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Analyzing the Effect of Local Government Competition on Green Total Factor Productivity From the Market Segmentation Perspective in China—Evidence From a Three-Stage DEA Model

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Under both Chinese-style fiscal decentralization (vertical competition) and promotion tournament systems (horizontal competition), the economic development system used by the government determines whether local government competition significantly influences green total factor productivity (GTFP). Moreover, market segmentation, an important strategic tool for local government competition, will significantly impact GTFP because of the implied changes in production efficiency and blocked factor flows. This study applies GMM and the mediation effect model to explore the relationship between local government competition and GTFP from the market segmentation perspective using statistical data from 30 provinces from 2006 to 2017 in China. Overall, our results demonstrate that local government competition significantly inhibits GTFP promotion. Local government competition also has a negative impact on GTFP by promoting market segmentation. As a mediating variable, the market segmentation coefficient was statistically significant. Considering regional heterogeneity, in the eastern region, local government competition has no significant inhibitory effect on GTFP. Moreover, market segmentation has no intermediary effect. In the central and western regions, GTFP remains significantly inhibited by local government competition, and the mediation effect of market segmentation is significant. Finally, our empirical results are robust.

Keywords: local government competition, market segmentation, green total factor productivity, mediation effect, China

INTRODUCTION

In the past 40 years of reform and opening-up, China's economy has achieved a "growth miracle," with gross domestic product surging from approximately 367.9 billion to 99 trillion yuan in 1978 and 2019, respectively[1]. Simultaneously, eco-damage and environmental pollution have followed one after another, and emissions of pollutants such as industrial waste haze and greenhouse gases

[1]See in more detail: http://www.stats.gov.cn/.

continue to surge (Ahmed et al., 2020; Lin et al., 2021). The China Ecological Environment Status Bulletin 2019 shows that among the 337 prefecture-level cities, 180 exceeded the ambient air quality standard, accounting for 53.4%[2]. Moreover, the problems of a suboptimal energy structure and low-energy utilization efficiency are more prominent. China's coal consumption has since comprised more than 60% of the total energy consumption. Therefore, although extensive growth modes such as high capital input, high consumption of resources, and high environmental pollution have created an economic "growth miracle," the ecological and social benefits have been seriously undermined, causing China's economy to suffer from the low output and low efficiency (Wu et al., 2020a; Wang J. et al., 2021). Currently, China's economy is in a critical period of transforming development, optimizing economic structure, and changing growth momentum. Promoting efficient change and achieving green economic development has become the major direction of China's future economic development (Ouyang et al., 2019; Zhang et al., 2020). Normally, improving green total factor productivity (GTFP) can become a win-win situation for both economic and environmental performance. Therefore, for China to nurture high-quality economic development in the new era, the deep-rooted motives damaging coordinated development of the economy and environment and further improving GTFP must be determined.

In this context, the worldwide scholarly community has explored various perspectives concerning the causes of ecological degradation (Can et al., 2021a; Ahmed et al., 2021; Yang et al., 2021a). Many scholars attribute the inefficiency of Chinese environmental governance and its ecological plight to the "bottom-to-bottom competition" among local governments in environmental governance. That is, local governments compete to seek lower environmental regulation standards to entice financial and technological resources, resulting in environmental degradation (Zhang et al., 2021). Particularly, after the 1994 tax reform formalized the fiscal decentralization system, competition among local governments increased significantly, as induced by the "GDP-only" performance appraisal system. However, under constrained resources, the environmental problems caused by chaotic competition among local governments are gradually intensifying (Qian and Weingast, 1997). Meanwhile, under the goal-oriented approach of economic growth, local governments inadvertently compete to weaken environmental regulations and shelter-polluting industries regardless of ecological costs, which, in turn, has an essential impact on GTFP.

Market segmentation occurring alongside local government competition in China is often overlooked (Bai et al., 2019). Since China's reform and opening-up, the central government has been reassigning power to local governments, including decentralizing fiscal and taxation, investment and financing, and enterprise management authorities. Although decentralization helps stimulate local development, this process also directly contributes to increasing local protectionism. Local protectionism occurs when local governments protect their key industries through administrative interventions in factor markets, setting trade barriers, or using invisible preferential policies for local economic interests, resulting in market segmentation (Li and Lin, 2017). Market segmentation not only contributes to distorting the economic operation system but also does not facilitate the optimal allocation of factor resources (Hou and Song, 2021). The Chinese government has implemented a series of policy practices to reduce the constraints of market segmentation on economic operations and factor flows. Moreover, China's socialist market economic system has gradually improved in recent years. While the degree and scale of marketization have led to substantial development, the degree of market segmentation has gradually declined (Li et al., 2003). However, because of the constraints of institutional and stage factors, such as the household registration system, non-marketization of interest rates, fiscal decentralization, political promotion tournaments, and enterprise rent-seeking, the development of China's factor market still lags. Existing institutional and regional segmentation results in the non-marketization of labor, capital, energy, and resource allocation, which easily affects the GTFP (Duanmu et al., 2018; Zhang et al., 2021).

Currently, China still has a negative situation of local disorderly competition and market fragmentation. Combining a competent government and an effective market is an essential way to promote GTFP. Therefore, under regional green development, ecological civilization construction, and proper handling of government-market relationships, exploring how to endow the efficiency shift and power shift of economic operations through market and government actions is highly significant for facilitating GTFP improvement to empower high-quality economic development. This study has the following objectives. Based on a more comprehensive portrayal of the relationship between local government competition, market segmentation, and GTFP, we empirically analyze the mechanism of local government competition on GTFP from a market segmentation perspective. Simultaneously, this study must further confirm and explain the following key questions. In the context of competition for economic growth, is local government competition a significant contributor to GTFP? If market segmentation has a transmission effect, is there regional heterogeneity in the effect of market segmentation on GTFP? How does local government competition act on GTFP through market segmentation? Solving these problems would be of great theoretical and practical significance for realizing the transformation of the mode of competition for local governments and breaking the situation of market segmentation to promote the construction of a new mechanism of green development in China from the perspective of the connection between the government and the market.

The marginal contribution of this study is as follows. First, based on the actual market-oriented system reform situation, this study brings local government competition, market

[2]See in more detail: http://www.mee.gov.cn/hjzl/sthjzk/zghjzkgb/202006/P020200602509464172096.pdf.

segmentation, and GTFP into a unified analysis framework. We then discuss the influence mechanism of local government competition on GTFP by market segmentation. This not only enriches the green development theory but also provides a new research perspective for exploring sustainable economic development. Second, a three-stage EDA model was applied for measuring the GTFP. Considering the bias of controlling endogenous estimation, we verify the intrinsic mechanisms of local government competition, market segmentation, and GTFP to determine the dynamic path of urban green development. Third, from the regional heterogeneity perspective, this study analyzes the enhancement or offsetting of the effect of local government competition on GTFP through market segmentation. Our results can provide some guidance for more accurate analyses of the possible problems and drawbacks of the Chinese government and the scientific formulation of relevant policies. Finally, this paper provides a policy basis and theoretical support for developing countries similar to China's economic development.

The following research arrangements are as follows. *Literature review* presents a review of studies related to local government competition, market segmentation, and GTFP. *Three-stage DEA model* presents a three-phase DEA model to measure and analyze GTFP. *Methods* includes the construction of the empirical model and the description of variables. *Results* briefly describes the empirical results. *Discussion* presents the analysis and discussion of the results. Finally, *Conclusion and policy implications* summarizes the study and provides the corresponding policy suggestions.

LITERATURE REVIEW

Local Government Competition and Green Total Factor Productivity

As the economic growth leader and executor of environmental protection policy, the local government's competitive behavior has significant influence on regional economic growth and environmental quality, and this has been examined by scholars. However, few studies have directly examined the effect of local government competition on GTFP. Most existing literature focus on how local government competition affects economic growth or environmental quality. Two views support that economic growth is affected by local governments. The first is that government competition can significantly promote regional economic growth (Oates, 1999). Keen and Marchand, (1997) believe that local government competition can limit the interests of special interest groups, which are beneficial for regional economic development. Hence, under China's special political system, local governments generally use public expenditure and tax policy adjustments to compete for liquidity resources, which inevitably lead to strategic competition (Yılmaz, 2013; Chirinko and Wilson, 2017). Yan et al. (2013) analyzed the path of local government competition on economic growth and found that local governments can encourage investment and accelerate economic growth through land price competition and land revenue expenditure competition. Finally, the diversity of government competition behaviors (financial resource, fiscal expenditure, and infrastructure competition among local governments) and environmentally friendly goods, contributes to local governments having positive effects on economic growth (Hatfield and Kosec, 2013; Deng and Xu, 2013; Yushkov, 2015; Canavire-Bacarreza et al., 2019; Ding et al., 2019).

