Study on the effect of land elements on technical efficiency of economic growth in China based upon Stochastic Frontier Analysis

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Abstract: The purpose of this paper is to apply stochastic frontier analysis to estimate the Chinese provincial regions' technical efficiency before and after the introduction of land elements in 2002-2012, and analyze the effect of land elements on technical efficiency of economic growth, providing the basis for differential land regulation policy. Methods of literature analysis and stochastic frontier analysis are employed. The results show that (1) the contribution of land elements to China's economic growth is significant, the technical efficiency of economic growth increases (0.0835) after introducing land element; (2) the effect of land elements on technical efficiency varies in different areas(from -0.0743 to 0.1930, distributed like a sloping echelonment),larger in the economically backward districts; (3)the effect is the largest(0.1175) that land elements have on the average technical efficiency of the economic growth in western region, while the east district has a rather high technical efficiency of economic growth(0.1038) to which land elements contribute the least(0.0454). The conclusion of this article is that macro-control of land has a promoting effect on the technical efficiency of economic growth and it remains sustainable by now, as a result, the goal of land policy in macroeconomic regulatory should be further defined, the main policy tools of land macro-control should be adjusted according to circumstances, and corresponding policies should be formulated on the basis of differential impacts of land element on regional technical efficiency.

Key words: land economy; stochastic frontier analysis; technical efficiency; differential regulation

Introduction

China's GDP has been growing at a high speed since the launch of reform and opening up 30 years ago. The land, as an indispensable factor of production and a carrier of social and economic activities, has a significant impact on China's economic growth during the transition period. However, some people hold the view that China's economic miracle is just a replica of the Asian economic model in the past half century, which is acquired by a high input of capital and labor. In order to promote urbanization and economic growth, land increase relies largely on land acquisition and "Pie-style" expansion, which does not have the basis of sustainable development. Whether the land has a sustainable impact on China's economic growth depends largely on the correct calculation and decomposition of its impact on the technical efficiency of China's economic growth. Given the huge regional difference in China, the calculation of the land's impact on the technical efficiency of economic growth in various regions has also an important practical significance in the study of optimizing the regional allocation of land resources, improving the efficiency of land use, reducing regional disparities and promoting regional economic growth convergence.

When considering the impact of resources on economic growth, the mainstream economics often fail to separate effectively the impact of land on economic growth and cannot provide the theoretical basis of the land policy's participation in the macroeconomic control. However, in 2004, the Chinese government made it clear that the land policy participate in macroeconomic control in goal of regulating macro-economy by adjusting the quantity and time of land input in economic construction. In this background, the quantitative research concerning the impact of land input on economic growth has become the focus of academia and policy level. The study of the land factor's impact on China's economic growth not only tests the correctness of the land policy's participation in macro-regulation mechanism, but also provides basis and reference for the differentiated land regulation and control policy. Therefore, on the basis of related literature, this paper estimates and discusses the land factor's impact on the technical efficiency of China's economic growth by using Cobb-Douglas production function and stochastic frontier analysis, compares the different regions and sums up finally the policy implications.

Literature review

Stochastic Frontier Analysis

Correct study of efficiency is of great significance to determine whether output growth is sustainable. Farrell (1957) first analyzed the measure of efficiency, pointing out that the economic efficiency can be divided into technical efficiency and allocative efficiency, and the concept of production frontier was used to measure the size of the inefficiency. In terms of efficiency estimation, non parametric Malmquist index data envelopment analysis (DEA) has been widely applied. But the disadvantage of this method is not considering the possible impact of random events or some other factors on the output, all the deviations of production frontier are regarded as inefficient. The stochastic frontier analysis (SFA) method allows the existence of random disturbance, that technical inefficiency and random disturbance both can cause the production running off the boundary and the two kinds of deviation can be differentiated by their sources, but due to the fact that the estimate result depends on the production function and the probability distribution of the random item set beforehand, different forms often lead to different results, which may create productivity estimation errors. Comparing the two methods of DEA and SFA, foreign scholars' study found that there is no evidence that one kind of method is absolutely more effective than the other one , it is generally thought that the two have different applicable conditions and that choice should be made according to specific problems. Fu Xiaoxia and Wu Li (2007), Wei Xiahai and Yu Lingzheng (2011) all made comparison between the applicability of the DEA method and the SFA method in China, but have come to the opposite conclusion. Wei Xiahai and Yu Lingzheng (2011) consider that conclusions obtained by the DEA method may be more reliable and can better satisfy the needs for the interpretation of China's economic reality,

