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Co-integration Analysis of Urban Residents' Income, Agricultural Financial Expenditure and Farmers' Income

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Abstract Based on the previous research result, ADF test method, Johansen test method and Error Correction Model are introduced. According to the relevant data in Guangdong Province in the years 1985–2006, co-integration analysis, Error Correction Model, impulse response function and variance decomposition technology are used to study the dynamic impacts of urban residents' income and agricultural financial expenditure on rural residents' income in Guangdong Province. Result shows that although urban residents' income has temporary negative effects on rural residents' income in Guangdong Province, its long-term, stable and positive effect is more important. Increase of urban residents' income can promote the income growth of rural residents. Effect of agricultural financial expenditure on rural residents' income is relatively unstable in the short term; but in the long term, it has steady and weak positive effect on rural residents' income. Rural residents' income has relatively great impact on its own, indicating that when rural residents' income reaches a certain level, it can form a mechanism of self-promotion in order to promote the continued increase in the rural residents' income.

Key words Rural residents' income; Urban residents' income; Agricultural financial expenditure; Co-integration analysis; Guangdong Province; China

The key of "Three Agricultural Problem" and new countryside construction is to increase the income of farmers in order to ensure the steady increase in farmers' income. Per capita income of rural residents in Guangdong Province has increased greatly from 495.31 yuan in 1985 to 5 624.00 yuan in 2006, up by more than 11 times. At the same time, per capita income of urban residents has also increased from 954.12 yuan in 1985 to 17 699.30 yuan in 2006, up by 18 times. Therefore, it can be concluded that increase of per capita income of rural residents is slower than that of urban residents. Moreover, the ratio of per capita income of urban residents to per capita income of rural residents has raised from 1.9 to 3.1 during the years 1985–2006, indicating that the increasing income gap between rural and urban residents has directly restricted the steady growth of economy in Guangdong Province. Co-integration analysis on the relationship among rural residents' income, urban inhabitant income and agricultural financial expenditure is carried out in order to offer references for the decision making of relevant policies.

1 Review of literatures

Many scholars have carried out researches on the farmers' income from various aspects. Wang Min *et al.* carry out the co-integration analysis on the relationship between net income of farmers and financial investment in agriculture, and establish the error correction model. They also verify the long-term cointegration relationship and the short-term correction relationship, indicating that financial investment in agriculture has positive effect on the growth of farmer's income^[1]. Gao Yan uses cointegration relationship, Granger Causality Test and other measuring methods to conduct Econometric Test on the relationship between rural informal finance and per capita net income of farmers. Result shows that informal finance has greater impact on farmer's income growth than the formal finance for a long time^[2]. Li Meng-jue obtains that industrialization rate and urbanization rate have positive correlation with farmers' income according to the actual situation^[3]. Liu Yan *et al.* put forward that it is urgent to accelerate the circulation of land use right in order to increase farmer's income based on the research on the correlation between farmers' income and farmland use circulation^[4]. Wei Jie *et al.* distinguish the internal mechanism and external mechanism that decide the income by starting from the theoretical model determining the actual income of rural residents. Result shows that the ultimate solution for rural residents' income must rely on the coordination between internal and external solving mechanisms, that is, when improving the ratio of costs-earnings, we must put the emphasis on the surplus labor transfer from rural to urban areas, the supply of public goods, and the increase of agricultural technical input^[5].

However, at present, many scholars only focus on the effects of agricultural financial expenditure on farmer's income. Although market economy construction has gained great achievement in Guangdong Province, we are still at the stage of "dual economy". Therefore, it is necessary to analyze the effects of urban inhabitant income on rural residents' income.