Second, local government competition inhibits regional economic growth. Some scholars believe that the government increases the intensity of tax incentives and introduces regional competition into the "competition towards the bottom line" to attract residents, enterprises, and capital to the region. The direct consequence is the reduction in the supply capacity of government public goods (Can et al., 2021b). From this perspective, local government competition harms economic growth by distorting tax burdens, reducing the efficiency of resource allocation, and widening regional economic disparities (Cai and Treisman, 2004; Aaberge et al., 2019; Pan et al., 2020; Thanh et al., 2020). Su et al. (2021) highlight that behaviors such as local protectionism, industrial isomorphism, over-investment, and investment wars accompanying the competition process eventually inhibit regional economic growth. Guang-Bin (2005) argues that while administrative decentralization and tax incentives cause local government competition, it does not necessarily help increase investment in infrastructure and local protectionism. However, inter-governmental opportunism and gaming are the important factors affecting economic development. Additionally, Qingwang and Junxue (2009) argued that the 1994 tax-sharing reform significantly changed the pattern of strategic interaction between local governments, effectively curbing competition between extreme regions and significantly weakening competition between local governments, inhibiting regional economic growth. Using a panel dataset of 63 provinces in Vietnam from 2006 to 2017, Thanh and Nguyen (2021) found that decentralization drives significant differences in TFP between high and low self-financing provinces. However, decentralization in high self-financing provinces results in bottom-up competition because of governance reforms. Finally, some scholars have highlighted the uncertainty of local government competition in economic growth. Tang et al. (2011) highlighted that local government competition is a deep-rooted cause of investment impulses in provinces. This, in turn, causes economic fluctuations in China's macroeconomic regulation.

There may be two aspects wherein environmental pollution is affected by local governments: *bottom-to-bottom* competition and *top-to-top* competition. In the case of bottom-to-bottom competition, local governments may compete for high-quality resources, relax environmental control, and indulge enterprises' pollution emission behaviors to encourage promising enterprises to enter the local area. This will lead to environmental degradation and form the "bottom-to-bottom competition" effect of environmental pollution (Oates and Portney, 2003; Banzhaf and Chupp, 2012; van der Kamp et al., 2017; Kuai et al., 2019). Cumberland, (1980) believed that competition among governments would reduce pollution supervision of enterprises and cause environmental deterioration. Meanwhile,

under fiscal decentralization, environmental concerns will be ignored (Li et al., 2019). Under top-to-top competition, the local government may improve local environmental supervision standards and transfer pollutants to other areas by adopting more stringent environmental policies to improve the local environmental quality, which forms the "top-to-top competition" effect (Glazer, 1999; List and Gerking, 2000; Albornoz et al., 2009; Haufler and Maier, 2019). Levinson (2003) argued that government competition will help the government prioritize the ecological environment, create environmental conditions for attracting investment, and improve environmental quality. Yan (2012) found that fiscal decentralization can significantly weaken investment in environmental governance through government competition, which, in turn, has positive impact on environmental pollution. Zhang et al. (2021) applied a spatial autoregressive (SAR) model to confirm that local government competition exacerbates haze pollution under factor market distortions.

Market Segmentation and Green Total Factor Productivity

As an equilibrium result of local government competition, market segmentation is mainly manifested in the fact that local governments hinder the cross-regional flow of resources through financial support and policy preference to protect local enterprises and the economy from external fierce impact (Ke, 2015). Since Young (2000) proposed the existence of market segmentation in China, many scholars have discussed the many aspects of market segmentation. Additionally, researchers have found significant differences in the effect of market segmentation on GTFP in different periods (Duffee, 1996; Bancel et al., 2009; Guesmi et al., 2014). In the short term, market segmentation may be conducive to promoting GTFP. Pan et al. (2020) highlighted that local governments have an incentive to divide the market in terms of economic aggregate, fiscal revenue, and employment stability. For example, market segmentation allows local governments to not only protect the market share of local enterprises but also support the development of enterprises with poor local competitiveness and vulnerable industries. Therefore, the local government can obtain sustainable economic growth and more fiscal and tax revenue in the region, which will promote GTFP (Weitzman, 1989; McNabb and Whitfield, 1998).

However, in the long run, interregional market segmentation hinders the flow of factors and spatial mismatch of resources. On the one hand, market segmentation inhibits the free flow of production factors such as resources, energy, and labor among regions. This results in a low level of efficiency in the use of production factors and failure of economies of scale (Poncet, 2003; Hsieh and Klenow, 2009; Hubbard, 2014). For example, Hou and Song (2021) noted the positive spillover effects of market integration on GTFP not only within regions but also in neighboring regions. Simultaneously, in the market segmentation, local protectionism prevails and collusion between government and enterprises is serious, which leads to a lack of fairness and marketization in energy and resource distribution. This significantly inhibits resource allocation and utilization efficiency and, in turn, the improvement of GTFP. Qin et al. (2020) found that market segmentation exacerbates the control of oligopolistic firms in the market, which not only compresses the survival space of SMEs but also severely inhibits the efficiency of factor allocation. On the other hand, market segmentation also hinders diffusion and spillover of technological innovation and regional technical cooperation to a certain extent, which makes applying and promoting new energy-saving and emission-reducing technologies across regions through marketization difficult (Duanmu et al., 2018; Jiang et al., 2020; Zhang et al., 2020). Additionally, trade barriers formed by market segmentation worsen the benign competition between markets, resulting in enterprises losing the power and pressure of technological innovation (Bai et al., 2004; Epifani and Gancia, 2011; Ye and Zhang, 2017). Sun C. et al. (2020) suggested that market segmentation negatively affects the environmental efficiency of the electricity sector by inhibiting technological innovation, and this phenomenon is more significant in regions with poorer institutional quality. Market segmentation also indirectly affects GTFP through the channels of industrial structure, productivity, export trade, investment promotion, and so on (McNabb and Whitfield, 1998; Anouliès, 2016; Chen and Huang, 2016). For example, Bai et al. (2019) highlighted that market segmentation intensifies competition among regions and increases the incentive for local governments to sacrifice the ecological environment for economic growth. This reduces the threshold of environmental regulation and environmental law enforcement, which has negative impact on GTFP. Cheng and Jin (2020) found that agglomeration economies significantly enhance GTFP by improving technical efficiency and technological progress significantly. However, market segmentation can encourage local protectionism, ultimately negatively impacting regional economic growth efficiency. Lai et al. (2021) highlight that market segmentation has an inverted U-shaped effect on the current and future industrial transformation of the region, which is key in improving GTFP.

In summary, a rich theoretical framework and research basis have been proposed by previous scholars to elaborate on the mechanism among local government competition, market segmentation, and GTFP. However, the relationship among the above three needs further discussion. Current research focuses on the impact of local government competition on economic growth and environmental pollution and the relationship between market segmentation and GTFP. Research on local government competition on GTFP in China from the market segmentation perspective is lacking. For instance, Jin et al. (2020) found that excessive cross-jurisdictional competition has a negative impact on GTFP, while moderate competition is important for promoting GTFP. Moreover, Song et al. (2018) reached a similar conclusion. Bin et al. (2016) revealed that strategic decentralization by local governments contributes to GTFP and positively moderates the dampening effect of FDI on GTFP. When measuring market segmentation, scholars mostly consider market segmentation in the product market as a characterization index, which lacks the analysis of market

segmentation in other markets. Therefore, this study applies the three-stage DEA model to measure the GTFP from 2006 to 2017. Additionally, market segmentation is incorporated into the framework of local government competition on GTFP. Additionally, the mediation effects model and the generalized method of moments model were used to examine the transmission mechanisms of market segmentation, which further broadened and refined existing research related to GTFP.

THREE-STAGE DEA MODEL

Three-Stage DEA

The relative efficiency of the decision-making unit (DMU) is affected by many factors, such as management inefficiency, statistical noise, and environmental factors. However, the traditional DEA model attributes environmental factors and statistical noise to management inefficiency, which will conceal real efficiency value. Additionally, the analysis of relative efficiency is only affected by management factors. Therefore, to filter and remove the impact of nonoperating factors on efficiency to allow measured efficiency values to more accurately reflect the efficiency level of decision evaluation units, this study uses a three-stage DEA model to measure GTFP (Fried et al., 2002). Through stochastic Frontier analysis, the effects of environmental factors and statistical noise on relative efficiency were effectively eliminated to ensure the robustness of calculation efficiency.