while Fu Xiaoxia and Wu Lixue (2007) hold just the opposite point of view. Due to the difference of using data, sample interval and model set; there is no conclusion of which method is better. But Cai Jinghan (2011) thinks that the SFA method considers more of the effect of random shocks on economic system, and also avoids the danger of "data mining", therefore is more suitable for China's economy which contains growing factors of uncertainty, meanwhile, it can estimate the effects of various factors on the inefficiency of technology, which is instructive to find ways to improve the technical efficiency .There are also many domestic researches on the application of the stochastic production.

land factors impact on technical efficiency of economic growth

From the existing literature, although research method, model selection and sample interval as well as the research conclusion of the land investment's influence to China's economic growth of different scholars are of difference, but that land is an important production factor to China's rapid economic growth has become a consensus, to quantify its impact has become a hot topic among scholars and government departments. In the study about the efficiency of land elements, the current studies tend to use data envelopment analysis (DEA), economic analysis, multiple attribute comprehensive evaluation method for land use structure configuration, input and output, land transfer and other aspects of efficiency. Zheng Xinji and Wang Xiaoming (2004) apply data envelopment analysis (DEA) method to judge the rationality and efficiency of urban land use structure. Song Jitao (2006) uses DEA model to analyze the characteristics of the efficiency of urban land use structure as well as its relationship with city size. Guo Guancheng and Wu Qun (2009) uses welfare economics to analyze the policy effects on land market allocation efficiency. Zhang Liangyue (2009) applies super efficiency data envelopment analysis method to measure the regional difference of Chinese urban land use efficiency. Bao Xinzhong (2009) constructs the city land utilization efficiency evaluation index system of multiple attributes comprehensive evaluation. Long Kaisheng (2008) uses C-D production function and stochastic dominance model to analyze the input-output efficiency of different types of land. Cao Jianhua(2007) by setting the index of land transfer willingness analyzes farmers' land supply willingness and estimated the efficiency of corresponding economic welfare. In addition, the present study also tends to study the degree of a number of factors that influence the efficiency of land use , usually uses some replace indicators to replace the land use efficiency. Liu Tao (2006) selects the two indexes of multiple cropping index of arable land and the land comprehensive productivity to represent farmers' land use efficiency, using multiple linear regression model to make empirical research of land fragmentation and the influence of land transfer to land use efficiency. To sum up, the current research in the aspect of the influence of land to economic efficiency is relatively scarce, tends to measure the efficiency of land use by measuring the intensity of land use, land marginal input and output ignoring that land is an important factor

for economic growth efficiency. Therefore, this paper introduces the land factors in estimating regional total factor of technical efficiency, then uses the stochastic frontier analysis (SFA) method to analyze the change of economic growth technical efficiency after the introduction of land factors as supplement to the existing research in theory.

Research methods and models

Stochastic frontier production function models were created by Aigner, Lovell and Schmidt and developed by Meeusen and Vanden Broeck in 1977. Specifically, the determination of the stochastic production frontier model can be expressed as Formula 1:

$$y_{it} = f(x_{it}, t, \beta)e^{-\mu_{it}} \quad 或 \ln y_{it} = \ln f(x_{it}, t, \beta) - \mu_{it} \qquad (1)$$

Moreover stochastic error term is added into stochastic production frontier to reflect the measurement error, economic fluctuation and various kinds of uncontrollable random factors，, which can be expressed as Formula 2:

$$y_{it} = f(x_{it}, t, \beta)e^{-\varepsilon_{it}} \ ，其中 \varepsilon_{it} = \nu_{it} - \mu_{it}, u_{it} \geq 0 \qquad (2)$$

Among the formula 2 the vector x_{it} on behalf of the various factor inputs of region i at time t an β is the coefficient vector to be estimated, while t represents the time trends can be used as a proxy variable of technical change. as the random error, ε_{it} is consisted of the two independent variables , ν_{it}和μ_{it},which cannot be observed but independent of each other. As shown in formula 3, ν_{it} is on behalf of the bilateral error term of random noise and obey the distribution $N(0, \sigma_v^2)$, while μ_{it} stands for the unilateral error term of output-oriented technical inefficiency.

$$\mu_{it} = \delta_{it} + \varpi_{it} \qquad (3)$$

Among them, the Z_{it} represents the external environment variables influencing technology inefficiency, δ represents external environment variable coefficients in the inefficient equation. If suppose inefficient factors does not change with time, $\mu_{it}=\mu_i$; If suppose inefficient factors change over time, $\mu_{it} = \exp\{-eta(t - T_i)\} * \mu_i$. ϖ_{it} obey nonnegative normal distribution $N^+(0, \sigma_\mu^2)$, and μ_{it} obey distribution of $N^+(\delta Z_{it}, \sigma_\mu^2)$ homoplastically.

