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Empirical Study on the Influences of Rural Land Circulation on Grain Security

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Abstract

Focusing on the phenomenon that rural land circulation has translated farmland into non-agricultural and non-grain land in recent years, this paper tries to theoretically solve the significant practical issue of sharp reduction in farmland caused by urbanization and grain security that is badly in need of solution in China through constructing models to study the relations between rural land circulation and grain security. As an important part of national security, grain security is a key strategic issue concerning national economy and the people's livelihood. Grain security, energy security and financial security are called three major kinds of economic security in the world. In 2014, China's grain output reached 607.10 million tons, seeing increases for 11 consecutive times, but the self-sufficiency rate of grain reduced to under 90%, and the grain supply gap continued to widen. To this end, the CPC Central Committee has proposed the new national grain security strategy of "Self-centered, state-based, capacity-guaranteed, and technology-supported with appropriate import" and taken important measures to strengthen land circulation and expand business scale. However, in theory, the issues whether agricultural production has scale operation and whether scale operation can increase grain output have remained controversial for a long time. In reality, China's rural land circulation proportion in 2014 reached 28.8%, but the phenomena of non-grain farmland and non-agricultural farmland become serious. Therefore, this paper shows significance in both theory and practice with regard to the study on the relations between China's grain security and rural land circulation as well as relevant policies. Through construction of Nerlove model of grain supply response, quantitative analysis is conducted to study the influences of rural land circulation on grain safety and relevant policies and suggestions are proposed in this paper.

Keywords: *Rural land circulation; Grain security; Urbanization; Nerlove model*

1. Introduction

From the perspective of the historical development of human society, land is the most important production factor. Along with the transformation of Chinese society from a traditional one to a modern one, the operation mode and use of land resources have changed correspondingly. In terms of operation mode, transformation from decentralized operation to intensive operation of a certain degree is an inevitable trend. Currently, China is at the stage of the second leap of agricultural development and reform, that is, China should meet the needs of scientific farming and socialization of production to develop moderate scale management and collective economy. This is great progress and certainly a long process. Regarding use, in the process of land resource allocation and evolution, some of the land use will surely change, especially the acceleration of modernization process, and transformation from rural land to urban construction land is another inevitable trend.

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Such a change is realized through rural land circulation. Certainly, a majority of Chinese and foreign scholars believe that this is one of the features of social progress to some extent, while from the perspective of grain production security, land circulation is bound to pose a great threat to grain security. On the one hand, modernization and urbanization are imperative. According to Ou Jian [1], land circulation is an inevitable trend of economic development and social transformation. On the other hand, grain security is an important part of national security and it is an issue that China must handle appropriately at the current state. In this context, how to prudently and normatively guide and promote reasonable rural land circulation is not only a significant theoretical issue but also an urgent practical issue.

Foreign studies on rural land circulation and grain security mainly focus on such aspects as rural land system, market-oriented land circulation, government intervention to land circulation, and influences of land circulation on grain security. Feder [2] proposes that rural land systems should include formal systems and informal systems. According to Exizabeth Brabec [3] and Chip Smith, rural land circulation man change the modes of land utilization, increase or decrease the scale of rural land and even change the structure of agricultural production. Macmilian [4] states that market failure may occur in the process of land transaction and governments should appropriately intervene in land circulation market to make up for the inadequacy of market regulation. Pardey [5] states that normalized land circulation system can enhance the rural land utilization efficiency. Alvarez [6] believes that land circulation has a significant influence on operation scale while improvement of agricultural scale operation and production efficiency is greatly affected by rural land fragmentation.

China has made great achievements in the study of rural land circulation and grain security, with the research areas mainly focusing on such three aspects as the relations between rural land circulation and grain security, the influences of rural land circulation on grain security, and countermeasure study concerning the “non-grain phenomenon” after rural land circulation. According to Zhang Yunhua [7]*et. al.,* agricultural scale operation needs reasonable and normalized rural land circulation to realize reduction in unit production cost, enhancement of agricultural output capacity and increase in grain output and guarantee national grain security. Nie Liangpeng *et. al.,* [8] propose that land circulation has facilitated scale production of grain, created conditions for the application of large-scale mechanization and promotion of new agricultural technology and new products, provided a platform for scientific field management and mechanized harvesting, enhanced the productive labor efficiency and improved the per unit area yield of grain, while low economic benefit of grain growing, serious “non-grain phenomenon” tendency and sharp decrease in the total grain-growing area have led to reduction in the gross output of grain and threatened grain security. Zhu Zhonggui [9] suggests applying systems that can strictly restrict land use changes, implementing corresponding legal means and exercising tight control over the “non-grain phenomenon” after rural land circulation. Zhang Wugang [10] proposes that we should increase input and subsidies through policies to enhance benefits of grain growing.