2 Research method and data processing

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2.1 Research method

2.1.1 Stationary test. Before the co-integration test on varia-

ble, stationary test is needed. Unit root test is usually used during stationary test on variables, that is, testing the existence of unit root in original sequence. If there is unit root, we can conclude that the original sequence is not stationary, and *vice versa*. The most common method for unit root test is the ADF Test (Augment Dickey-Fuller Test), which is

$$\Delta X_t = \delta X_{t-1} + \sum_{i=1}^m \beta_i \Delta X_{t-i} + \varepsilon_t, \quad (1)$$

$$\Delta X_t = \alpha + \delta X_{t-1} + \sum_{i=1}^m \beta_i X_{t-i} + \varepsilon_t, \quad (2)$$

$$\Delta X_t = \alpha + \beta t + \delta X_{t-1} + \sum_{i=1}^m \beta_i \Delta X_{t-i} + \varepsilon_t, \quad (3)$$

where ΔX_t is time series needed to be determined, t is time trend item, α is constant term, β is regression coefficient, m is lagging order number, and ε_t is residual term.

Equations (1), (2) and (3) represent the models having neither intercept term nor trend item, having intercept term but no trend item, and having both intercept term and trend item. Null hypothesis of the three models is $H_0: \delta = 0$, that is, there is a unit root. Actual test starts from equation (3), followed by equation (2) and equation (1). When null hypothesis is rejected, that is, there is no unit root in original sequence, the test should be stopped.

2.1.2 Co-integration test. If certain linear combination of these variables is stationary, we can conclude that these variables have co-integration relationship. Co-integration reflects the long-term equilibrium relationship among variables, indicating that there is no internal mechanism in economic system that destroys the equilibrium. As for the co-integration test of variables obeying $I(1)$ process, there are two test methods, which are EG test and Johansen test. EG two-step method is widely used in early stage due to its easy calculation. But it has the disadvantages of greater error of parameter estimation under small sample. When the variable is more than two, there might be a plenty of "co-integration" relationships. According to these problems, Johansen put forward the Maximum Likelihood Estimation Method (MLE). Research shows that Johansen test is superior to EG two-step method^[6]. Since this research has more than two variables and relative limited samples, we use Johansen test. Assuming that Y_t and X_t are k th and d th order vectors, respectively, and they obey $I(1)$ process, VAR Model is established:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \quad (4)$$

where, $\Pi = \sum_{i=1}^p A_i - I, \Gamma_i = -\sum_{j=i+1}^p A_j$.

If the rank of coefficient matrix $r < k$, α and β in $k \times r$ order matrix can make matrix $\Pi = \alpha\beta'$ and $\beta'y$ obey the stationary

$I(0)$ process. Then, Trace Test and Maximum Eigenvalue Test are conducted. Statistics of trace test is

$$\eta_r = -T \sum_{i=r+1}^k \ln(1 - \lambda_i),$$

where η_r is the statistics of characteristic root, λ_i is the i th eigenvalue, T is the total number in observation period, and k is the number of endogenous variable. When η_0 is insignificant, there is k unit roots and 0 co-integration vector, that is, there is no co-integration relationship. When η_0 is significant, there is at least one co-integration vectors. Thus, significance of η_1 is needed to be tested. If η_1 is insignificant, there is only one co-integration relationship. The statistics of Maximum Eigenvalue Test is

$$\xi_r = -T \ln(1 - \lambda_{r+1}),$$

where ξ_r is the statistics of Maximum Eigenvalue Test. If ξ_r is smaller than the critical value, indicating that there is no co-integration relationship. If ξ_r is bigger than the critical value, indicating that there is at least one co-integration relationship.

2.1.3 Error Correction Model (ECM). It is assumed that $y_t = \beta_0 + \beta_1 x_t + \beta_2 y_{t-1} + \beta_3 x_{t-1} + \varepsilon_t$, where ε_t is the process of white noise. Based on this, Error Correction Model is obtained:

$$\Delta y_t = \beta_0 + \beta_1 x_{t-1} + (\beta_2 - 1) \left(y_t - \frac{\beta_1 + \beta_3}{1 - \beta_2} x \right)_{t-1} + \varepsilon_t, \quad (5)$$

where $y_t - \frac{\beta_1 + \beta_3}{1 - \beta_2} x$ is error correction model. If there is long-term equilibrium relationship between x and y , we have $y = \frac{\beta_1 + \beta_3}{1 - \beta_2} x$. Therefore, ECM reflects the effects of long-term equilibrium on short-term fluctuation.