First Stage: Undesirable-Outputs Model

This study selects an undesirable output model (Shyu and Chiang, 2012; Lu et al., 2020). The undesirable output model includes desirable output and undesirable output, which can effectively reduce the influence on raw data changes and subjective factors. The model takes the following form: Set $DMU(X_0, Y_0)$, X_0 is the input, Y_0 is the output. Y_0 includes desirable output (Y^g) and undesirable output (Y^b), that is, $DMU(X_0, Y^g, Y^b)$. Let the production possibility set be $P = \{(x, y^g, y^b) | x \geq X\lambda, y^g \leq Y^g, y^b \geq Y^b\lambda, L \leq e\lambda \leq U, \lambda \geq 0\}$. The specific model is as follows:

$$\rho^* = min \frac{1 - \frac{1}{m}\sum_{i=1}^{m} \frac{s_{i0}^-}{X_{i0}}}{1 + \frac{1}{s}\left(\sum_{r=1}^{s_1} \frac{s_r^g}{y_{r0}^g} + \sum_{r=1}^{s_2} \frac{s_r^b}{y_{r0}^b}\right)} \tag{1}$$

$$Subject\ to \begin{cases} x_0 = X\lambda + s^- \\ y_0^g = Y\lambda - s^g \\ y_0^b = Y\lambda + s^b \\ L \leq e\lambda \leq U \\ s^-, s^g, s^b, \lambda \geq 0 \end{cases} \tag{2}$$

Here, if $\rho^* = 1$, $s^{-^*} = 0$, $s^{g^*} = 0$, $s^{b^*} = 0$, DMU is effective; otherwise, it is not, and, hence, the efficiency value has room for improvement. The efficiency value obtained by undesirable output-bad outputs-C is the comprehensive technical efficiency (TE). The efficiency value obtained from undesirable output-bad outputs-V is pure technical efficiency (PTE). The ratio of Te to PTE was scale efficiency (SE). Through efficiency decomposition, the main factors affecting the comprehensive efficiency value can be measured.

Second Stage: SFA Regression

Because the relative efficiency obtained in the first stage is easily affected by management inefficiency, environmental factors, and statistical noise, this study uses stochastic Frontier analysis (SFA) to incorporate the above factors into a stochastic Frontier analysis model based on input redundancy. Simultaneously, this study takes the input redundancy value of each decision-making unit obtained in the first stage as the explanatory variable. Environmental factors were selected as the explanatory variables. Through regression and adjustment of the SFA, the decision-making units are introduced in the same external environment. The SFA regression model is constructed as follows:

$$S_{mj} = f^m\left(Z_j, \beta^m\right) + \nu_{mj} + u_{mj}, m = 1, 2\cdots, M, j = 1, 2\cdots, N \tag{3}$$

where $S_{mj} = x_{mj} + X_m\lambda$ represents the redundancy value of the M_{th} input variable of the j_{th} DMU in the first stage. Subsequently, Z_j represents the unbalanced regional development factor of the jth DMU, β^m is the parameter estimation value for the unbalanced variable of regional development, and u_{mj} denotes the random interference term.

Then, we use the regression results of the SFA model $(\hat{\beta}^m, \hat{\sigma}_{vm}^2, \hat{\sigma}_{um}^2)$ to adjust the input items of each decision-making unit. All decision-making units are adjusted to the same external environment and the same random disturbance state to obtain PTE excluding other influencing factors. The adjustment method was selected to increase the investment of decision-making units with better external nonoperating factors. The adjustment of the input of each decision-making unit is as follows:

$$\begin{aligned} x_{mj}^A = x_{mj} + \left[max\left\{f^m\left(Z_j, \hat{\beta}^m\right)\right\} - f^m\left(Z_j, \hat{\beta}^m\right)\right] + \left[max\left\{\hat{\nu}_{mj}\right\}\right. \\ \left. - \hat{\nu}_{mj}\right]; m \\ = 1, 2\cdots, M; j = 1, 2\cdots, N \end{aligned} \tag{4}$$

where x_{mj}^A represents the adjusted value of the M_{th} mth input variable of the j_{th} DMU. $[max\left\{f^m(Z_j, \hat{\beta}^m)\right\} - f^m(Z_j, \hat{\beta}^m)]$ means adjusting all the decision-making units to the same external environment. $[max\left\{\hat{\nu}_{mj}\right\} - \hat{\nu}_{mj}]$ adjusts the random interference of all decision-making units in the same situation. To obtain the estimated value of the random error $(\hat{\nu}_{mj})$, following Jondrow et al. (1982), the following equation is established:

$$\hat{E}\left[\nu_{mj} | \nu_{mj} + u_{mj}\right] = S_{mj} - f^m\left(Z_j, \hat{\beta}^m\right) - \hat{E}\left[u_{mj} | \nu_{mj} + u_{mj}\right] \tag{5}$$

$$E\left[u_{mj} | \nu_{mj} + u_{mj}\right] = \mu_* + \sigma_* \frac{f\left(-\mu_*/\sigma_*\right)}{1 - F\left(-\mu_*/\sigma_*\right)} \tag{6}$$

where $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\mu_* = -\sigma^2\varepsilon/\sigma^2$, $\sigma_*^2 = -\sigma_u^2\sigma_v^2/\sigma^2$, $\varepsilon = S_{mj} - f^m(Z_j, \hat{\beta}^m)$. By introducing the corresponding estimation value, this article can get ν_{mj}.

Third Stage: Constructing a Green Total Factor Productivity Index

The adjusted input value and original output value obtained in the second stage are introduced into the undesirable output model to calculate the relative efficiency. Using the regression results of the second stage, we adjust the input of each decision-making unit to keep the output unchanged. The relative efficiency value excluding environmental factors and statistical noise is obtained using the undesirable outputs model. Finally, the efficiency value is analyzed, and that based on the GTFP index is constructed.

Index Selection and Data Processing

This study estimates the GTFP of China under environmental constraints. The input variables, desired outputs, undesired outputs, and environmental variables are treated as follows:

Input variables. Capital stock, labor, and energy are required in the production process. Capital stock is measured by the regional total investment in fixed assets and the fixed assets investment price index. The specific calculation equation is as follows:

$$K_{it} = I_{it} + (1 - \delta_{it})K_{it}$$

where K, I, δ are the capital stock, investment, and depreciation rates, respectively. For depreciation rate processing, Zhang et al. (2004) establish the capital depreciation rate of each province as 9.6%. Moreover, the data to the capital stock are deflated at a constant price in 2006. The employment number of urban units in various provinces is used as the index of labor input. Considering differences in factor endowment, energy consumption scale, and structure in different regions, the energy consumption of coal, natural gas, electricity, oil, and heat is converted into the final energy consumption with a unit of ten thousand tons of standard coal as the measurement index of energy input (Sun et al., 2019; Zhao et al., 2020).

Output variables. The desired outputs are expressed as the GDP of the provinces. Considering the price changes, this study takes 2006 as the base period to deal with the constant price of GDP. Six types of pollution indicators were selected to measure undesired outputs, including industrial sulfur dioxide emissions, total industrial wastewater emissions, industrial nitrogen oxide emissions, industrial smoke (powder) dust emissions, industrial chemical oxygen demand (COD) emissions, and industrial ammonia nitrogen emissions.

Environment variable. Simar and Wilson (2007) highlighted that environmental variables should satisfy the so-called separation hypothesis, that is, select those factors that have an impact on GTFP but are not within the subjective control range of the sample. Therefore, financial development, urbanization, industrial structure, and openness are regarded as environmental variables of the GTFP. Financial development is reflected in per capita GDP (Zhao et al., 2020). The index for measuring the degree of urbanization is the resident population divided by the total population at the end of the year (Sun et al., 2014). This study uses the added value of the tertiary industry divided by the added value of the secondary industry to measure industrial structure (Yang et al., 2021b). Openness is based on the total FDI amount of foreign direct investment (Wu et al., 2020b).

TABLE 1 | Regression results of the first stage.

DMU	1-TE	1-PTE	1-SE
Beijing	1.000	1.000	1.000
Tianjin	0.947	0.957	0.990
Hebei	0.485	0.526	0.921
Shanxi	0.344	0.367	0.938
Inner Mongolia	0.720	0.732	0.985
Liaoning	0.464	0.489	0.950
Jilin	0.505	0.534	0.946
Heilongjiang	0.541	0.555	0.973
Shanghai	1.000	1.000	1.000
Jiangsu	0.872	1.000	0.872
Zhejiang	0.641	0.676	0.948
Anhui	0.502	0.522	0.963
Fujian	0.672	0.696	0.966
Jiangxi	0.512	0.535	0.956
Shandong	0.720	0.909	0.793
Henan	0.503	0.538	0.934
Hubei	0.561	0.584	0.961
Hunan	0.561	0.590	0.951
Guangdong	1.000	1.000	1.000
Guangxi	0.509	0.535	0.950
Hainan	0.697	1.000	0.697
Chongqing	0.506	0.533	0.949
Sichuan	0.512	0.539	0.949
Guizhou	0.362	0.429	0.843
Yunnan	0.404	0.433	0.932
Shaanxi	0.473	0.493	0.960
Gansu	0.378	0.446	0.846
Qinghai	0.311	1.000	0.311
Ningxia	0.267	0.673	0.397
Xinjiang	0.333	0.377	0.884
Mean	0.577	0.656	0.892

Calculation Results of Green Total Factor Productivity in China

First-Stage Estimation Results

In the first and third stages, DEA solver Pro 5.0 is used to measure the efficiency value. **Table 1** shows that when ignoring the interference of environmental factors and random errors, the average value of GTFP, *PTE*, *SE* is 0.404, 0.433, and 0.932, respectively. This indicates that the efficiency value can still be significantly improved. Overall, the level of GTFP is not high, and it is mainly restricted by the low level of *PTE*. From the value of each province, the GTFP of Beijing, Shanghai, and Guangdong are relatively high, with a value of 1.000, reaching the DEA efficiency situation and being at the forefront of production efficiency. However, the GTFP of Hebei, Shanxi, Shaanxi, Gansu, Ningxia, and Xinjiang, and the other 10 regions are all less than 0.500, and DEA is in a situation of inefficiency, demonstrating that the provinces have some room to improve in *PTE* or *SE*. *TE* is easily disturbed by environmental factors and random errors, which cannot reflect the real situation of the efficiency value. Therefore, further separating the environmental factors and random errors to obtain the *TE* under the same conditions is necessary.