Chinese and foreign scholars have conducted in-depth studies on the influences of rural land circulation on grain security, but such studies mainly focus on qualitative analysis. As there is no relevant study on quantitative analysis through modeling, it is expected to build models for quantitative analysis in this aspect. In this paper, Nerlove model of grain supply response is constructed to quantitatively analyze the influences of rural land circulation on grain security so as to fill in the gaps in existing studies and provide useful reference for the policy suggestions on perfecting land circulation and ensuring national grain security.

2. Materials and Methods

In this paper, a grain output supply response model is constructed based on the Nerlove model to analyze the influences of rural land circulation on grain security. For the problems such as the correlation of residuals between variables, the generalized least squares (GLS) method is adopted in this paper to carry out regression so as to make random error terms eliminate auto-correlation. In addition, augmented Dickey—Fuller (ADF) unit root test and Johansen co-integration test are adopted to verify that the regression belongs to real regression.

2.1. Nerlove Model

Nerlove supply response model is a relatively mature and most widely applied model among the existing econometric models of agricultural supply response. Nerlove [11] used this theory for the first time to analyze the dynamic supply response of agricultural products, and some scholars made improvements to it in the research process according to different practical situations. The influences of this model and the combinatory analysis that utilizes production function according to a group of input factors on industries are different. Nerlove model supposes that peasant households adjust area (output) according to the expected price to respond to external stimulus and in the meantime takes the features of adaptive expectations and local adjustment theory into account. This model can be indicated as not only the crop output response but also the crop planting area response.

In this study, Nerlove model is applied in the grain crop output response. As the lagged terms of dependent variables and other explanatory variables are included in the model, Nerlove model is a dynamic auto-regression model. The key components of the model are as follows:

$$A_t^* = \alpha_0 + \alpha_1 P_t^* + \alpha_2 Z_t + \mu_t \tag{1}$$

$$P_t^* = P_{t-1}^* + \beta(P_{t-1} - P_{t-1}^*)(0 \le \beta \le 1) \tag{2}$$

$$A_t = A_{t-1} + \gamma(A_t^* - A_{t-1})(0 \le \gamma \le 1) \tag{3}$$

Among these components, A_t and A_t^* are respectively the actual output (or the actual sowing area) and the long-term equilibrium output (or the sowing area); P_t and P_t^* are respectively the actual price and expected prices at t; β and γ respectively stand for the expected supply adjustment coefficient and the expected price adjustment coefficient; Z_t refers to other external variable affecting the crop output or planting area in No. t year; μ_t is a random disturbance term.

A_t^* and P_t^* are unobservable variables. To effectively use the Nerlove supply response model, equations (1), (2) and (3) must be used to carry out computational elimination. The result after computation is:

$$\begin{aligned} A_t = {} & (\beta\gamma)\alpha_0 + (\beta\gamma)\alpha_1 P_{t-1} + (2-\beta-\gamma)A_{t-1} + (1-\beta)(1-\gamma)A_{t-2} + \gamma\alpha_2 Z_t + \gamma\alpha_2(1-\beta)Z_{t-1} + \\ & \gamma\mu_t + \gamma(1-\beta)\mu_{t-1} \end{aligned} \tag{4}$$

Suppose: $\mu_t = \rho\mu_{t-1} + e_t \ \ (-1 < \rho < 1)$;

$\mathrm{E}(e) = 0; \mathrm{cov}(e) = \sigma^2$.

If $(\beta\gamma)\alpha_0 = b_0$; $(\beta\gamma)\alpha_1 = b_1$; $(2-\beta-\gamma) = b_2$; $(1-\beta)(1-\gamma) = b_3$; $\gamma\alpha_2 = b_4$; $\gamma\alpha_2(1-\beta) = b_5$; $\gamma\mu_t + \gamma(1-\beta)\mu_{t-1} = v$, then (4) is translated to:

$$A_t = b_0 + b_1 P_{t-1} + b_2 A_{t-1} + b_3 A_{t-2} + b_4 Z_t + b_5 Z_{t-1} + v \quad (5)$$

In the equation, b_1 is the short-term supply price elasticity needed, $\frac{b_1}{1-b_2-b_3}$ is the long-term price elasticity, and the coefficient of expectation is $(1-b_2-b_3)$.