2.2 Data treatment Data are from the statistics database and Guoyan Network database with sample interval within the years 1985–2006. Urban inhabitant income (CS) is represented by per capita disposable income of urban residents. To eliminate the factor of price, consumer price index (CPI) can be converted into comparable income. Agricultural expenditure (CN) is represented by the expenditure of financial support for agricultural production in Guangdong Province, and CPI is used to eliminate the impacts of price. At the same time, to eliminate or reduce the heteroscedasticity, CS , CN and NS are taken the natural logarithm, which are $\ln CS$, $\ln CN$, and $\ln NS$.

3 Empirical analysis

3.1 Stationary test Equations (1), (2) and (3) are used to conduct unit root test on CS , CN and NS series, the result of which is shown in Table 1.

Table 1 Unit root test of variable time series data

Variable	ADF value	P value	(C,T,K)	Conclusion	Variable	ADF value	P value	(C,T,K)	Conclusion
$\ln CS$	1.13	0.899	(C T 0)	Non-stationary	$d \ln CS$	-2.35	0.021 3 * *	(0 0 0)	Stationary
$\ln CN$	-1.86	0.637	(C T 0)	Non-stationary	$d \ln CN$	-4.42	0.000 1 *	(C 0 0)	Stationary
$\ln NS$	1.57	0.769	(C T 1)	Non-stationary	$d \ln NS$	-2.32	0.023 0 * *	(C 0 0)	Stationary

Note: C and T means having constant term and trend term, respectively. K is lagging order number, which is determined by SIC and AIC standards. * and * * stand for significant levels at 0.05 and 0.01, respectively, the same as follows. d means first-order differential.

Table 1 indicates that original time series of the three variables is non-stationary. But their first order difference series are

all stationary, that is, they are all first order unit root series $I(1)$.

3.2 Co-integration test Johansen co-integration analysis method is used to test the co-integration relationship among $\ln CS$, $\ln CN$, and $\ln NS$. Optimal lag phase of VAR Model should be first determined. In order to keep a reasonable degree of freedom to obtain stronger explanatory power of model parameter and to eliminate the autocorrelation of error term, we select the fourth order as the maximum lag order. The optimal lag order of VAR Model is selected from the fourth order to the

Table 2 Result of co-integration test

Null hypothesis	Eigenvalue	Statistics	5% critical value	P value	Statistics of maximum eigenvalue	5% critical value	P value
No co-integration relationship	0.72	55.64	35.19	0.000 01	24.48	22.30	0.024 4
At most one co-integration relationship	0.62	32.06	20.26	0.000 08	18.32	15.89	0.020 4
At most two co-integration relationships	0.51	13.74	9.16	0.006 40	13.74	9.16	0.006 4

Table 2 shows that at 5% significant level, there are three co-integration relations among variables, indicating that co-integration relationship among CS , CN and NS is stationary and there is long-term co-integration relationship among the three variables.

Co-integration relationship after standardization is

$$ec_t = \ln NS_t - 0.748 \ln CS_t - 0.044 \ln CN_t - 1.081 \\ (0.022\ 59) \quad (0.031\ 32) \quad (0.214\ 72). \quad (6)$$

Data in brackets are progressive standard error, indicating that variables are significant in co-integration relationship. Based on the unit root test on ec_t , ADF value of series is -2.08 , which is greater than the critical value at 5% level and the P value is 0.393 . Therefore, there is no unit root in ec_t , that is, residual series is stationary. Co-integration relationship equation reflects the long-term equilibrium relationship among rural residents' income, urban inhabitant income and agricultural financial expenditure. Every one percentage point increase of urban inhabitant income will result in the 0.748 percentage point increase of farmers' income; and every one percentage point increase of financial expenditure will lead to 0.044 percentage point increase of farmers' income. According to equation (5),