TABLE 2 | Regression results of the second-stage (SFA).

Variables	Labour input slack	Capital stock input slack	Energy consumption input slack
Financial development	3.9,974,084	628.00353	1,058.7633***
	(0.348)	(1.592)	(3.268)
Urbanization	275.70503***	12,061.05***	−2,815.4045***
	(4.959)	(41.257)	(−29.867)
Industrial structure	−12.179,611	−1,359.0588	−1,165.9285***
	(−0.841)	(−1.402)	(−4.470)
Openness	−76.642,066***	−9,408.2617***	−1,183.8227**
	(−5.119)	(−17.428)	(−2.304)
σ^2	23,400.543***	168,382,550***	27,400,435***
	(8.926)	(168,379,690.000)	(27,377,432.000)
γ	0.90,311,339***	0.85,452,375***	0.90,873,159***
	(56.810)	(76.185)	(137.123)
Constant term	−138.85609***	−3,014.0564***	1731.6898***
	(−3.662)	(−5.061)	(2.766)
Log function value	−0.1967	−0.3618	6,54,320,000
LR test	306.68914***	323.48504***	447.6203***

*Note: T statistics are put in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01.*

TABLE 3 | Regression results of the third stage.

DMU	3-TE	3-PTE	3-SE
Beijing	1.000	1.000	1.000
Tianjin	0.866	0.978	0.885
Hebei	0.591	0.631	0.936
Shanxi	0.387	0.498	0.777
Inner Mongolia	0.621	0.707	0.877
Liaoning	0.553	0.596	0.926
Jilin	0.534	0.674	0.792
Heilongjiang	0.574	0.720	0.797
Shanghai	1.000	1.000	1.000
Jiangsu	1.000	1.000	1.000
Zhejiang	0.715	0.753	0.950
Anhui	0.542	0.633	0.857
Fujian	0.709	0.791	0.896
Jiangxi	0.505	0.652	0.775
Shandong	0.835	0.926	0.902
Henan	0.576	0.620	0.928
Hubei	0.615	0.679	0.906
Hunan	0.626	0.706	0.886
Guangdong	1.000	1.000	1.000
Guangxi	0.504	0.642	0.786
Hainan	0.412	1.000	0.412
Chongqing	0.532	0.676	0.787
Sichuan	0.591	0.639	0.924
Guizhou	0.343	0.578	0.593
Yunnan	0.416	0.574	0.725
Shaanxi	0.513	0.630	0.813
Gansu	0.336	0.613	0.549
Qinghai	0.196	1.000	0.196
Ningxia	0.180	0.788	0.229
Xinjiang	0.333	0.520	0.641
Mean	0.587	0.741	0.792

The Second-Stage Estimation Results

Hence, urban unit employment, capital stock, and energy consumption relaxation are considered dependent variables. Stock SFA regression model is then established with four external environmental variables: financial development, urbanization, industrial structure, and openness as independent variables. **Table 2** indicates that the LR one-sided test has passed the significance test. This demonstrates that the SFA method has strong applicability. σ^2 and γ values passed the significance test of 1%, which showed that compared with v_{mj}, the interference of environmental factors was more significant. Moreover, this proves that a strong relationship between the slack of input factors and selected environmental variables exists. Simultaneously, most of the environmental variables passed the significance test for input slack. Among them, financial development has a significant negative correlation with capital investment slack, a significant positive correlation with energy input slack, and no correlation with labor input slack. This shows that a higher level of financial development increases energy consumption. Urbanization has a positive relationship between labor force and capital investment slack, and there is a significant negative relationship with energy investment slack. Industrial structure, which reflects industrial competition, has no significant impact on the slack of personnel and asset investment. However, it has significant negative impact on energy slack. This may be because China's industrial focus is gradually shifting from the secondary industry to the tertiary industry. Moreover, knowledge-intensive industries are gradually replacing labor-intensive industries, thus significantly reducing energy consumption. Openness in the labor force, capital, and energy slack are significantly negative, showing that the improvement in regional openness is a positive factor for GTFP.

The Third-Stage Estimation Results

After eliminating environmental factors and statistical noise, the efficiency of the third stage changed significantly compared with that of the first stage. This indicates that it is not objective and realistic to attribute all the factors affecting efficiency to management factors without eliminating environmental factors and statistical noise. **Table 3** shows that after the second stage of adjustment, the average value of GTFP is 0.587, which is higher than the preadjustment efficiency value, but still at a low level.

This shows that enterprises can achieve the original output level even if the input is reduced by 41.3% by improving resource utilization efficiency and management. The average value of the adjusted *PTE* is 0.741, which is a small distance from the front of the efficiency and forms a great contrast with the value before adjustment. The higher level of *PTE* confirms that China's high-tech industry has a higher level of *TE* of China's high-tech industry. This indicates that the state and enterprises attach great importance to technological innovation and have achieved certain results in recent years.

The average value of *SE* of the third stage is 0.792, which is lower than the level before adjustment, and room for improvement at 20.8% remains. This is because enterprises overly focus on the application of technology but neglect moderate-scale production. Compared with the first stage, the *TE* and *PTE* increased by 0.010 and 0.085, respectively, whereas the *SE* decreased by 0.100. The adjusted efficiency results show that the low GTFP is mainly caused by the low level of SE. From the data of each province, Beijing, Shanghai, Jiangsu, and Guangdong are at the forefront of the adjusted production efficiency. Compared with before the adjustment, the number of regions with GTFP values less than 0.500 decreased to 7. This demonstrates that environmental variables have a significant impact on the GTFP in different regions.

METHODS

Model Construction

For analyzing GTFP, most scholars ignore the systematic bias that can result from time-lagged effects. Therefore, this study introduces a one-period lag of the explanatory variables into the benchmark model to constitute a more accurate dynamic panel model, which enables the dynamic interpretation of the model. However, generally endogenous problems in the dynamic models exist. To solve the endogeneity problem, Arellano and Bond (1991) proposed a generalized method of moments (GMM) using instrumental variables to derive the appropriate moment conditions, known as the "Differential Generalized Method of Moments (DIFF—GMM)." The basic principle of the method is to first perform a first-order difference transformation on the original model to eliminate the individual heterogeneous terms in the model. Then, for the transformed difference equation, the lagged variables of the endogenous variables are treated as instrumental variables of the endogenous variables. Although the DIFF-GMM approach reduces the impact of endogeneity on model estimation, DIFF-GMM suffers from a serious "weak instrumental variable" issue in the limited sample condition, resulting in worse accuracy of coefficient estimation results. A solution to this problem was proposed by Arellano and Bover (1995), who proposed the "system generalized method of moments (SYS-GMM) approach" based on a new composite moment condition. The SYS-GMM approach not only provides simultaneous estimation of the original model and the differentially transformed model but can also correct for unobserved individual heterogeneity issues, omitted variable bias, measurement error, and potential endogeneity that often affect model estimation when using mixed OLS and fixed effects methods. Additionally, the SYS-GMM approach reduces the potential bias because of the use of first-order DIFF-GMM estimation approaches. Based on this, the two types of methods of SYS-GMM and DIFF-GMM are chosen to analyze the research problem, where the DIFF-GMM plays more of a robustness check role and the SYS-GMM reflects more of the estimation results of the research issue[3]. The equation is set as follows:

$$GTFP_{it} = \beta_0 + \beta_1 GTFP_{it-1} + \beta_2 ECU_{it} + \sum_{k=3}^{8} \beta_k X_{it} + \varepsilon_{it} \quad (7)$$

where *i* represents the province, *t* represents the year, and *GTFP* represents the green total factor productivity. *ECU* is a local government competition. *X* denotes a series of control variables, including government expenditure (*GOV*), human capital (*HUM*), marketization (*MAR*), intellectual property protection (*PRO*), per capita road area (*ROA*), and informatization (*MES*). ε_{it} is the disturbance term[4].