As has been pointed out that although the mainstream economics usually only consider the role of capital and labor, but regard land element inputs effect as part of the improvement of resources allocation in the generalized technology progress when considering the influence of resources endowment on economic growth, however, a large number of Chinese scholars' researches on the land inputs' impact on the economic growth have proved that: land input has great effect on economic growth factors of land. As a result, this article maintains the inputs including capital K, labor N and land L, and chooses the cobb-douglas production function which is constructed by some scholars introducing land element as the form of $f(x_{it}, t, \beta)$, in order to further estimate technical efficiency $Te_{it} = E[\exp(-\mu_{it})|\varepsilon_{it}]$ as Formula 4.

$$\ln Y_{it} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \beta_3 \ln N_{it} \qquad (4)$$

Model estimation and analysis

Variable and data sources

This article selects 2002-2012 panel data on China's 30 provinces and cities random boundary analysis, exclude the Hong Kong special administrative region, Macao special administrative region and Taiwan region. The measurement of output Y is the provincial GDP and measurement for labor input L is the total number of employees of whole society in different province, The measurement of land element N is the urban construction land area.In terms of the estimate of provincial material capital stock 1952-2000 proposed by Zhang (2004), this paper applies the perpetual inventory method to calculate the 2002-2012 provincial material capital stock data. To avoid Philips and Sul (2007)′s questions of so-called "base year prices index", all the data when making price deflator are discount to 2000 as the base period. Three be estimated parameters β_1、$\beta_2$andβ_3 respectively measure the elasticity of capital, labor and land to the output; I stands for province, I = l, 2,... 31; T stands for time, T = l, 2,... 11. Investment in fixed assets, nominal GDP and employment data are from China statistical yearbook and the data of urban construction land area comes from the urban construction statistical yearbook.

Estimation and test results

Technical efficiency estimation before and after the introduction of land element

Based on the above theoretical analysis, this paper applied FRONTIER Version 4.1 software for 2002-2012 panel data on China's 30 provinces panel stochastic frontier analysis, as the estimate eta is very close to zero and only under the 5% significant level, so we can impose constraints eta = 0, in accordance with hypothesis that the technical efficiency in ten years does not change with time, respectively to estimate the average technical efficiency before and after the introduction of land element. Model estimation results are shown in Table 1. Thereinto (1) and (2) respectively present estimation results of stochastic frontier production function before and after the introduction of land of random boundary production function.

Tab.1 Comparison results of stochastic frontier estimate of production function before and after the introduction of land element

estimated parameters	(1) Before	(2)after
β_1	0.263***	0.157***
	(0.027)	(0.027)
β_2	0.804***	0.757***
	(0.009)	(0.011)
β_3	—	0.201***
		(0.031)
_cons	-0.499***	-0.763***
	(0. 181)	(0.136)
N	300	300
sigma2	0.1698***	0.0805***
	(0.0444)	(0.0220)

gamma	0.9634***	0.9272***
	(0.0105)	(0.0211)
log likelihood	272.0972	291. 0377
LR test	337.2228	227.3056
mean efficiency	0.7062	0.7897

mu and eta is restricted to be zero

Standard errors in parentheses，* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As can be seen from table 1, each coefficient of Model estimation results is very significant and conforms to the theoretical expectations. The coefficients of lnK and ln_L are significant before and after the introduction of land element, and the sum is close to 1, according with the economic significance of Cobb-Douglas production function. The likelihood ratio tests (LR test) were respectively 337.2228 and 227.3056, refusing the null hypothesis of non technical efficiency. However, after the introduction of land elements, the coefficients of lnK and ln_L, β_1 and β_2 both have varying degrees of decline, while the coefficient of land element ln_N (0.201) shows significant, which means land elements have important positive effect on economic growth, its output is even more flexible than the output elasticity of labor input (0.157), but China's economic growth still belongs to a kind of capital-driven growth (0.757).