2.2. Generalized Least Square (GLS)

Ordinary least square method and weighted least square method are special cases of GLS. The most common way of existing sequence correlation is GLS.

$$Y = XB + U$$

$$Y = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix} \quad X = \begin{pmatrix} 1 & x_{11} & \cdots & x_{1m} \\ 1 & x_{21} & \cdots & x_{2m} \\ \vdots & \vdots & & \vdots \\ 1 & x_{n1} & \cdots & x_{nm} \end{pmatrix} \quad B = \begin{pmatrix} b_0 \\ b_1 \\ \vdots \\ b_m \end{pmatrix} U = \begin{pmatrix} u_1 \\ u_2 \\ \vdots \\ u_n \end{pmatrix}$$

$$E(U) = 0 \quad \mathrm{cov}(UU') = E(UU') = \sigma^2\Omega$$

$$\Omega = \begin{pmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ & w_{22} & \cdots & \\ \vdots & \vdots & & \vdots \\ w_{n1} & w_{n2} & \cdots & w_{nn} \end{pmatrix}$$ Heteroscadacity exists.

Given: $\Omega = DD'$, let D^{-1} be multiplied by $Y = XB + U$ on both sides

$D^{-1}Y = D^{-1}XB + D^{-1}U$ *i.e.*,

$Y^* = X^*B + U^*$

$\mathrm{cov}(U^*U^{*'}) = E(U^*U^{*'}) = E(D^{-1}UU'D^{-1'})$

$= D^{-1}E(UU')D^{-1'}$

$= D^{-1}\sigma^2\Omega D^{-1'} = \sigma^2 D^{-1}DD'D^{-1'}$

$= \sigma^2 I$

The result obtained through the least square method is:

$\hat{B} = (X^{*'}X^*)^{-1}X^{*'}Y^*$

$= (XD^{-1'}D^{-1}X)^{-1}XD^{-1'}D^{-1}Y$

$= (X'\Omega^{-1}X)^{-1}X'\Omega^{-1}Y$

This is the parameter estimator of the model estimated with the GLS method.

2.3. Principle of ADF Test

For the AR (p) process, if all characteristic roots in the characteristic equation are in the unit circle, array $\{x_t\}$ is stationary; if a characteristic root exists and is 1, the array is very stationary and the sum of auto-regression coefficients exactly equals 1. Proof is as follows:

$$\lambda^{p}-\phi_1\lambda^{p-1}-\cdots-\phi_p=0$$

$$\overset{\lambda=1}{\Longrightarrow}1-\phi_1-\cdots-\phi_p=0$$

$$\Longrightarrow\phi_1+\phi_2+\cdots+\phi_p=1$$

Therefore, for the AR (p) process, we can test the stationarity of the array by checking whether the sum of auto-regression coefficients equals 1. The hypothesis testing is as follows:

$H_0: p=0 \leftrightarrow H_1: p<0$, and $p=\phi_1+\phi_2+\cdots+\phi_p-1$

ADF test statistics: $\tau=\frac{\hat{p}}{S(\hat{p})}$, wherein, $S(\hat{p})$ is the sample standard deviation of parameter p.

There are three types of ADF test:

Type 1: a p-order auto-regression process that has no constant mean and trend: $x_t=\phi_1 x_{t-1}+\cdots\phi_p x_{t-p}+\varepsilon_t$

Type 2: a p-order auto-regression process that has a constant mean and has no trend: $x_t=\mu+\phi_1 x_{t-1}+\cdots\phi_p x_{t-p}+\varepsilon_t$

Type 3: a p-order auto-regression process that has a constant mean and a linear trend: $x_t=\mu+\beta t+\phi_1 x_{t-1}+\cdots\phi_p x_{t-p}+\varepsilon_t$

2.4. Johansen Co-Integration Test

Johansen co-integration test is a VAR model-based test method, but it can be directly used for multivariate co-integration tests. Johansen co-integration likelihood ratio (LR) test:

H_0: means there is 0 co-integration relation; H_1: means there are M co-integration relations.