The mediation effect model uses the third variable to explore the internal mechanism of the independent variable influencing the dependent variable. If local government competition (*ECU*) can affect GTFP by market segmentation (*MSEG*), market segmentation can be used as a mediation variable. Following Baron and Kenny (1986), considering the time lag of GTFP, this study constructs regression models as shown in **Eq. 8** and **Eq. 9** to the indirect effect of local government competition on GTFP. To determine the robustness of the mediation effect and reduce the model's possible endogeneity, the system generalized method of moments (SYS-GMM) and differential generalized method of moments (DIFF-GMM) are applied to estimate the model.

$$MSEG_{it} = \delta_0 + \delta_1 MSEG_{it-1} + \delta_2 MSEG_{it} + \sum_{k=3}^{8} \delta_k X_{it} + \varepsilon_{it} \quad (8)$$

[3]Meanwhile, appropriate instrumental variables can make the estimation results more accurate, thus the Sargan test or Hansen test for the validity of instrumental variables is necessary. The validity of the moment condition can be performed by Sargan test or Hansen test with the original hypothesis that all instrumental variables are exogenous. Therefore, if the instrumental variables are valid, the original hypothesis should not be rejected. However, Iqbal and Daly (2014) argued that the Sargan test method is valid only if the disturbance term is homoskedastic. In addition, Bowsher (2002) suggested that the Sargan test is difficult to reject the original hypothesis when the sample size is small and the instrumental variable is usually considered valid, while the original hypothesis of serially uncorrelated errors is over-rejected in one-step GMM estimation. In view of the above-mentioned disadvantages of the Sargen test and the fact that the Hansen test is often used in practice, the Hansen test is chosen in this article to test the validity of the instrumental variables.

[4]Discussion on the disturbance term (ε_{it}). GMM cannot be used as a consistent estimator unless the disturbance terms are not autocorrelated. To ensure that the moment conditions are not over-constrained, the number of instrumental variables cannot be more than the number of endogenous variables. If lagged endogenous and weakly exogenous variables are used as valid instrumental variables, the absence of autocorrelation in the current disturbance terms (ε_{it}) in the underlying model is necessary. The above situation implies that the disturbance terms (ε_{it}) of the difference model have significant first-order correlation and insignificant second-order autocorrelation. For this reason, we used Arellano-Bond tests for first-order serial and second-order serial correlations in the first-order difference residuals.

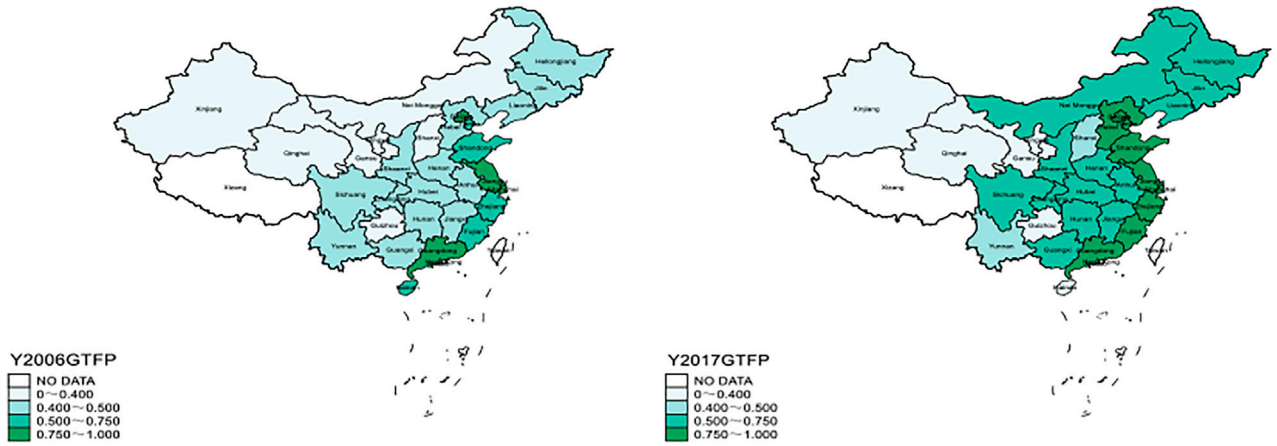

FIGURE 1 | China's GTFP in 2006 and 2017.

$$GTFP_{it} = \varphi_0 + \varphi_1 GTFP_{it-1} + \varphi_2 ECU_{it} + \varphi_3 MSEG_{it} + \sum_{k=4}^{9} \varphi_k X_{it} + \varepsilon_{it} \tag{9}$$

Here, *MSEG* is the mediation variable. If δ_2 and φ_3 are significant, local government competition is implied to have an impact on GTFP by market segmentation, and the mediation effect is $\delta_2 \times \varphi_3$. According to Iacobucci (2012), the discriminant equation for the mediation effect is as follows:

$$Z_{mid} = \frac{Z_\delta \times Z_\varphi}{\sqrt{Z_\delta^2 \times Z_\varphi^2}} \tag{10}$$

The biggest advantage of this method is that the probability of making the first kind of error in statistics is very low, which is usually lower than the significance level, thus ensuring results validity. Z_{mid} in **Eq. 10** determines the significance of the mediation effect when the variable is continuous. In **Eq. 10**, δ represents the influence coefficient of the independent variable (*ECU*) to the mediation variable (*MSEG*) and the mediation variable (*MSEG*) to the dependent variable (*GTFP*). Z_δ and Z_φ are the Z values of the coefficients a and the coefficient δ, respectively.

Variables Specification

1) Explained variables. GTFP is measured by the third-stage efficiency measured by the three-stage DEA model. Additionally, this article uses Stata 15.0 software to draw the distribution map of China's GTFP. Owing to limited space, this study only lists the distribution of GTFP in 2006 and 2017. **Figure 1** shows that considering geographical distribution, areas with higher GTFP are mainly concentrated in the eastern coastal areas, such as Beijing, Tianjin, Guangdong, Shandong, Fujian, Shanghai, and Jiangsu. However, with time, the number of green areas in China has gradually increased. The promotion of GTFP mainly spreads from the eastern coastal areas to the central region, which shows that the green development policy implemented by China has achieved remarkable results. Although the Chinese government has since faced serious environmental pollution, the central government has always prioritized the construction of ecological civilization and implemented a strict environmental protection system. Simultaneously, the construction of ecological civilization is constantly emphasized by the central government in the assessment indicators of local government officials. These encourage local government officials to prioritize the green elements of economic growth and promote the GTFP.
2) Core explanatory variables (*ECU*). The government can not only compensate for market deficiency and enhance the standardization of the market mechanism through appropriate administrative intervention but also compel the market to play a decisive role in resource allocation to lead the current trend of economic development. However, the extensive development mode of local government's blind pursuit of GDP growth increases undesired input and output, decreases investment in environmental governance, and increases the difficulty of ecological protection. Therefore, local government competition is characterized by the economic catch-up level of (*ECU*). Referring to Miao et al. (2017), this study selects the adjacent province dimension and the national provincial dimension to jointly determine the economic catch-up level of each province. The calculation method is as follows:

$$ECU = \frac{NGDP_{it}}{LGDP_{it}} \times \frac{WGDP_{it}}{LGDP_{it}} \tag{13}$$

Among them, *NGDP* is the highest per capita GDP of neighboring provinces, *WGDP* is the highest per capita GDP of all provinces in China, and *LGDP* is the per capita GDP of this province.

3) Mediation variables. Based on the above theoretical analysis, this study selects the market segmentation index as the mediation variable. However, the trade law, production method, and specialization index method used in the existing literature to measure market segmentation have inherent defects, and forming a panel database is difficult (Naughton, 1999; Young,

2000; Poncet, 2003; Bai et al., 2004). Therefore, referring to Shao et al. (2019), this study adopts the relative price index analysis method to measure 65 pairs of market segmentation indices of neighboring provinces and then merges the 65 pairs of indexes of adjacent provinces to obtain the market segmentation index of each province and its adjacent provinces. For instance, Beijing's market segmentation index is the average value of the market segmentation index between Beijing and Tianjin, and between Beijing and Hebei. The market segmentation indices of other provinces and cities adopt the same calculation method. Thus, a total of 360 (= 30 × 12) market segmentation observations are obtained, which show the changes in the market segmentation degree of 30 provinces and all adjacent provinces.

4) Control Variables.

This study selects the following control variables while eliminating the environmental variables that affect GTFP.

Government expenditure (*GOV*). Increased government spending will stimulate production and demand, which will undoubtedly play a greater role in promoting GTFP. Referring to Hao et al. (2020), government expenditure is measured as the ratio of fiscal expenditure to GDP.

Human capital (*HUM*). Human capital is an important source of economic growth. Improving the human capital level has a more significant effect on the improvement of GTFP. According to Wu et al. (2020a), human capital is measured by the number of years of education per capita in each province.

Marketization (*MAR*). Improving the marketization level will lead to the expansion of economic scale and improvement of market potential. However, it will also lead to an increase in polluting enterprises and an in total pollution. Following Li (2015), the proportion of employees in non-state-owned enterprises in various provinces and cities was used to measure the MAR marketization level of marketization (*MAR*).

Intellectual property protection (*PRO*). Intellectual property protection promotes the continuous development of innovation by ensuring that the achievements of innovation subjects are not infringed and ultimately affect the GTFP. Referring to Kim et al. (2012), this study uses the quotient of technology market transaction volume and GDP to measure intellectual property protection (*PRO*).

Transport infrastructure (*ROA*). The degree of transportation convenience can enhance the factor flow between different regions and affect the GTFP of the region. This study uses the per capita road area of each city to measure the level of traffic infrastructure (*ROA*) (Sun X. et al., 2020).