$$\Delta \ln NS_t = -0.240 ecm_{t-1} + 0.616 \Delta \ln CS_t + 0.028 \Delta \ln CN_t + 0.159 \Delta \ln CS_{t-1} + 0.089 \Delta \ln CN_{t-1} + 0.114 \Delta \ln CN_{t-2} \\ (-3.591) \quad (12.509) \quad (2.019) \quad (3.177) \quad (6.473) \quad (2.565) \quad (7)$$

$$R^2 = 0.976, D.W = 1.797, AIC = -4.241, SC = -3.943.$$

Coefficient of error correction is negative, satisfying the reverse repair mechanism. This reflects the short-term fluctuation law, that is, income growth of rural residents in Guangdong Province is affected by the urban inhabitant income and the agricultural financial expenditure. Error correction coefficient reflects the adjustment of short-term deviation from the long-term equilibrium. Therefore, -0.240 error correction coefficient indicates that the adjustment strength is weak. Adjustment speed of rural residents' income from disequilibrium to equilibrium is about 4.17 years. Error correction equation includes the income change of lag 2. And it can be found out that the influence of income change of urban residents in lag 2 is bigger than that in lag 1, indicating that increase of urban residents' income can rapidly form the purchasing power of agricultural industry, so as to promote the income growth of rural residents. Impact of agricultural financial expenditure on rural residents' income increases with the growth of lag phase and its effect becomes

first order. AIC and SIC information standards, Final Prediction Error Method (FPE), and LR statistics are used as test standard for the optimal lag order. Autocorrelation LM statistic is used to test the autocorrelation of residual series. JB test is adopted to test the normality of residuals. Based on this, VAR (3) Model is determined as the optimal model. Therefore, lag stage of VAR Model in co-integration test should be 2.

urban inhabitant income does not increase with the decrease of farmers' income. In the long run, increase of urban inhabitant income will accelerate the growth of farmers' income. Meanwhile, agricultural financial expenditure has positive impact on farmers' income but the impact is small. Therefore, we can conclude that agricultural financial expenditure is inefficient and the loss of efficiency is relatively high. agricultural financial expenditure has not yet become a major factor for income growth of rural residents in Guangdong Province.

3.3 Error correction model (ECG) In the long term, there is equilibrium relationship among rural residents' income, urban inhabitant income and agricultural financial expenditure. But in the short term, the three variables may deviate from the equilibrium. Therefore, it is necessary to establish the ECG to examine the short-term dynamic relationship between the three variables.

Let error correction term $ecm_t = ec_t$; and take $\Delta \ln NS$ as the explained variable, $\Delta \ln CS$ and $\Delta \ln CN$ and their lag items at each order as the explanatory variables. After several attempts, correction model is established with comprehensive consideration of t value and R^2 , which is

the maximum at lag 2, indicating that agricultural financial expenditure of Guangdong Province needs more time to exert the effect of increasing farmers' income. Coefficients of $\Delta \ln CS$ and $\Delta \ln CN$ are positive, showing that change of variable growth rate is 1% and the income growth rates of farmers have homonymous change of 0.616% and 0.028% . This also verifies the above point of view, that is, agricultural financial expenditure has a little impact on income growth of farmers, and the efficiency is relatively low. Therefore, use efficiency of agricultural financial expenditure needs to be improved as soon as possible in order to give full play to the role of the financial support for agriculture.

3.4 Impulse response function and variance decomposition prediction In order to further explore the dynamic relationship among the urban residents' income, agricultural financial expenditure and farmers' income in Guangdong Province, vector autoregression (VAR), which is put forward by Sims, is

used to conduct impulse response and its variance decomposition forecast.