Test statistics: $LR_M=-n\sum_{i=M-1}^{N}\log(1-\lambda_i)$. In the equation, M is the number of co-integrated vectors; λ_i is the No. i characteristic value arranged in order of size; n is the sample size.

Johansen test is not an independent test that can be completed in one time but a continuous test process targeting different values.EViews starts with testing the null hypothesis that a co-integration relation does not exist, and then at most a co-integration relation. For N-1 co-integration relations, N times of tests need to be conducted.

2.5. Model Analysis Procedure

Based on the Nerlove model, this paper analyzes the influences of rural land circulation on grain security with the analysis procedure as follows: step 1, constructing the Nerlove model of grain output supply response; step 2, selecting variables based on the model; step 3, testing the model, *i.e.*, conducting ADF test and Johansen test of the model; step 4, discussing the test results.

3. Results and Discussion

3.1. Data Sources and Processing

This paper is based on quantities of literature research as well as real data. The data about grain output, crop sowing area, grain sowing area and effective irrigation area are from the *Statistical Yearbook of H Province (2010-2014)*; the data about the price index of means of agricultural production, grain price index and vegetable price index are from the *Rural Statistical Yearbook of H Province (2010-2014);* the data about rural land circulation area are from the survey conducted by relevant rural management and administration departments of H Province.

3.1.1. Model Building: As the Nerlove model supposes that peasant households adjust area (output) according to the expected price to respond to external stimulus, this paper introduces some external variables to quantitatively study the influences of rural land circulation on grain security based on Nerlove model. Land is an essential input factor in agricultural production, and peasant household's production and business decisions are usually that they allocate land areas according to the expected prices of different crops. Meanwhile, grain production is influenced by the effective irrigation area, grain crop sowing area and other factors. Therefore, according to the agricultural product production theory, this paper takes the gross output of grain as a dependent variable and introduces such dependent variables as grain planting area, crop sowing area and land circulation area.

In view of that directly estimating the Nerlove model may result in auto-correlation and approximate multicollinearity existing in arrays, this paper gives logarithmic treatment to each variable to ensure that residual obeys normal distribution and short-term supply elasticity is secured. To inspect the grain supply response of different regions, this paper mainly uses the fixed effect model in the panel data model for demonstration and adopts GLS method to carry out panel data regression to reduce cross-section data heteroscedasticity phenomena.

Therefore, the grain output supply response model in this paper is:

$$\ln lszcl_{i,t} = b_0 + b_1 \ln lsjgzs_{i,t-1} + b_2 \ln scjgzs_{i,t-1} + b_3 \ln lsbzmj_{i,t} + b_4 \ln ndlzmj_{i,t} + b_5 \ln yxggmj_{i,t} + \mu_t$$

In the equation, $lszcl_{i,t}$ stands for the grain output in the very term of grain production; $lsjgzs_{i,t-1}$ stands for the grain price index in the lagged term; $scjgzs_{i,t-1}$ stands for the vegetable price index in the lagged term; $\ln lsbzmj_{i,t}$, $\ln ndlzmj_{i,t}$ and $yxggmj_{i,t}$ respectively stand for grain crop sowing area, rural land circulation area and effective irrigation area in the very term of grain production; μ_t stands for random disturbance term, i stands for different regions, and t stands for term.

3.1.2. Variable Selection: As this paper studies the rural land policies from the perspective of grain security, the most basic availability dimension of grain security is selected as a dependent variable, that is, grain output is selected as a dependent variable and the rural land circulation area is selected as an independent variable, and meanwhile other factors influencing grain output are introduced into the paper, such as grain crop sowing area, agricultural effective irrigation area, grain price index and vegetable price index (See Table 1).