Informationalized level (*MES*). The improvement of information level can promote the speed of information dissemination, and then have an impact on GTFP (Yang et al., 2021b). This article uses per capita posts and telecommunications to measure the level of informatization (*MES*).

Data Sources

The original data used in the above variables are derived from the China Environmental Statistical Yearbook, China Financial Statistical Yearbook, China Energy Statistical Yearbook, Provincial Statistical Yearbook, China Macro Statistical database, and China Labor Force Statistical Yearbook. **Table 4** shows the multicollinearity test and the descriptive statistics of the data. The variance inflation factor (VIF) of each variable is less than 10, so the multicollinearity problem of the explanatory variables is within the controllable range[5].

TABLE 4 | Variables description.

Variables	N	Mean	Sd	min	max	VIF
GTFP	360	0.587	0.241	0.139	1	—
ECU	360	4.719	3.556	0.553	21.56	1.87
GOV	360	0.222	0.0962	0.0837	0.627	1.50
HUM	360	8.800	0.980	6.594	12.50	3.13
MAR	360	0.708	0.106	0.440	0.899	1.83
PRO	360	0.0105	0.0230	0.000172	0.160	2.32
ROA	360	3.936	2.267	0.000167	10.94	1.94
MES	360	0.177	0.163	6.22e-06	1.438	1.70
MSEG	360	0.0266	0.0248	0.00518	0.271	1.08

RESULTS

Benchmark Regression Results

To verify the robustness of the results, the regression results of the system random effect model, fixed effect model, SYS-GMM, and DIFF–GMM models are presented (see **Table 5**). The coefficients of *L.GTFP* are significantly positive, demonstrating that GTFP is affected by the early stage. In columns (3)–(6), the *p* values of AR (2) and Hansen statistics are greater than 0.1. This demonstrates that it is reasonable to include the first lag term of *GTFP* into the model for regression, and the selection of instrumental variables is effective. In Columns 1) and (2), the impact of *ECU* on GTFP is negative but not significant. Columns 3) and (5), respectively, represent the regression results of SYS-GMM and DIFF-GMM without control variables. Columns 4) and 6) show the regression results of the dynamic GMM after adding control variables. It was found that local government competition significantly inhibited GTFP at the 1% level[6].

Transmission Mechanism Analysis

In the following, based on the double mechanism test of the SYS-GMM and DIFF-GMM models, the transmission mechanism is analyzed from the path of market segmentation (see **Table 6**). The results of the AR 2) test in Columns (1)–6) show that there is no second-order autocorrelation in random error terms, and the Hansen test results show that the selection of instrument variables is effective. Columns 1) and 4) imply that local government competition inhibits the GTFP. The estimation coefficients of local government competition in Columns 2) and 5) are significantly positive, indicating that regional competition intensifies market segmentation. In Column (3), the estimated coefficients of *ECU* and the coefficients of *MSEG* coefficient are significantly negative. After calculation, Z_{mid} values are 2.07 and 3.14, respectively. The mediation effect indicates the existence of a

[5]Following Hair et al. (1995), when the tolerance of the independent variable is greater than 0.1, a range of variance inflation factors less than 10 is acceptable.

TABLE 5 | Benchmark regression results.

Variables	RE	FE	SYS-GMM		DIF-GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
L.GTFP			0.962***	0.803***	0.537***	0.439***
			(397.42)	(53.28)	(233.41)	(21.35)
ECU	−0.004	−0.001	−0.007***	−0.008***	−0.053***	−0.032***
	(−0.83)	(−0.11)	(−15.75)	(−3.62)	(−65.19)	(−3.59)
GOV	−1.205***	−0.154		−0.496***		0.230
	(−6.22)	(−0.57)		(−6.67)		(1.57)
HUM	0.112***	0.067**		0.008		−0.030***
	(4.00)	(2.07)		(1.27)		(−7.81)
MAR	0.466***	0.437**		0.685***		1.285***
	(2.78)	(2.43)		(12.30)		(7.93)
PRO	0.186	−0.841		0.468		2.972**
	(0.17)	(−0.63)		(1.07)		(2.37)
ROA	0.061***	0.056***		−0.005		−0.000
	(6.26)	(4.98)		(−1.58)		(−0.00)
MES	0.016	−0.027		−0.033		−0.132***
	(0.22)	(−0.39)		(−1.22)		(−5.28)
AR (1)			−1.98	−1.93	−1.82	−1.87
			[0.048]	[0.054]	[0.069]	[0.061]
AR (2)			1.26	1.22	1.19	0.91
			[0.207]	[0.224]	[0.233]	[0.361]
Hansen test			28.70	24.61	26.84	26.01
			[0.991]	[0.989]	[0.997]	[0.986]
Constant	−1.900***	−1.691***	0.022***	−0.497***		
	(−8.79)	(−7.30)	(16.81)	(−8.76)		
N	360	360	330	330	300	300

*Note: T statistics are put in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01; Z values are put in [].*

mediation effect of market segmentation, that is, local government competition, inhibits GTFP through market segmentation.

Regional Heterogeneity

Given China's unique geographical conditions and strong heterogeneity of resource endowment, significant differences in the forms of local government competition exist, leading to great differences in performance incentives in the eastern and central-western regions (Wu et al., 2021). Therefore, this study divides the research samples into eastern, central, and western regions to analyze the regional heterogeneity of the results of this study (see **Table 7**).

The AR (2) test results show that there is no second-order autocorrelation in the random error term. The Hansen test shows that the instrumental variable selection is effective. In columns 1)–(3), the effect of local government competition (*ECU*) on (*GTFP*) and market segmentation (*MSEG*) is not significant in the eastern region, indicating that *ECU* will not significantly inhibit GTFP. Local government competition does not cause market segmentation. The mediation effect of market segmentation on local government competition and GTFP does not exist. Column 4) shows that *ECU* in the central-western region inhibits the GTFP. Column 5) shows that *ECU* promotes market segmentation in the central-western region. The estimated coefficients of *ECU* and *MSEG* in column 6) are negative and significant at the 5% level. By calculation, the Z_{mid} value is 1.91, more than 1.65, which indicates that the mediation effect of market segmentation on local government competition and GTFP exists in the central-western regions.

Robustness Test

Referring to Zhang et al. (2019), competition intensity (SF) is used as the local government competition proxy variable, and the specific measurement method is as follows:

$$SF = \frac{1}{TAX}, \quad TAX = \frac{LTAX - PTAX}{LGDP} \tag{14}$$

where TAX is the tax burden level, $LTAX$ is the local tax revenue, $PTAX$ is the personal income tax, and $LGDP$ is the local GDP. This study tests the robustness of the above results by using the OLS, FE and RE, SYS−GMM, and DiFF-GMM models (see **Table 8**). The local government competition in Columns (1)–(5) inhibits the improvement of GTFP, and Columns (1), (3), and (5) indicate that local government competition inhibits the growth of GTFP. **Table 9** shows the results of the robustness test for the mediation effect. The results of the national and regional mediation effect tests show that the mediation effect of market segmentation exists and shows regional heterogeneity. As all test results are consistent with the previous study, the conclusion of this article is robust.

DISCUSSION

Discussion of Benchmark Regression Results

Table 5 indicates that the local government's competition policy, intended to match the economic level of the surrounding areas or the economically developed regions in China, will reduce GTFP

TABLE 6 | Transmission mechanism analysis.

Variables	SYS-GMM			DIFF-GMM		
	(1) GTFP	(2) MSEG	(3) GTFP	(4) GTFP	(5) MSEG	(6) GTFP
L.GTFP	0.803***		0.529***	0.439***		0.380***
	(53.28)		(35.79)	(21.35)		(14.95)
ECU	−0.008***	0.002***	−0.030***	−0.032***	0.005***	−0.036***
	(−3.62)	(3.26)	(−5.64)	(−3.59)	(4.70)	(−6.50)
GOV	−0.496***	0.009	−1.187***	0.230	0.111***	0.511***
	(−6.67)	(1.08)	(−14.45)	(1.57)	(4.09)	(5.81)
HUM	0.008	−0.013***	0.083***	−0.030***	−0.036***	−0.065***
	(1.27)	(−7.66)	(8.42)	(−7.81)	(−23.47)	(−4.33)
MAR	0.685***	−0.017*	0.564***	1.285***	0.067***	1.325***
	(12.30)	(−1.66)	(7.38)	(7.93)	(3.78)	(20.18)
PRO	0.468	0.297***	−0.759*	2.972**	0.367	5.045***
	(1.07)	(7.33)	(−1.93)	(2.37)	(1.22)	(4.22)
ROA	−0.005	0.003***	−0.010**	−0.000	0.007***	−0.006
	(−1.58)	(3.68)	(−2.03)	(−0.00)	(5.13)	(−0.94)
MES	−0.033	0.026***	0.055***	−0.132***	0.023***	−0.106**
	(−1.22)	(6.66)	(2.78)	(−5.28)	(7.85)	(−2.53)
L.MSEG		0.146***			0.235***	
		(13.46)			(11.06)	
MSEG			−0.310***			−1.183***
			(−2.69)			(−4.23)
AR (1)	−1.93	−2.33	−1.85	−1.87	−2.52	−1.86
	[0.054]	[0.020]	[0.064]	[0.061]	[0.012]	[0.063]
AR (2)	1.22	−0.89	1.01	0.91	−1.23	0.92
	[0.224]	[0.373]	[0.315]	[0.361]	[0.218]	[0.360]
Hansen test	24.61	27.37	26.74	26.01	23.23	26.62
	[0.989]	[1.000]	[1.000]	[0.986]	[0.918]	[0.184]
Z_{mid}	2.07	3.14				
Constant	−0.497***	0.113***	−0.961***			
	(−8.76)	(9.41)	(−12.53)			
N	330	330	330	300	300	300

