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How do resource misallocation and government corruption affect green total factor energy efficiency? Evidence from China

Yu Hao [a,b,c,d,e], Zhiqiang Gai [a], Haitao Wu [a,b,f,*]

[a] School of Management and Economics, Beijing Institute of Technology, Beijing, 100081, China
[b] Center for Energy and Environmental Policy Research, Beijing Institute of Technology, Beijing, 100081, China
[c] Beijing Key Lab of Energy Economics and Environmental Management, Beijing, 100081, China
[d] Sustainable Development Research Institute for Economy and Society of Beijing, Beijing, 100081, China
[e] Collaborative Innovation Center of Electric Vehicles in Beijing, Beijing, 100081, China
[f] College of Economics and Management, Xinjiang University, Urumqi, 830047, China

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ABSTRACT

At present, China is undergoing industrial restructuring. However, the resource misallocation problem in China is still serious, which may affect China's green total factor energy efficiency (GTFEE). Based on previous studies, misallocation may be exacerbated by corruption, which would further inhibit GTFEE. In this study, we utilize the provincial panel data of 30 provinces in China from 2005 to 2016 to investigate the relationship between misallocation, corruption and GTFEE by employing appropriate spatial econometric methods and panel threshold model. The results indicate that there is spatial dependence in GTFEE. Local GTFEE is negative impacted by labor misallocation, while it is not affected by labor misallocation in the neighboring area. There is also evidence that capital misallocation in the local area is negatively correlated with GTFEE, although not statistically significant; while the capital misallocation in the neighboring area has significant negative correlation with local GTFEE. The results also indicate that GTFEE is not significant affected by corruption. It is also found that local corruption would aggravate the inhibiting effect of labor resource misallocation on GTFEE, while the inhibiting effect of capital resource misallocation on GTFEE would not be affected by local government corruption.

1. Introduction

Since the beginning of the reform and opening-up, China has made remarkable achievements in economic development. Currently, China has become the focus of the world economic stage. The rank of China's economic scale in the world has risen from the 11th place in 1978 to the second place by 2019, and its comprehensive national strength and international influence have achieved a historic leap (Shi et al., 2019). In recent years, China has contributed more than 30% to world economic growth, and has increasingly become a driving force for the world economic growth (Freeman, 2019). But the rapid development of China's economy also brought serious environmental problems. According to Yale university, Columbia University, and the World Economic Forum jointly issued the 2018 environmental performance index, China was ranked 120th in the 180 economies.[1] And China ranked fourth in environmental quality assessment involving $PM_{2.5}$, which illustrates China's current environmental pollution severity. Urban air pollution has always been the core of environmental pollution problems due to its susceptibility and strong harmfulness to human body (Wu et al., 2020). According to the latest ranking of causes of death of China's urban residents released by the national health commission of the People's Republic of China, the death of malignant tumors ranks first.

* Corresponding author. School of Management and Economics, Beijing Institute of Technology, Beijing, 100081, China.
E-mail addresses: haoyuking@gmail.com, haoyuking@bit.edu.cn (Y. Hao), gzq31618@163.com (Z. Gai), 15875706@qq.com (H. Wu).

[1] Environmental Performance Index (EPI) is a quantitative measure of environmental performance in national policies. The indicator is derived from the environmental performance experimental indicator, which was first published in 2002 and designed to assist the environmental goals of the UN Millennium Development Goals. In the 2018 environmental performance index, from the perspective of overall environmental protection, the world is still far from achieving international environmental protection goals, with a score of 46.16. The global total score was mainly lowered by the environmental health policy goal, with a score of 31.50. The top 10 countries in the total list are Switzerland (87.42), France (83.95), Denmark (81.60), Malta (80.9), Sweden (80.51), United Kingdom (79.89), Luxembourg (79.12), Australia (78.97), Ireland (78.77) and Finland (78.64).

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The World Health Organization International Agency for Research on Cancer published a list of carcinogens that identified air pollution as a type of carcinogen on October 27, 2017. In addition to the great harm to the health of residents, air pollution also causes huge economic losses (Zhu et al., 2019). According to Asia-Pacific Economic Cooperation (APEC) assessment report on air pollution costs published at the annual summit of the International Transport Forum, the global health cost of outdoor air pollution is as high as 3.5 trillion US dollars, while China 's economic loss is about 1.4 trillion US dollars.