Based on the VAR (3) model mentioned above, we adopt Cholesky Decomposition Method to establish an impulse response model of rural residents' income to urban residents' income, agricultural financial expenditure and its own. Fig. 1 illustrates that urban residents' income has a weak negative impact on rural residents' income in short term. But from the 4th period, it has positive impact on the rural residents' income and it reaches the maximum at the 7th period, and then declines steadily. After the 9th period, it fluctuates within a very narrow range and maintains the positive effect. The first impact of agricultural financial expenditure has the maximum positive effect at the 2nd period and then falls back. It reaches the maximum negative impact at the 6th period, and then gradually rises again. After the 15th period, the impact becomes very weak. Impact of income of rural residents on itself reaches a high value at the 1st period, and then declines rapidly. After the 3rd period, it begins to show an increase trend, and reaches the maximum value at the 6th period. Then, it falls rapidly and maintains a relatively stable positive effect after the 14th period. This indicates that income level at the earlier period has huge impact on that of later period, and growth of rural residents mainly depends primarily on its own basis and accumulation. Combining with the actual situation of Guangdong Province, farmers earn income by being engaged in farming or working outside. If they obtain higher income through farming, they will invest more money in agricultural production, which accelerates the agricultural output and further enhances the income level of rural residents. Besides, if farmers working outside want to earn more money, they may increase investment in human capital. And according to the economic theory, investment in human capital is a very important path to increase the residents' income steadily.

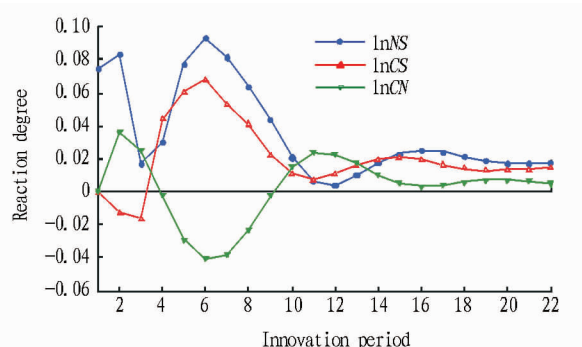


Fig.1 Curve of impulse response

Forecast variance decomposition technology can decompose the mean square error (MSE) into the contribution of variable impact in system. Therefore, any random information from variance decomposition has relative importance to VAR model. Fig. 2 illustrates that rural residents' income has relatively great contribution to the forecast of mean square error. It declines from the 1st period, and maintains at about 60% at the 6th period. Thus, it can be concluded that the forecast mean square error has been in the dominant position before the 22nd period. Contribution degree of urban residents' income to fore-

cast mean square error of rural residents' income is relatively low at the beginning, and maintains at about 25% after the 6th period. It exceeds the contribution of agricultural financial expenditure after the 4th period, indicating that urban residents' income has relatively long-term impact on the rural residents' income. Contribution degree of agricultural financial expenditure to the forecast mean square error rural residents' income is relatively stable (at a low level of about 15%) within the 22 periods, indicating that agricultural financial expenditure has long-term impact on farmers' income, but its effect is not as significant as those of urban residents' income and farmers' income itself.

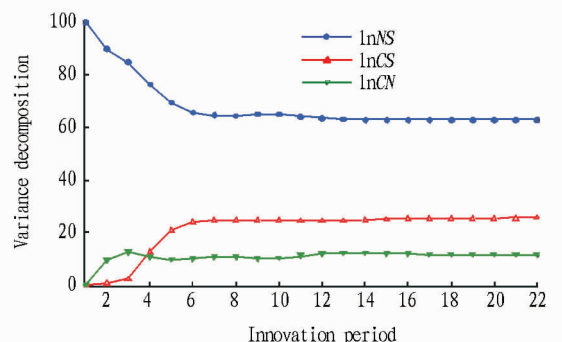


Fig.2 Forecast of variance decomposition

4 Conclusion and suggestion

(1) Increase of urban residents' income has negative impact on rural residents' income in Guangdong Province in the short term. But in the long term, it has stable positive impact on the rural residents' income, which is similar to the research result of Li Jianjun^[7]. Just as he pointed out, increase of urban residents' income has transitory and weak "cake cutting" effect in Guangdong Province; but in the long term, "cake making" effect is more significant and important. Therefore, it is inappropriate to set the rapid increase of urban residents' income and the slow increase of rural residents' income against each other. And narrowing the gap between urban and rural areas in Guangdong Province can not be realized through slowing down the income increase of urban residents. On the contrary, we should accelerate the growth speed of rural residents' income. Specifically, we should promote the complete flow of product market and factor market in rural and urban Guangdong Province, accelerate the circulation speed of agricultural products, and promote the urban capital flow into rural areas to invest and to conduct other productive business activities.