In table 1, gamma stands for the specific value of variance σ_μ^2 and total variance $\sigma_\mu^2+\sigma_v^2$ in the inefficient technology part of the error term, which is not only significant and close to 1, showing that deviation mainly produced in the technology of production frontier efficiency rather than the measurement error. At the same time, in accordance with $Te_{it} = E[\exp(-\mu_{it})|\varepsilon_{it}]$,the paper calculated the average technical efficiency of land element. The results suggest that after the introduction of land element, the average technical efficiency of economic growth increases (average technical efficiency increased from 0.7062 to 0.7897), and showing that the introduction of land has important influence on the technical efficiency of economic growth. The reason may be that, at the research point, land policies are regarded as an instrument of macroeconomic regulatory and the government is trying to implement the land policy to limit the proportion and time of land element in economic construction and investment, in order to "gas" the under cooling macroeconomic and "brake" the overheating macroeconomic. Therefore land element shows a positive effect on technical efficiency. In the process of land policy participating in macro regulation and control, land prices, land tax, land planning, land finance and land management mechanisms etc. cooperate fiscal, monetary and industrial policies implemented, to a large extent affected the government's fiscal income, income redistribution, industrial structure and industrial layout, and so on. In addition, through the adjustment of the comparative balance, land supply and demand could reach a dynamic balance, which benefit in promoting the development of the macroeconomic scale, speed and structure optimization, and contributing to the urbanization process while speeding up transformation of economic growth mode. Namely, the introduction of land element tames the short-term fluctuations and ensures a long-term stable economic growth, thus straightening the deviation of the best production efficiency in theory and increasing the

average technical efficiency of China's economy. At the same time, the average technical efficiency still has some room to be improved, which means in the future or for a period of time land element still can promote economic growth by technical efficiency improvement and land-related macro-control is still sustainable for economic development at present.

Comparison of technical efficiency estimation results in different regions

Since China is a large country with vastly different regional resources and social and economic development situations, on the basis of the previous researches, this article apply stochastic frontier analysis to further calculation on the changes of average technical efficiency in different provinces before and after the introduction of land, in order to clarify how the land elements affect the average technical efficiency in different areas and provide a basis for the discrepant formulation of land macro-control policies. the estimated results are shown in table 2.

Tab.2 Comparison of the provincial average technical efficiency change before and after the introduction of land element

region	before	after	variation	region	before	after	variation
Beijing	0.9657	0.9571	-0.0086	Hunan	0.6992	0.8149	0.1157
Shanghai	0.9846	0.9103	-0.0743	Guangdong	0.9666	0.9742	0.0076
Tianjin	0.9353	0.9856	0.0503	Hainan	0.7411	0.8591	0.1180
Sichuan	0.5674	0.6493	0.0819	Guizhou	0.5266	0.6665	0.1399
Hebei	0.6790	0.7866	0.1076	Yunan	0.5519	0.7005	0.1486
Shanxi	0.7631	0.8720	0.1089	Shanxi	0.6049	0.7395	0.1346
Liaoning	0.7135	0.7282	0.0147	Gansu	0.6173	0.7310	0.1137
Jilin	0.6838	0.7303	0.0465	Qinghai	0.5669	0.7599	0.1930
Heilongjiang	0.7900	0.7993	0.0093	Inner Mongolia	0.7858	0.8539	0.0681
Jiangsu	0.7589	0.8066	0.0477	Guangxi	0.6659	0.7955	0.1296
Zhejiang	0.7970	0.8683	0.0713	Tibet	0.5654	0.7253	0.1599
Anhui	0.5637	0.6487	0.0850	Ningxia	0.5851	0.6620	0.0769
Fujian	0.8318	0.9777	0.1459	Xinjiang	0.6470	0.6932	0.0462
Jiangxi	0.6172	0.7461	0.1289	Eastern average	0.8104	0.8558	0.0454
Shandong	0.6877	0.7422	0.0545	Central average	0.6611	0.7649	0.1038
Henan	0.6525	0.7675	0.1150	Western average	0.6077	0.7251	0.1175
Hubei	0.6706	0.7400	0.0694	National average	0.7062	0.7897	0.0835