Table 1. Variable to Explain and Forecast

Type of variable	Variable	Code	Definition	Effect forecast
Dependent variable	Gross output of grain	$lszcl_{i,t}$	Gross output of grain in the very year of an individual	

Type of variable	Variable	Code	Definition	Effect forecast
Explanatory variable	Grain price index	$lsjgzs_{i,t-1}$	Grain price index in the lagged term	+
Explanatory variable	Vegetable price index	$scjgzs_{i,t-1}$	Vegetable price index in the lagged term	-
Explanatory variable	Crop sowing area	$lsbzmj_{i,t}$	Supply response reflecting the scale of grain sowing	+
Explanatory variable	Effective irrigation area	$ndlzmj_{i,t}$	Supply response reflecting the scale of agricultural effective irrigation	+
Explanatory variable	Total area of rural land circulation	$yxggmj_{i,t}$	Supply response reflecting the scale of rural land circulation	

3.1.3. Model Testing: Before conducting GLS regression, stationarity test and co-integration test of the collected data are conducted. Stationarity refers to that a random process fluctuates around its mean value graphically. In other words, the variance and mean value of a random process and the value of covariance between two random terms depend on the length and lag of these two terms. They are all constants on time sequence and do not depend on the real time of this variance. In reality, any time series data can be regarded as the results of a random process, but most of these data are non-stationary. However, a non-stationary time series can go through several times of differential conversion, as long as differential conversion is not very often and the real information of original data is not lost. If the data are still not stationary after several times of differential conversion, then the regression may be spurious regression. After the stationarity test is completed, it is needed to adjust whether the impact factors are co-integrated next.

ADF test is completed through three models. First, ADF test starts with a model containing intercept and trend terms, then the model only containing intercept terms is tested, and finally the model containing neither intercept term nor trend term is tested. Only when the test results of the three models cannot refuse the null hypothesis can we regard that the time series is non-stationary; as long as the test results of a model refuse the null hypothesis can we deem that the time series is stationary. Software eviews6.0 is used to conduct ADF test (See the results as shown in Table 2).

Table 2. ADF Unit Root Test Results

Variable	ADF statistics	1% critical value	5% critical value	10% critical value	Conclusion
Gross output of grain	-8.620731	-3.546089	-2.911720	-2.5935520	Stationary*
Δ Gross output of grain	-10.567365	-3.546089	-2.911720	-2.5935520	Stationary *
Grain crop area	-2.89043	-3.530040	-2.904838	-2.5899060	Stationary ***
Δ Grain crop area	-13.43215	-3.530040	-2.904838	-2.5899060	Stationary *
Vegetable price index	-0.984028	-3.5285140	-2.904188	-2.5895630	Non-stationary ***
Δ Vegetable price index	-8.173767	-3.530040	-2.904838	-2.5899060	Stationary *
Land circulation area	-2.89054	-3.530040	-2.904838	-2.5899060	Stationary ***

Variable	ADF statistics	1% critical value	5% critical value	10% critical value	Conclusion
Δ Land circulation area	-13.43215	-3.530040	-2.904838	-2.5899060	Stationary *
Effective irrigation area	-7.893242	-3.546089	-2.911720	-2.5935520	Stationary *
Δ Effective irrigation area	-9.327492	-3.546089	-2.911720	-2.5935520	Stationary *
Grain price index	-1.114613	-3.528514	-2.904188	-2.589563	Non-stationary ***
Δ Grain price index	-8.16798	-3.53004	-2.904838	-2.589906	Stationary *

Note: Δ refers to first difference, *critical value at the significance level of 1%, ** critical value at the significance level of 5%, and *** critical value at the significance level of 10%.

As what the co-integration test aims to prove is whether a long-term stationary relation exists between the model variables, the premise is that explanatory variables and explained variables are same-order integration in root unit test. Unit root ADF test has been conducted above, so it is needed to carry out same-order integration conversion. Only when they are same-order integration can we directly take difference or logarithm to conduct a regression analysis.

According to the results of ADF test, co-integration test having intercept terms but having no trend term is conducted. However, before co-integration test, lag order is determined first. In this paper, Akaike Information Criterion (AIC) and Schwarz Criterion (SC) are used to determine the lag difference (P) and make the value of AIC and SC minimum simultaneously in the process of p-value increasing. Software eviews6.0 is used to conduct an analysis (See Table 3) and work out that the lag order of the VAR model is 2. As the unconstrained lag order of the VAR model is 1 greater than the lag order of the Johansen co-integration test, the lag order of the Johansen co-integration test determined is 1-order.

Table 3. Unconstrained Lag Order of the VAR Model

Lag	log L	Lr R	FPE	AIC	SC	HQ
1	1325988	200.8974	5.13E-06	-8.9688	-8.0382	-8.5284
2*	152.2624	31.2456	5.44E-06	-9.3825*	-8.5493	-8.9945

Note: The row marked * refers to the lag orders determined in accordance with the criteria.