How does China's environmental pollution develop? It always is the focus of academic research, and some good results are achieved by its predecessors. Some scholars believe that China's environmental pollution is caused by the imbalance of the industrial structure. The industrial structure dominated by heavy industry will cause air pollution. And due to space spillover effects, environmental pollution is aggravated in other regions (Chen et al., 2019a,b). The level of China's independent innovation also plays a decisive role in environmental pollution (Chen et al., 2019a,b). Empirical analysis in this area is also very rich. It is proved that the coal-based energy consumption structure promotes air pollution through dynamic panel models and threshold models, and this effect has "inertia", which will affect the next period of air quality (Wang et al., 2019a,b).

Regulators are an important part of environmental protection and prevention. They have an inescapable responsibility for environmental pollution, and the level and severity of environmental regulations of the Chinese government are closely related to air pollution (Zhou et al., 2019). According to the Environmental Kuznets Curve (EKC), there is a non-linear causal relationship between economic growth and environmental pollution. Environmental quality is affected by economic effects through energy consumption. China 's energy consumption has a one-way causal relationship with CO_2 emissions, and economic growth has a two-way causality with energy consumption. GTFEE is so low that China's environmental pollution is serious (Wang et al., 2019a,b).

An important issue China's economic growth facing is the excess production. Affected by the era of the planned economy, misallocation problems in various regions and industries in China are very serious mainly presented as capital misallocation and labor misallocation. GTFEE is the combination of various inputs of production factors, which is inevitably affected by the misallocation problem. So does misallocation affect China's GTFEE, which in turn causes environmental pollution in China? In order to study this issue, we use the provincial panel data of 30 provinces in China from 2005 to 2016,[2] and spatial measurement is used to investigate the relationship between misallocation, corruption, and China's GTFEE. It is found that there is a close relationship between misallocation and China's GTFEE, and corruption plays an important role in it. In areas with lower levels of corruption, the degree of misallocation is relatively low, and the reduction in GTFEE due to misallocation is also smaller, and vice versa.

This research contributes in the following three aspects: (1) Considering the spatial spillover effects, we figure out how labor misallocation and capital misallocation affect China's GTFEE by using spatial econometric models. (2) Government corruption is an important factor. We validate how labor misallocation and capital misallocation affect China's GTFEE under the regulation of government corruption in the spatial econometric model. (3) We develop a dynamic threshold panel model that can solve endogenous problems to study the heterogeneity of the impact of misallocation on China's GTFEE under different levels of government corruption.

The remainder of the article is organized as follows. In Section 2, the research literature on total factor energy efficiency, resource misallocation and government corruption are summarized and reviewed. In Section 3, the measurement method and the sources of data are introduced. In Section 4, the empirical results of this study are briefly introduced. In Section 5, the estimation results are discussed. In Section 6, the conclusions and related policy implications are provided.

2. Literature review

2.1. Capital misallocation

Since the reform and opening up, China shifts from the planned economy to the market economy. The Chinese economy has a period of rapid growth, but this "Chinese-style catch-up" also exposes many problems in recent years. One of them is the problem of capital misallocation (Moll, 2014). Capital misallocation usually refers to the fact that funds in a market economy environment cannot flow freely under the influence of external human factors. The normal flow of funds is from low-yielding industries to higher-yielding industries. However, under capital misallocation, funds will flow to certain regions, industries and enterprises with low economic benefits. The capital needs of the regions industry and enterprises with higher economic benefits can't be effectively met, so that the overall economic benefits of the market cannot reach the best. China's capital misallocation usually manifests as excess production. Not only traditional heavy chemical industries but also many emerging industries including photovoltaics are also plagued by capital misallocation.