*Note: T statistics are put in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01; Z values are put in [].*

in **Table 5**. Our findings differ from those of Jin et al. (2020), who confirm that local government competition exhibits an inverted U-shaped relationship with GTFP. However, Hong et al. (2020) and Zhang et al. (2021) argued that unregulated competition among local governments contributes to deterioration of environmental quality and reduction of GTFP. Hence, the above results can be interpreted from the following perspectives: to obtain significant economic growth performance, local governments will spare no effort to compete for production factors, enrich the mode of production, and increase the scale of economic growth to maximize economic performance in a limited term (Keen and Marchand, 1997; Oates, 1999; Canavire-Bacarreza et al., 2019). However, most productive projects with small investments and quick results are concentrated in the secondary industry and are both characterized by high pollution and high-energy consumption, which may not be conducive to promoting GTFP (Yushkov, 2015). Second, local governments will also have horizontal competition in terms of fiscal expenditure. For example, local governments prefer to invest in projects such as high-return, quick-impact infrastructure, and expansion of traditional businesses and reduce spending on environmental protection and energy conservation. Additionally, local governments often ignore the slow-acting and heavily invested public services represented by environmental governance, which leads to continued environment deterioration. Finally, owing to the externality of environmental governance, local governments in adjacent regions have been unable to control pollution to prevent free-riding and have fallen into the prisoner's dilemma. Hence, local governments have no incentive to prevent and control pollution, further inhibiting GTFP.

Discussion of Transmission Mechanism Analysis

Columns 1) and 4) indicate that local government competition inhibits GTFP improvement in **Table 6**. Columns 2) and 5) indicate that interregional competition intensifies market segmentation. In Column (3), the local government competition (*ECU*) coefficient and market segmentation coefficient are significantly negative. Z_{mid} value is 2.07 and 3.14, respectively. This indicates that local government competition inhibits GTFP by market segmentation. Our findings adhere to those obtained by Wang J. et al. (2021) and Hou and Song (2021), which also fulfilled our expectations. Hence, market segmentation is conducive to protecting the

TABLE 7 | Regional heterogeneity.

Variables	Eastern region			Central—western regions		
	(1) GTFP	(2) MSEG	(3) GTFP	(4) GTFP	(5) MSEG	(6) GTFP
L.GTFP	1.273***		0.622*	0.711***		0.783***
	(2.69)		(1.93)	(23.65)		(30.04)
ECU	0.257	0.005	0.265	−0.030***	0.006***	−0.017**
	(1.41)	(0.71)	(1.30)	(−3.20)	(3.23)	(−2.05)
GOV	−2.697***	−0.042	−8.965***	−1.144***	0.018	−0.378***
	(−3.10)	(−0.30)	(−3.00)	(−9.25)	(0.66)	(−4.13)
HUM	−0.093	−0.001	0.592***	−0.018	0.010**	−0.030
	(−0.45)	(−0.07)	(2.86)	(−0.52)	(2.15)	(−0.93)
MAR	−1.955	−0.101**	−0.689	−0.253*	−0.043**	0.284
	(−1.22)	(−2.04)	(−0.29)	(−1.78)	(−2.30)	(1.63)
PRO	10.759	−0.072	−5.146**	2.573*	−0.181	−0.949
	(1.17)	(−0.22)	(−2.38)	(1.82)	(−0.76)	(−0.30)
ROA	0.134	0.005	0.065	0.008	0.003***	0.015***
	(1.39)	(1.62)	(0.64)	(0.70)	(2.89)	(2.66)
MES	−0.254	0.048***	0.246	−0.102***	0.033***	0.024
	(−1.04)	(3.51)	(0.93)	(−2.79)	(4.70)	(0.35)
L.MSEG		0.353**			0.478***	
		(2.01)			(10.46)	
MSEG			4.652			−1.990**
			(1.49)			(−2.36)
AR (1)	−1.74	−2.44	−1.12	−1.53	−2.04	−1.62
	[0.081]	[0.015]	[0.262]	[0.126]	[0.041]	[0.106]
AR (2)	0.77	−1.02	−0.98	1.43	0.76	1.42
	[0.439]	[0.309]	[0.326]	[0.154]	[0.450]	[0.155]
Hansen test	2.90	6.19	1.36	17.10	12.80	16.28
	[1.000]	[1.000]	[1.000]	[0.516]	[0.172]	[1.000]
Z_{mid}	0.64	1.91				
Constant	1.436	0.057	−4.769***	0.552*	−0.091*	0.094
	(0.67)	(0.51)	(−3.51)	(1.93)	(−1.74)	(0.43)
N	110	110	110	209	209	209

*Note: T statistics are put in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01; Z values are put in [].*

market share of local enterprises in backward areas and supporting development of local enterprises with poor competitiveness and weak industries (Bian et al., 2019). Therefore, local governments in the region receive sustained economic growth and more tax revenue while they close the local market to ensure employment of local labor, leading to regional non-specialization and factor market segmentation.

Market segmentation inhibits the free flow of production factors such as resources, energy, and the labor force among regions (Young, 2000). The production activities in some regions with relatively abundant energy and resource endowments are limited because of insufficient matching of production factors (Li and Lin, 2017). Meanwhile, in market segmentation, local government intervention leads to a lack of normal and necessary market competition, and there is much collusion between governments and enterprises (Shao et al., 2019). Local governments manage the initial distribution of natural resources, especially that of energy and other production factors. Hence, a close relationship with the government enables enterprises to acquire advantages in price or tilt in quantity in resource allocation, which puts enterprises not closely related to the government in an inferior position because of the lack of fairness in the market environment (Li and Lin, 2017). The above results lead to a lack of fairness and marketization in the distribution of energy and resources, which seriously reduces the allocation efficiency and ultimately inhibits GTFP (Duanmu et al., 2018; Bian et al., 2019; Jiang et al., 2020).

Discussion of Regional Heterogeneity

In the eastern region, local government competition will not significantly inhibit GTFP and promote market segmentation. The mediation effect of market segmentation on local government competition and GTFP does not exist. Our findings are reasonable in that they are also a useful supplement to the studies of Hou and Song (2021), Wang X. et al. (2021), and Zhang et al. (2021). Economic development in the central and western regions is not as good as that in the eastern regions. Moreover, there are a large number of enterprises, and most of which produce light industrial products and high-tech products (Zhang et al., 2021). The performance evaluation standards of the government departments were relatively high. When pursuing economic growth targets, they also prioritize sustainable economic development, presenting a situation of "top-to-top competition" (Wu et al., 2020a). Additionally, the eastern region is rich in capital and labor resources, and the

TABLE 8 | Test results of direct effect robustness.

Variables	OLS	FE	RE	SYS-GMM	DIFF-GMM
	(1)	(2)	(3)	(4)	(5)
L.GTFP				0.798***	0.468***
				(30.90)	(21.96)
SF	−0.012***	−0.0000327	−0.008*	−0.013***	−0.021***
	(−3.48)	(−0.01)	(−1.72)	(−7.52)	(−12.56)
GOV	−2.563***	−0.149	−1.354***	−0.702***	0.223***
	(−15.65)	(−0.49)	(−6.09)	(−7.04)	(2.99)
HUM	0.069***	0.068**	0.104***	−0.022***	−0.031***
	(3.35)	(2.11)	(3.72)	(−4.29)	(−4.66)
MAR	0.274*	0.439**	0.447***	0.805***	1.198***
	(1.84)	(2.42)	(2.67)	(15.65)	(20.94)
PRO	0.812	−0.861	0.058	0.690	2.359**
	(1.06)	(−0.64)	(0.05)	(1.31)	(2.33)
ROA	0.055***	0.056***	0.060***	0.003	−0.002
	(8.01)	(4.93)	(6.10)	(0.62)	(−0.49)
MES	0.332***	−0.027	0.039	−0.044	−0.072***
	(3.51)	(−0.38)	(0.54)	(−1.19)	(−3.53)
AR (1)				−1.98	−1.96
				[0.048]	[0.050]
AR (2)				1.26	1.12
				[0.209]	[0.261]
Hansen test				27.56	25.34
				[0.968]	[0.989]
Constant	−0.963***	−1.703***	−1.683***	−0.155***	
	(−4.40)	(−6.21)	(−6.58)	(−4.93)	
N	360	360	360	330	300

*Note: T statistics are put in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01; Z values are put in [].*

abundance of certain factor resources also weakens the influence of distortion of the factor resource allocation brought about by this type of market segmentation, thus weakening the inhibition of GTFP.