(2) In the short term, negative effect of agricultural financial expenditure on rural residents' income plays the dominant role, especially from the 4th to 9th period. But in the long term, agricultural financial expenditure has stable and weak positive effect on the rural residents' income, indicating that agricultural financial expenditure in Guangdong Province needs a long cycle to play its effect. Besides, according to the error co-integration model, agricultural financial expenditure has relatively weak impact on the income of rural residents in Guangdong Province, reflecting the relatively low efficiency of agricultural financial expenditure. Therefore, on the one hand, we should do our best

to reduce the cycle of effect exertion of agricultural financial expenditure. On the other hand, we should enhance the use efficiency of agricultural financial expenditure and reduce the efficiency loss.

(3) Rural residents income in Guangdong Province has great impact on the income growth of rural residents, indicating that income growth of rural residents will form a mechanism with self-promotion, so as to promote the steady increase of income. This mechanism exerts its function through the following channels. Firstly, growth of income has increased the input of agricultural production, and leads to the income increase of the next period. Secondly, growth of income has strengthened the investment in human capital. According to the human capital theory, investment in human capital can play a role in the long term. Therefore, Guangdong Province should promote the formation of mechanism with self-promotion for rural residents from the aspects of finance, education and so on. Moreover, Guangdong Province should promote the subsidy and insurance systems in order to ensure the smooth operation of mechanism with self-promotion.

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广东省城镇居民收入,农业财政支出与农民收入的协整分析

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摘要 在简述前人研究成果的基础上,介绍了 ADF 检验法、Johansen 检验法以及误差修正模型。根据 1985~2006 年广东省的相关数据,运用协整分析、误差修正模型以及脉冲响应函数、方差分解技术研究了广东省城镇居民收入、农业财政支出对农村居民收入的动态影响。结果表明,虽然广东省城镇居民收入对农村居民收入有短暂的负向效应,但更主要的是其长期、稳定的正效应,城镇居民收入的增加总体上可以促进农村居民收入的增长;农业财政支出对农村居民收入增长的效应在短期较不稳定,而在长期,其对农村居民收入具有稳定而微弱的正效应;农村居民收入自身对农村居民收入增长的影响较大,这意味着当农村居民收入达到一定水平时,便可能产生一种自我增进机制,促进农村居民收入的持续增加。

关键词 农村居民收入;城镇居民收入;农业财政支出;协整分析;广东省

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我国农村金融发展与农民收入增长关系的实证研究

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摘要 通过国内学者对农村金融与农民收入增长关系的研究发现,在时间序列数据进行平稳性的检验、模型设计、在数据收集 3 个方面存在着一些不足。基于此,依据 1993~2006 年《中国统计年鉴》中 1992~2005 共 14 年的数据,分别选取农民人均纯收入、农村的信贷投入、农村从业人员的结构、农产品价格指数 4 项指标,采取统一规范的分析方法,采用 Eviews5.0 统计软件对农村金融发展与收入增长之间的关系进行计量分析,通过格兰杰因果关系检验、ADF 检验、以及协整关系检验,建立 OLS 回归模型。结果表明,检验统计量值为 -2.871 8,小于显著性水平 5% 时的临界值为 -1.971 0,可以认为估计残差序列 ϵ 为平稳序列,表明序列农民人均纯收入、农村的信贷投入、农村从业人员的结构、农产品价格指数之间具有协整关系,因而提出应该加大农村金融的发展,以及对农村信贷的支持力度,从而提高农民收入。

关键词 农村金融;农民增收;格兰杰因果关系检验;协整检验