There are many causes of capital misallocation. The academic community does a lot of detailed research and reaches a certain consensus. That is capital misallocation problems in different countries have their own unique causes, but there are some common reasons (Zhao et al., 2020). At the macro level, financial friction is one of them. The inflow and outflow of capital in a country will inevitably produce a certain amount of friction, which may prevent capital from entering the expected industry (Wu, 2018). At the micro level, the flow of capital is affected by the judgment of the person who in charge of the investment company on the economic situation. Investors who like risk may prefer to concentrate capital in emerging industries or industries with high investment risks, but investing in these industries doesn't meet the goal of maximizing profits (Ek and Wu, 2018). In addition, due to corporation tax law, different marginal tax rates between companies can also lead to capital misallocation issues. If the difference in the marginal tax rate between companies is eliminated, the capital misallocation problem can be effectively solved, so that the output of the company will increase significantly (Kaymak and Schott, 2019). The capital misallocation problem in China has its own unique reasons. Most scholars agree that capital misallocation is caused by many policies of the Chinese government, such as fiscal subsidies, financial repression, administrative market entry barriers and policy banks' credit tilt (Sun et al., 2020). As many household savings are pushed to state-owned enterprises, these policies will prevent China's public sector from providing adequate capital assistance to the growing private sector, which will not only cause friction in the capital market, but also hinder domestic private sector As a result of the company's investment and consumption, the problem of capital misallocation arises (Cubizol, 2018). Of course, the misallocation problem in China cannot be attributed solely to the Chinese government. Insufficient financial liquidity and financial pledge capabilities of Chinese companies will also lead to capital misallocation (Piao et al., 2016).

Because objective economic laws are violated, many problems and troubles to the economic operation are brought for the capital misallocation. Japan's corporate structural change is severely hindered due to capital misallocation. The new sector tends to be more impacted than the old sector because the new sector's total factor productivity and the quantity of goods supplied are much lower than the old sector, and the company naturally loses its momentum for structural change (Hirakata and Sunakawa, 2019). The case of Ukraine also proves that the total factor productivity will be significantly reduced by capital

[2] For the convenience of analysis and to save space, the term "province" is utilized to represent all provincial administrative units in China, including provinces, municipalities, and minority autonomous regions.

misallocation. By accelerating the redistribution of resources and lowering the threshold for entry and exit of capital, the problem of capital misallocation in Ukraine can be effectively solved, and total factor productivity can be increased by 72.4%−149.5% (Ryzhenkov, 2016). In addition to the impact on total factor productivity and structural changes, as mentioned earlier, China's capital misallocation problem causes excess production. In a monopolistic competitive market, the full release of production capacity is prevented by the capital misallocation, which resulting in a large accumulation of low-end production capacity (David and Venkateswaran, 2019).

2.2. Labor misallocation

The misallocation problem usually refers to the capital misallocation and labor misallocation. Similar to the capital misallocation problem, the labor misallocation problem is also a major problem in China's economic development process. Although labor-intensive industries concentrate a large amount of labor, they still lack high-end technical talents. And labor misallocation is exacerbated for wage mismatch problems (Cheng et al., 2018). Labor misallocation also shows an imbalance in the allocation of labor resources between various industries. Many people are subject to China's "official standard" thinking, so their first career choice is to enter a government agency rather than enter the business. Even those who choose to work in enterprises often choose to enter the financial industry or monopoly industries, because these industries have higher wages. However, the labor force in high-tech industries represented by computers is seriously insufficient (Yian, 2019). With the adjustment of China's economic structure, the labor misallocation in the manufacturing industry has continued to improve, but the average labor misallocation in the industry has gradually increased since 2009, and its value has gradually increased from 0.91 in 2009 to 1.15 in 2013. And it is getting worse (Caggese et al., 2019), so it is urgent to solve the problem of labor misallocation.

Some scholars attribute the misallocation problem mainly to individual workers. Just as consumers pay attention to product quality in consumption choices, the labor force also pays more attention to the quality level of enterprises or institutions when choosing employment, such as development prospects and corporate culture. Therefore, differences between enterprises will inevitably lead to labor misallocation (Murphy et al., 1991). The labor market is a two-way selection market. Labor has the right to choose a company, and labor is also chosen by enterprises according to the differences, this difference often refers to the innate ability of labor. Defective labor will be discriminated by the labor market and cause it mismatch in ability and occupational assignments (Neumark, 2018). Similar to the capital misallocation, on the issue of labor misallocation, scholars are more directed at the Chinese government. Industrial entry barriers are set up by government to allow privileged rich state-owned enterprises or monopoly enterprises to make these enterprises obtain a large amount of excess profits (Yang and Shi, 2018). Some of these profits become employee benefits. The gap between the state-owned enterprise employees and employees in other enterprises is widen, which leads a large number of labor flocking to state-owned enterprises that have already been overloaded. In addition to the imbalance in labor allocation between industries, the labor allocation between regions is also very serious, which is mainly related to China's household registration and land system. The free movement of labor is greatly restricted for China's urban-rural "dual structure", which exacerbates labor misallocation in China (Fontagné and Santoni, 2019). The reform of China's social security system is relatively lagging behind, and it is difficult to protect the legitimate rights and interests of "migrant workers", which seriously affects the transfer of labor from rural to urban and agricultural to non-agricultural industries. Enterprises are also seriously hindered from drawing from the labor of rural areas for the above reason (Munshi and Rosenzweig, 2016).