After the lag order in the Johansen co-integration test is determined to be 1-order, software eviews6.0 is used to conduct an analysis and obtain the characteristic root tracing test results and the max-eigenvalue test results (See Table 4, and 5).

Table 4. Johansen Characteristic Root Tracing Test Results

Number of null hypotheses and co-integration equations	Characteristic value	Characteristic root tracing statistics	Critical value at the significance level of 5%	P-value
Zero*	0.13420	3.380528	15.49472	0.0004
At most 1	0.000362	0.010108	3.841467	0.9196

Johansen characteristic root tracing test results indicate that 1 co-integration relationship exists between such six variables as gross output of grain, grain crop sowing area, land circulation area, effective irrigation area, grain price index and vegetable price index at the significance level of 5%.

Table 5. Johansen Maximum Characteristic Value Test Results

Number of null hypotheses and co-integration equations	Characteristic value	Characteristic root tracing statistics	Critical value at the significance level of 5%	P-value
Zero*	0.113420	3.370420	14.26462	0.0006
At most 1	0.000362	0.010108	3.841467	0.9238

Note: * stands for refusing the null hypothesis at the significance level of 5%

The Johansen maximum characteristic value test results indicate that there is a long-term stationary relation and a co-integration relationship between the variables that have gone through the logarithm process. In other words, the GLS of these variables is real meaningful regression but not spurious regression.

3.2. Discussion

Based on the grain supply response of different regions in H Province, the fixed effect model in the panel data model and GLS method are adopted to conduct regression in this paper. See Table 6, for the eviews 6.0 results.

Table 6. Grain Supply Response GLS Estimation Results

Variable	Code	Coefficient	Standard error	T statistics	P-value
Intercept term	C	4.670301	0.941906 5.520475	0.0000	Intercept term
Grain price index	$\ln lsjgzs_{i,t-1}$	0.050218	0.012013	6.539428	Grain price index
Vegetable price index	$\ln scjgzs_{i,t-1}$	-0.000014	0.000008	1.112837	Vegetable price index
Grain sowing area	$\ln lsbzmj_{i,t}$	0.040607	0.001726	0.890468	Grain sowing area
Effective irrigation area	$\ln ndlzmj_{i,t}$	0.016425	0.000781	-3.53497	Effective irrigation area
Total area of rural land circulation	$\ln yxggmj_{i,t}$	-0.027722	0.003417	1.705965	Total area of rural land circulation

The analysis results show that the model's R^2 =0.998952, the adjusted R^2 =0.997692, and F=267. 69. It can be seen that all statistics are significant and the model fitting degree is very good. According to the quantitative analysis results, the features of grain supply response can be summarized as follows:

First, a positive correlation exists between grain crop sowing area, effective irrigation area and grain output. It can be seen from the computation results that grain sowing area has a great influence on grain output. Therefore, to ensure grain security, we should stick to the 1.8 billion-mu-red line of farmland area decided by the state and strictly control the grain planting area. As effective irrigation has enhanced the grain's ability to resist natural risks, when droughts or water logging disasters happen, we can ensure that the per unit output of grain will not decrease and will prevent farmers from completely depending on the weather, which helps to guarantee grain security.

Second, a positive correlation exists between grain price index and grain output and a negative correlation exists between vegetable price index and grain output. Peasant households usually allocate grain crop planting areas according to the profits of crops. Vegetable, as a kind of commercial crop, is equivalent to the opportunity cost of grain-growing, thus, when the profit of commercial crop in the lagged term is high, peasant households would make decisions based on the expected prices.

Third, a negative correlation exists between total area of rural land circulation and per unit area yield of grain. According to the results in Table 6, it seems that a negative correlation exists between total area of rural land circulation and gross output of grain, but the conclusion is not exactly so after in-depth analysis. In the grain supply response model, the dependent variable is the gross output of grain, and independent variables include grain sowing area, rural land circulation area and other variables. As the gross output of grain equal the product of the grain sowing area times the per unit area yield of grain, the coefficient before the rural land circulation area variable actually reflects the influences of rural land circulation area on per unit area yield of grain. In the model, the coefficient of rural land circulation area is -0.027722, indicating that if the rural land circulation area increases by 1%, the per unit area yield of grain will decrease by -0.027722%. Therefore, if rural land circulation area is increased and operation scale is enlarged, peasant households will determine grain production input according to income maximization. This is different from peasant household's operational decision of self-sufficiency, as the latter is determined by output maximization. Thus, increase in the rural land circulation area may lead to decrease in the per unit area yield of grain.

