	495.21	550.79	1785.28	1714.48	515.32	483.62
Skewness	0.119586	0.014638	0.893571	0.662762	−0.189121	0.231148
Kurtosis	3.772930	3.472638	3.985100	3.062522	2.848396	2.919863
J-B statistics	59.3253***	20.3220***	377.3895***	159.5835***	15.0484***	19.9501***
Q(5)	61.64***	31.89***	246.53***	18.20***	189.03***	25.00***
Q(10)	126.93***	34.61***	278.71***	22.74**	227.12***	27.67***
$Q^2(5)$	120.91***	42.14***	267.72***	48.86***	218.62***	26.54***
$Q^2(10)$	128.87***	48.00***	311.79***	55.40***	255.36***	30.70***

Note: ***, **, and * signify 1%, 5% and 10% significance level respectively.

5 Empirical analysis on the spillover effect between future and spot price of agricultural products

5.1 Mean spillover effect analysis We used ADF test and Engle-Granger two-step co-integration test to test the stationarity and co-integration of variables. In the analysis of the mean spillover effect, we first analyzed the transmission relationship between the same types of spot. It should be noted that the futures-related information has certain influence on the spot price[7]. On this basis, we further studied the linkage relationship between future and spot price of different types at the mean value level. In the empirical analysis, all the price series were logarithmically processed to eliminate the heteroscedasticity of original series. Now, we tested the stationarity of each variable.

Table 2 Stationarity test of variables

Type	Variable	Original series				First-order differential series			
		ADF value	5% level critical value	*P* value	Results	ADF value	5% level critical value	*P* value	Results
Spot	*ln*ss	−1.3435	−1.9411	0.1662	Not stationary	−3.9245	−2.8643	0.0019	Stationary
	*ln*so	−0.8637	−1.9410	0.3419	Not stationary	−18.5343	−2.8630	0.0000	Stationary
	*ln*sp	−0.0395	−1.9412	0.6694	Not stationary	−5.8835	−2.8645	0.0000	Stationary
Future	*ln*fs	1.2289	−1.9410	0.9445	Not stationary	−12.5939	−2.8633	0.0000	Stationary
	*ln*fo	−0.2733	−1.9410	0.5877	Not stationary	−41.5833	−2.8629	0.0000	Stationary
	*ln*fp	0.3239	−1.9410	0.7790	Not stationary	−27.1594	−2.8630	0.0000	Stationary

Note: the first order difference had intercept term. We made logarithmic treatment of all price series, *ln*ss denotes spot soybean, *ln*so denotes spot soybean oil, *ln*sp denotes spot soybean meal, *ln*fs denotes future soybean, *ln*fo denotes future soybean oil, and *ln*fp denotes future soybean meal. The same below.

Through the above test, we obtained that the futures and spot logarithms of price series of soybean, soybean oil, soybean meal were not stationary. It was stationary in the case of first order difference and intercept term, *i. e.*, all were I(1) series. Therefore, the logarithmic series of soybean, soybean oil and soybean meal meet the prerequisite for the covariance test and building the GARCH model to measure the volatility. We used E-G two-step method to test the co-integration relationship between variables, and made further modeling analysis for variables with co-integration relationship.

According to results of EG two-step co-integration test, there was a co-integration relationship between the spot price of soybean, soybean oil and soybean meal at the 1% significance level, and there exists error correction model as long as there is co-integration relationship[8]. In the future and spot linkage transmission between different types, we found that there was no co-integration relationship between soybean oil and soybean meal, because soybean oil is the main edible oil, and soybean meal is the main livestock feed, their market role is different. For variables having co-integration relationship, we established the error correction model and found that the spot price of soybean, soybean oil, and soybean meal rose 1%, while the futures price went up 0.80%, 1.01%, and 0.91% respectively. The spot price of soybean oil rose roughly at the same rate as that the futures price, indicating that due to frequent hedging transactions of futures and spot market of soybean oil, the price transmission was good, the price discovery function was obvious. In the types of price linkage relationship, the spot price of soybean rose 1%, and the spot price of soybean oil and soybean meal went up 0.60% and 0.24%; futures price of soybean rose 1%, and the futures price of soybean oil and soybean meal went up 0.53% and 0.54%. We found that, in the futures market, co-integration relationship between the soybean and soybean oil was basically the same as between the soybean and soybean meal; in the spot market, the price transmission of soybean to soybean oil was significantly better than that of the soybean to soybean meal, showing that futures transaction had a better price discovery function; however, due to accidental factor of supply and demand sides in the spot transaction, there was certain difference in the price transmission between soybean oil and soybean meal.