Notes：The eastern region including Beijing, Shanghai, Tianjin, Hubei, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan, Liaoning, Jilin and Heilongjiang 13 provinces and cities (including the northeast region); The central region including Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan 6 provinces and cities; In the western region including Inner Mongolia, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinxiang, etc. 11 provinces and cities

As can be seen in the table 2, there are considerable technical efficiency differences among the Chinese provincial areas which illustrate that land elements different effect on technical efficiency of economic growth. Before the introduction of land elements, average technical efficiency of

Guizhou is the minimum at 0.5266, while average technical efficiency of Shanghai is the maximum at 0.9846. However, after introducing land element, average technical efficiency of Tianjin rank the first position with 0.9856 and Anhui is the lowest as 0.6487. Moreover, the influence of the factors on the economic and technological efficiency is ranged from 0.0743 to 0.1930, the reason may be that corresponding land policy demand of different provinces are likely be varying as regional social and economic development level and the resources endowment are not identical. For instance, hilly ground such as Guizhou may hanker for land policies to utilize low hills gentle slope due to the limitation of resources, while rapid developing region such as Zhejiang would like to get more construction land index by policies as "urban and rural construction land increase and decrease linked" to overcome land resource bottleneck. In addition, policy implementation details also distinguish from each other, which is to say, a national policy tend to focus on different goals in different regions when participating in macroeconomic regulation and control. In the case of land consolidation, Heilongjiang is one of the major grain producing areas in the northeast plain and the land policy mainly focus on agricultural land consolidation to ensure the grain security. Nevertheless, Northwest inland arid ecologically fragile area such as Qinghai tend to lay emphasis on ecological environmental renovation to improve the overall environmental quality of land resources. In these ways, land elements are likely to result in different effects on the technical efficiency in diverse areas.

It also can be seen that land element has positive influence on 28 provinces except for Beijing and Shanghai. The reason may be that for the two municipalities in high social and economic development level, the market system construction has been quite perfect but generally land supply is slightly strict in the past period which may improve the market friction and affect allocation of fixed-asset investment and Labor input, leading to a great deviation of the best production efficiency in theory. And for the rest of the 28 provinces， Land policies in macroeconomic regulation and control, have promoted the urbanization process in different extent and propel industrial structure adjustment and industrial development, which play a positive role in the average technical efficiency. As can be seen from the figure 1,the effect of land element presents in a ladder distribution: the impacts on the technical efficiency changes of land factor in Guangdong, Heilongjiang, Jilin, Liaoning, Xinxiang, Jiangsu are between 0.00 ~ 0.05, while the infection of Tianjin, Shandong, Inner Mongolia, Hubei, Zhejiang, Ningxia, Sichuan, Anhui and other places ranges from 0.05 to 0.10, and the affection of Hubei, Shanxi, Gansu, Henan, Hunan, Hainan, Jiangxi, Guangxi, Guizhou, Fujian, Shanxi, Yunnan vary between 0.10 and 0.15. Further, the changes of technical efficiencies caused by land element in Tibet and Qinghai are even more than 0.15. It can be inferred that land policy has lower impact on the technical efficiency in more developed regions, but on the opposite, the land policy can effectively promote the economic growth in most undeveloped cases, which is to say, the more economically backward areas are, the more significant land element impact is.