Grain sowing area is one of the important factors influencing gross output of grain. On the one hand, increase in rural land circulation area enables desolated rural land to be utilized effectively, thus helping increase in grain sowing area; on the other hand, "non-grain farmland phenomenon" and "non-agricultural farmland phenomenon" in rural land circulation will lower the grain sowing area. Non-agricultural farmland phenomenon can be prohibited through implementation of policies, and non-grain farmland phenomenon can be guided though the direct food subsidy policy. Pei Dongxin and Zhang Dongping [12] propose that we should center on the business needs of "large-scale grain production" overall process and systematically improve supportive policies. Policy design should finally achieve the aim of guaranteeing grain production and grain security through the rural land circulation system.

4. Conclusion

The author has conducted an empirical survey on the influences of rural land circulation on grain security through constructing Nerlove model. In terms of the negative influences of rural land circulation on grain security, the author deems that we should improve the rural land circulation system from the following aspects to guarantee national grain security:

Firstly, specifying farmer's land property rights. Although various kinds of laws, administrative regulations and documents of the CPC Central Committee require that we should ensure farmer's land property rights, and the decision of "ensure permanency of farmer's contractual right of land" was made at the Third Plenary Session of the 17th CPC Central Committee, actually farmer's land property rights are not stable, and forced or semi-forced circulation, regular or irregular adjustment, arbitrary expropriation and other behaviors harming farmer's land rights often happen. It can be known from the above analysis that rural collective and land circulation usually tends to change the original land use and engages in high value-added facility agriculture, while independent free circulation between peasant households tends to maintain the original land use because of dispersion and small size of land as well as farmer's consideration of future life. Therefore, we should guarantee complete farmer's land property rights to ensure grain security and prevent rural collectives from intervening in farmer's land property rights from the perspective of systems. In addition, ensuring farmer's land property rights is conducive to stabilizing farmer's benefit expectation and facilitating accelerated circulation of land. At present, we should turn the documents of the CPC Central Committee into law as early as possible, *i.e.,* revising the *Land Management Law*. Moreover, we should do well such groundwork as right confirmation and registration of rural land, certificate issuing etc to perfect the farmer's land property rights procedurally.

Secondly, continuously innovating in land circulation models. With the acceleration of China's economic development, urbanization and industrialization, traditional household contract responsibility system with remuneration linked to output has exposed some disadvantages, such as desolated, idle and wasted rural land resources. To realize optimized allocation of rural land resources and increase grain output, China has conducted experiments on rural land circulation. For the special national condition that China has a large population with relatively little land and the traditional factor that the land features high-degree fragmentation, land circulation models have presented some drawbacks, for example, scale operation with large-area land connected and forced circulation going against farmer's will may increase farmer's risks. Therefore, to ensure national grain security, we should adjust measures to local conditions and continuously innovate in rural land circulation models. Rural land circulation should follow four most basic principles: first, observing strictly national laws and regulations; second, respecting farmer's will; third, strictly controlling land use; fourth, balancing risks and benefits. Hence, China's innovation in the land circulation system can boost its innovation in rural land circulation models through legislation perfecting, institutional innovation, organizational innovation, policy support and other ways.

Thirdly, normalizing the behaviors of rural collectives and local governments. Undeniably, as China has a specific land property right system and an administrative management system, rural collectives and local governments play an important role in rural land circulation. How to stem the impulsion of rural collectives and local governments in non-grain-based land circulation? First of all, administratively, superior governments should require local governments and rural collectives to implement the "chief executive responsibility system" like the CPC Central Committee dose on grain and require them to ensure that the amount of arable land in their respective regions will not decrease, use of arable land will not change, quality of arable land will not degrade and grain output will not reduce. Additionally, local officials' work performance should be strictly assessed and linked up with promotion. Moreover, economically, we should change the situation of "large regions in grain output and poor regions in finance". In other words, breadbaskets should not suffer losses in fiscal revenue, and the central government and provincial governments should continue increasing financial transfer payment to breadbaskets so as to truly stem the economic interest motive of local governments and rural collectives for carrying out non-grain-based land circulation.

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