Table 3 Mean spillover effect between future and spot price of soybean, soybean oil, and soybean meal

Type	Variable	E-G test	Conclusion	Co-integration coefficient	ecm coefficient
Future and spot transmission of the same type	*ln*ss-*ln*fs	Stationary (−5.3419***)	Having co-integration	0.8004	−0.0160
	*ln*ss-*ln*fs	Stationary (−8.1686***)	Having co-integration	1.0123	−0.0525
	*ln*ss-*ln*fs	Stationary (−3.9150***)	Having co-integration	0.9141	−0.0107
Spot transmission between types	*ln*ss-*ln*so	Stationary (−3.6465***)	Having co-integration	0.6017	−0.0049
	*ln*ss-*ln*sp	Stationary (−3.1903**)	Having co-integration	0.2437	−0.0050
	*ln*so-*ln*sp	Not stationary (−1.1608)	No co-integration	–	–
Future transmission between types	*ln*fs-*ln*fo	Stationary (−3.1818**)	Having co-integration	0.5331	−0.0052
	*ln*fs-*ln*fp	Stationary (−3.3162**)	Having co-integration	0.5383	−0.0080
	*ln*fo-*ln*fp	Not stationary (−1.8235)	No co-integration	–	–

Note: ***, **, and * signify 1%, 5% and 10% significance level respectively.

Table 4 BEEK-GARCH (1, 1) variance equation and Wald test

	Matrix element	Future and spot market transmission between the same type		
		*ln*ss-*ln*fs	*ln*so-*ln*fo	*ln*sp-*ln*fp
Lower triangular matrix coefficient		0.0025*** (0.0001)	0.0037*** (0.0001)	0.0027*** (0.0001)
		0.0007*** (0.0001)	0.0023*** (0.0001)	0.0009*** (0.0002)
		0.0042*** (0.0001)	−0.0054*** (0.0001)	0.0059*** (0.0001)
ARCH matrix coefficient		0.2245*** (0.0000)	0.2270*** (0.0001)	0.2269*** (0.0000)
		−0.0004*** (0.0000)	−0.0030*** (0.0000)	0.0054*** (0.0000)
		0.0012*** (0.0000)	0.0015*** (0.0000)	0.0025*** (0.0000)
		0.2234*** (0.0000)	0.2223*** (0.0000)	0.2272*** (0.0000)
GARCH matrix coefficient		0.8660*** (0.0000)	0.8629*** (0.0000)	0.8719*** (0.0000)
		−0.0001*** (0.0000)	0.0033*** (0.0000)	0.0067*** (0.0000)
		−0.0003*** (0.0000)	−0.0037*** (0.0001)	0.0080*** (0.0000)
		0.8677*** (0.0000)	0.8702*** (0.0001)	0.8674*** (0.0000)
Original H_1	Wald value	33281.9638***	30510.5679***	650773.1720***
$\alpha_{12}=\beta_{12}=\alpha_{21}=\beta_{21}=0$	Significance	0.0000	0.0000	0.0000
Original H2	Wald value	3040.8149***	20859.0245***	475478.3034***
$\alpha_{12}=\beta_{12}=0$	Significance	0.0000	0.0000	0.0000
Original H_3	Wald value	25365.9421***	2694.1482***	356668.4499***
$\alpha_{21}=\beta_{21}=0$	Significance	0.0000	0.0000	0.0000

Note: parenthetic values are standard deviation. *** denotes significance at 1% significance level.

The model error correction term reflects the degree to which the variable deviates from its long-term equilibrium relationship in short-term volatility[22]. The error correction coefficient of China's soybean, soybean oil, and soybean meal spot price was −0.0160, −0.0525, and −0.0107, respectively. The error correction coefficient was negative, showing that the spot price changes had a reverse adjustment. The level of the absolute value of the error correction term indicated the rate at which the spot price was adjusted to the long-term equilibrium price after the short-term impact. Among them, the short-term adjustment of soybean oil prices was the most obvious, followed by soybean and soybean meal. In the spot market, the error correction coefficient was −0.0049 and −0.0050 for soybean and soybean oil, soybean and soybean meal, respectively, and the adjustment rate was basically the same. In the futures market, the error correction coefficient was −0.0052 and −0.0080 for soybean and soybean oil, soybean and soybean meal, respectively, indicating that when the soybean market suffered external impact, the price of soybean meal was more sensitive than the soybean price towards long-term equilibrium price of short-term adjustment. In other words, compared to soybean oil, the price transmission of soybean meal and soybean was more closely, that is, the price of soybean meal could better reflect the soybean price than the soybean oil price. The reason for this may be related to the yield of soybean oil and soybean meal produced by per unit of soybean (1 unit of soybean can yield 0.18 unit of soybean oil and 0.8 unit of soybean meal), that is, the vast majority products of soybean are soybean meal, and the relationship between the soybean and soybean meal is close. Soybean meal is large in yield but low in price, basically the same as the soybean. Instead, soybean is low in yield but high in price, so it is highly probable to be favored in the capital market.