However, Columns (4)–6) indicate that the mediation effect of market segmentation on local government competition and GTFP exists in the central and western regions. On the one hand, owing to the relative lack of financial funds, when local governments implement capital market segmentation, local enterprises lack the necessary funds to innovate and improve their productivity. Hence, enterprises cannot achieve scale expansion and technology upgrade. Finally, the upgrading and optimization of the industrial structure are hindered, and GTFP is also reduced. On the other hand, to complete the performance appraisal and pursue economic growth for the central and western regions, government officials often adopt the "yardstick competition" strategy, causing the economic development model to consider only quantity while neglecting quality. Furthermore, eco-environmental regulation is ignored, and flow factors are absorbed in large quantities to support economic growth in this region. Finally, it will fall into the dilemma of "race to the bottom," which will inevitably lead to local protection and market segmentation (Zhang et al., 2021). However, market segmentation causes deficits in enterprises' power to improve their operations, hinders free flow of factors, and reduces optimal resource allocation in the central and western regions. Moreover, market segmentation harms system innovation and management reform of enterprises, thus reducing their operational efficiency (Bian et al., 2019). Finally, market segmentation reduces the willingness of enterprises to pursue technological innovation, thus inhibiting the R and D of green technologies and GTFP.

CONCLUSIONS AND POLICY IMPLICATIONS

Local government competition (ECU) is crucial in promoting economic growth in China. Exploring the role of market segmentation and GTFP is highly significant to the green and steady development of the regional economy. Using statistical data from 30 provinces in China from 2006 to 2017, this study examines the impact of ECU on GTFP and investigates the mediating effect of market segmentation. Our results are as follows. 1) ECU significantly inhibits increase in GTFP. 2) ECU can not only directly inhibit the promotion of GTFP but also indirectly inhibit GTFP through market segmentation, and market segmentation as a mediation variable is very significant. 3) Considering regional heterogeneity, the effect of ECU on GTFP in the eastern region is positive, but not significant. Moreover, local government competition does not inhibit the growth of GTFP through market segmentation. Hence, ECU promotes market segmentation and inhibits the promotion of GTFP in the central and western regions, and ECU can inhibit the growth of GTFP through market segmentation.

Based on the above research conclusions, the author proposes the following policy implications. Formulating a single assessment index by the superior government is the root of

TABLE 9 | Test results for the robustness of mediation effects.

Variables	National region			Eastern region			Central – western regions		
	GTFP (1)	MSEG (2)	GTFP (3)	GTFP (4)	MSEG (5)	GTFP (6)	GTFP (7)	MSEG (8)	GTFP (9)
L.GTFP	0.798***		0.788***	0.435*		2.530*	0.832***		0.597***
	(30.90)		(72.31)	(1.69)		(1.82)	(27.18)		(6.88)
SF	−0.013***	0.002***	−0.013***	−0.156	−0.001	0.504	−0.027***	0.002***	−0.020**
	(−7.52)	(5.00)	(−7.98)	(−0.78)	(−0.23)	(0.71)	(−9.36)	(3.44)	(−2.55)
GOV	−0.702***	0.019**	−0.742***	−5.016	0.089	10.666	−1.194***	0.037***	−1.524***
	(−7.04)	(2.29)	(−11.61)	(−1.39)	(1.27)	(0.88)	(−7.25)	(2.89)	(−5.28)
HUM	−0.022***	−0.024***	−0.039***	−0.267	−0.015*	−1.817	−0.019	−0.019***	−0.074***
	(−4.29)	(−10.16)	(−3.02)	(−0.39)	(−1.89)	(−0.79)	(−0.85)	(−6.85)	(−2.88)
MAR	0.805***	0.009	0.843***	3.213	−0.068	16.316	0.238*	0.023*	0.837***
	(15.65)	(1.06)	(10.04)	(0.76)	(−0.21)	(0.90)	(1.94)	(1.76)	(4.13)
PAO	0.690	0.585***	0.921	4.745	0.100	75.891	3.188**	−0.156	5.104***
	(1.31)	(9.85)	(1.25)	(0.31)	(0.27)	(0.65)	(2.34)	(−0.30)	(3.74)
ROA	0.003	0.005***	0.000	−0.020**	0.004	−0.372	0.016***	0.002*	0.041***
	(0.62)	(6.83)	(0.14)	(−2.23)	(0.66)	(−1.03)	(3.40)	(1.67)	(5.24)
MES	−0.044	0.026***	−0.006	−0.435	0.042***	0.908	0.028	0.011	0.029
	(−1.19)	(6.75)	(−0.13)	(−0.50)	(5.55)	(1.59)	(0.51)	(0.95)	(0.38)
L.mseg		0.375***			0.454***			0.158***	
		(23.21)			(3.42)			(3.07)	
MSEG			−0.936***			−45.207			−0.717**
			(−4.35)			(−0.88)			(−2.48)
AR (1)	−1.98	−2.82	−1.99	−1.05	−1.66	0.40	−1.61	−2.02	−1.65
	[0.048]	[0.005]	[0.047]	[0.295]	[0.097]	[0.688]	[0.107]	[0.043]	[0.100]
AR (2)	1.26	−0.80	1.32	0.55	−0.66	−0.66	1.38	−0.41	1.41
	[0.209]	[0.424]	[0.186]	[0.584]	[0.508]	[0.507]	[0.169]	[0.681]	[0.159]
Hensen test	27.56	25.24	26.07	5.61	6.49	2.09	16.97	15.36	14.05
	[0.968]	[0.615]	[0.974]	[1.000]	[0.999]	[1.000]	[0.201]	[1.000]	[0.828]
Z_{mid}	3.28	0.22	2.01						
Constant	−0.155***	0.164***	−0.001	2.787	0.170	−1.361	0.546***	0.119***	0.334
	(−4.93)	(8.30)	(−0.02)	(0.45)	(0.51)	(−0.77)	(5.31)	(5.76)	(1.37)
N	330	330	330	110	110	110	209	209	190

*Note: T statistics are put in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01; Z values are put in [].*

local government competition. To achieve political goals, local governments sacrifice long-term interests for short-term and rapid economic development. Moreover, the GDP-oriented performance appraisal system has been widely criticized by society. Therefore, policymakers must improve the performance assessment system, reform the assessment system of local government officials, and facilitate the establishment of a local government competition system guided by high-quality economic development. Additionally, as performance appraisal of local government and the promotion incentive system of officials have strong guiding effect on local government behavior, content related to green development should be added to the performance evaluation index of local government by policymakers. Hence, policymakers should build a government performance appraisal system with economic and environmental coordination.

Second, market segmentation mainly manifests in the direct intervention of local governments through administrative means to restrict market access conditions and enterprise competition. Therefore, policymakers should establish a unified and open market system with orderly competition to further optimize the business environment. Moreover, market access conditions should be further relaxed. A system with a negative list of market access should be implemented uniformly throughout the country. Policymakers should ensure that all regions and all market entities have equal access to the market by law and prohibit all regions from creating a negative list of the nature of market access. This is to ensure fair competition among all market entities. Moreover, policymakers should allow local market regulators to conduct independent supervision and increase enforcement against unfair competition. Simultaneously, preventing and stopping unfair competition, restricting competition in market economic activities, and creating a market environment with fair competition are necessary.

Third, policymakers should formulate preferential tax policies to strengthen support for enterprises' technological innovation. Encouraging enterprises to develop green technology and building a green low-carbon circular development of the economic system will help them achieve green development. Policymakers should increase investment in enterprise technology incubation and R&D to develop the economy and improve GTFP while protecting ecosystem. Additionally, regional development was not balanced. In green transformation, policymakers need to implement differentiated economic policies according to local conditions.

Although this study extensively explores the impact of local government competition on GTFP based on the factor market segmentation perspective, certain limitations deserving further investigation remain. First, this study empirically verifies the role of local government competition on GTFP under the factor market segmentation scenario, which lacks analysis of the influence mechanism of local government competition on GTFP. Therefore, a more in-depth analysis of the influence mechanism will be informative for future research. Second, this study mainly uses provincial-level data for investigating the relationship between local government competition and GTFP based on the factor segmentation perspective. Further research can analyze the impact of local government competition on GTFP based on the market segmentation perspective at the prefecture and county levels, which will provide more precise policy guidance for enhancing GTFP. Finally, this study measures local government competition from the economic competition perspective, which has not been fully established as a comprehensive measure of local government competition. Therefore, more comprehensive construction of local government competition indicators can be conducted in the future using big data technology. For example, local government competition can be remeasured by collecting content about local government competition published on each provincial government's main office website and official media through tools such as Python.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

JT: grasp the theme and research direction, FQ: empirical research and data.

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