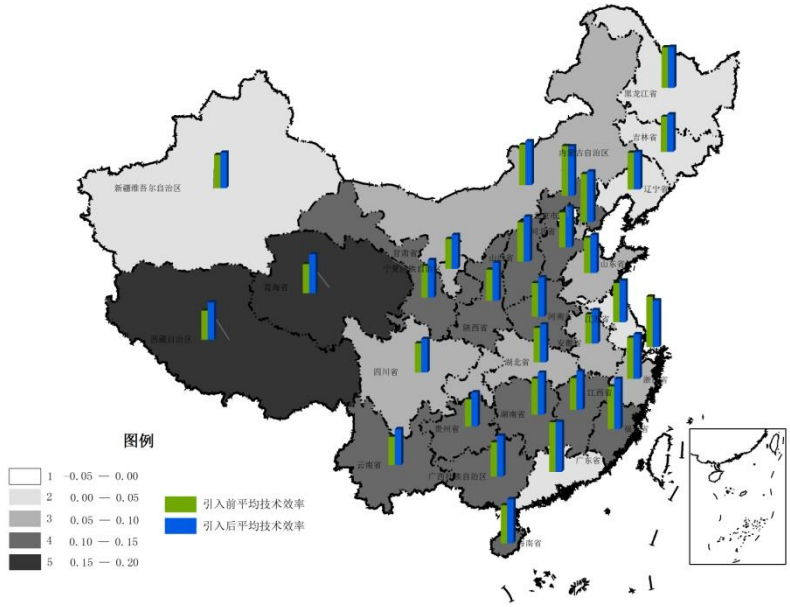

Fig.1 Differential effects of land element on regional technical efficiency

From the point of three regions, eastern regions' technical efficiency are the highest (0.8104) before and after the introduction of land whatsoever, following is the central section (0.6611) and western part is the lowest (0.6077). However the influence of land element on the economic efficiency occupies the first position in the west as 0.1175 and that of central section is 0.1038,both higher than that in the eastern region (0.0454). It can be concluded that since the land policy in macroeconomic regulation and control, land element plays the biggest role in the western region, due to the low technical efficiency in the western region itself on one hand. On the other hand, the western region have no obvious advantages of capital and labor factors and only through land elements to promote the improvement of technical efficiency and economic growth. This means that the differentiation of land macro-control should fully consider the regional characteristics, and further to give more advantageous, scientific and reasonable land policies to promote China's regional economic coordinated development, especially in the central and western regions. Moreover, the Midwest region itself should also focus on the promotion of technical efficiency, impelling output to the production frontier. In terms of the eastern region with higher technical efficiency and smaller interval to be improved, they should relent land policy's limitation on macroeconomic regulation and control appropriately and further strengthen its scientific technology innovation in order to propel production frontier forward through technology progress, promoting the economic sustainable development.

Conclusions and recommendations

On the basis of the literature review, this paper applies a stochastic frontier analysis about the effect of land factors on China's economic and technical efficiency, by using Douglas Production Function with land elements. Measurement empirical analysis shows that the role of the land element of China's economic growth is significant: the introduction of land

elements has some positive effect (0.0835) on the whole-element technical efficiency of economic growth. The reason may be that the land macro-control could promote the optimization in scale, speed, structure and other aspects of macroeconomic development, promote the urbanization process, coordinated regional economic development and economic growth mode, and improve the efficiency of resource allocation to ensure long-term sustainable stable economic growth currently. Meanwhile this paper discusses the different technical efficiency changes among various regions before and after the introduction of land element, which shows the impact of land on the technical efficiency are quite different in different regions (ranging from-0.0743 to 0.1930 with ladder distribution), because of various regional socio-economic development levels, different resource endowments, and discrepant implement of regional land policy. The results indicate that the land factor have relatively lower impact on technical efficiency in the developed areas of the economy, while in the economically backward area , land tend to have a significant impact on technical efficiency, effectively promoting economic growth. In addition, it can be found when comparing the three regions that land elements reflects the highest effect (0.1175) on the average technical efficiency of economic growth in the western region, but lowest impact(0.0454) on average technical efficiency of economic growth in the eastern region, though the technical efficiency (0.1038) is highest there.

Based on the empirical research above, mainly recommendations on land policy offered in this paper include: First, land macro-control has a role on in promoting the technical efficiency of economic growth, food security, urban development red line and ecological protection lead to the necessity of macro-control of land. Therefore the target of land policy as a macro-control measure should be further clarified to coordinating the efficient allocation of resources, protecting of the technical efficiency of economic growth, and promoting long-term sustainable economic growth. Second, main policy tools of the macro-control of land should be adjusted. We shall improve the land market and build long-term mechanism to protect its effective operation, suit land supply mechanism, pricing policies and administrative means to local conditions: the more initial level of economic and social development, the more attention of the role of macro-control policies of land. To the long term we shall regard further reform of land system as a guarantee of technical efficiency and sustainable economic growth. Third, according differences of land elements impact on technical efficiency, formulate corresponding policies and measures in the light of local conditions: Due to China's vast geopolitical different and significant differences of resource endowments between regions, the capacity and effectiveness of land policy in different regions in the macro-control has great difference. The government should give more support of land-related policy to the central and western regions, to improve the economic efficiency and growth in those areas; At the same time, we should appropriately relax the intensity of macroeconomic regulation and control of land in economically developed eastern regions and municipalities, to protect the

market functioning in a natural, orderly and reasonably manner and to encourage technological progress to promote sustainable economic growth.

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