5.2 Volatility spillover effect analysis With the aid of Winrat 8.0 software, using the maximum likelihood estimation method, we estimated the maximum likelihood of BEKK-GARCH (1,1) model parameters, and determined the volatility transmission relationship of variables through Wald test. Using the BFGS algorithm, the maximum number of iterations was set to 200, and the convergence criterion is 0.00001. In this part, we mainly focused on the correlation between the soybean, soybean oil and soybean meal in the second-order moments of the same type of futures and spot price. The specific conclusions are as follows.

Firstly, there was a two-way volatility spillover effect between the futures price and spot price of soybean, soybean oil and soybean meal. From Table 4, we can see that the non-diagonal elements were significant at the 1% test level, and there were both the ARCH type and the GARCH type volatility spillover effect. In other words, the variance time-varying and the volatility persistence coexisted. According to Wald test, all the three rejected the original hypotheses, that is, rejecting that there was volatility spillover effect in the futures and spot market, and it also verified the accuracy of the above conclusions. With more than ten years of futures market development, the futures price and spot price of China's soybean, soybean oil, and soybean meal had a closer linkage, market information transmission and price volatility transmission were excellent, and price discovery and hedging function played a great role. Secondly, the futures price and spot price were mainly affected by external market impact and their own pre-fluctuations. The coefficient of the diagonal elements of the parameter matrix was significant at the level of 1%, indicating that there were significant ARCH effect and GARCH effect in the same type of spot transmission, and the volatility spillover was affected by the external impact of the market and its early stage impact. Thirdly, the futures price of soybean guided the spot price of soybean significantly. From the coefficient of non-diagonal elements (volatility intensity), the volatility spillover of soybean futures price to spot price was greater than that to soybean spot price, showing some asymmetry, that is, under the premise of two-way volatility spillover, the guidance of soybean futures prices for soybean spot price was the main factor.

6 Conclusions

(i) There is mean spillover effect between future and spot price of soybean, soybean oil, and soybean meal. There is a long-term equilibrium relationship between futures and spot price transmission of soybean products, and the mean spillover effect is significant at 1% significance level. However, when the price is adjusted to the long-term equilibrium price after a certain period of time, the adjustment of price of soybean oil is most rapid, followed by soybean and soybean meal. The speed of the adjustment reflects the sensitivity of the product to the market information impact. In the degree of hedging transaction, it is required to pay close attention to the adjustment of the price of the product, which has certain reference significance for grasping the market price signal. (ii) There is a two-way volatility spillover effect between the futures price and spot price of soybean, soybean oil and soybean meal. With more than ten years of futures market development, the futures price and spot price of China's soybean, soybean oil, and soybean meal have a closer linkage, market information transmission and price volatility transmission are excellent, and price discovery and hedging function plays a great role. (iii) In the price linkage between the types, there is no co-integration relationship between soybean oil and soybean meal. Compared with soybean oil, the price transmission between soybean meal and soybean is closer. After external impact, the long-term equilibrium price adjustment rate of soybean oil and soybean meal is basically the same; after external impact to the soybean futures price, the price of soybean meal is more sensitive than the soybean price towards long-term equilibrium price of short-term adjustment. By closely monitoring the trend of futures price of soybean meal and soybean, it is feasible to use the futures contract as a temporary substitute for the sale and purchase of commodities in the spot market, establish hedging trading strategy, and effectively stabilize price of agricultural products and avoid market risks.

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Based on the active study of collective land registration laws and regulations, they should provide necessary information for registration and do the preparatory work. Registration entities should promote and restrict each other, and promote the smooth rural land registration and implementation.

6 Conclusions

Taking Ma'anshan City as the survey and study object, we analyzed and discussed the current situations of confirmation of collective land ownership, and came up with recommendations according to existing problems in the rural collective land registration of Ma'anshan City. The confirmation, registration and certificate issue of rural collective land ownership is an arduous work. The smooth implementation of this work requires not only the comprehensive guidance of government departments, but also active coordination of various departments, as well as active participation of the masses. In addition, China's land registration system needs to be further improved. In the work, it is required to realize having laws to comply and having data to check, so as to reduce the ownership disputes and provide guarantee for the construction of integrated urban and rural land market, consolidate the basis of rural economic and social development, and achieve integrated urban and rural development.

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