As an important factor of production, great distress to economic operations are caused by the labor misallocation. For the uneven flow of labor between regions, the degree of imbalance in China's regional economic development is objectively enlarged (Cunat et al., 2017). According to estimates, the negative effect of labor misallocation on TFP in China is between -2% and -18%, and it has a growing trend (Yuan et al., 2011). Moreover, huge economic losses are caused for the labor misallocation, because labor misallocation has a significant impact on total factor productivity, output and welfare (Bandyopadhyay et al., 2019). The labor misallocation problem in China resulted in an average total factor productivity loss of 4.45 percentage points per year from 2000 to 2007. The losses are mainly due to the large wages occupied by state-owned enterprises' higher wages. On the one hand, state-owned enterprises are in trouble, and the production enthusiasm of employees can't be filly stimulated by the "big pot" production form. On the other hand, due to insufficient labor resources, production potential can't be fully realized by private enterprises, which proves that China's state ownership system is one of the important reasons for labor misallocation (Dai and Cheng, 2019).

2.3. Capital misallocation, labor misallocation and GTFEE

Misallocation is an unavoidable problem in the process of economic development, because capital resources and labor resources cannot flow freely between industries and enterprises in various regions due to various factors. In order to make up for the lack of production factors, other means are used by producers that may violate the law of economic development, which GTFEE is affected in the process.

Subject to the idea of "promotion championship", a large number of capital and labor resources are concentrated by local governments on some enterprises through administrative orders, and capital misallocation and labor misallocation between industries are artificially formed. These enterprises are often traditional enterprises with high pollution and high energy consumption, so environmental quality is greatly affected. GTFEE is reduced for this improper allocation of artificial resources which causes a large amount of emissions of sulfur dioxide (SO_2), soot and suspended particulate matter ($PM_{2.5}$) (Bian et al., 2019). Implied by the local government, local financial institutions will also give these companies a green light on their lending business. Data shows that China's loan-based financial resources are clearly inclined to heavily polluting companies (Hu and Wang, 2006), and energy efficiency of these companies is often low. And in a certain geographical area, companies in the same industry tend to be highly concentrated, which is the industrial agglomeration effect. A large number of production factors are aggregated within the space, which makes the problem of capital misallocation and labor misallocation more serious, and the problem of low GTFEE caused by misallocation will further increase (Zhang et al., 2011).

China's "local protectionism" is heavy, which prevents capital and labor resources from flowing freely between regions. Factors of production cannot operate in accordance with the economic operating laws of entering regions with low marginal productivity into regions with higher marginal productivity, which leads to inefficient allocation of resources, triggers capital misallocation and labor misallocation issues between regions, and reduces GTFEE. And "local protectionism" is usually the product of China's GDP assessment system, because the pursuit of macroeconomic performance is put first by local governments. Economic growth is stimulated in the short term for local protection, but the misallocation problem caused by such local protection can lead to low GTFEE because of ignoring economic laws (Li and Hu, 2012).

Under the GDP assessment mechanism, adjacent local governments are often in a competitive relationship. Because capital and labor resources in a region are often limited. In order to compete for these factors of production, the more aggressive administrative methods are used to intervene in the factors of production free flow by government, which further exacerbates capital misallocation and labor misallocation (Wang et al., 2012).

By summing up the previous research results, it is easily found that

problems to China's economic growth faces capital misallocation and labor misallocation. In addition to affecting China's total factor productivity, China's GTFEE is also affected. The misallocation problem in China is greatly affected by local governments. For the relationship between the two, the existing research usually considers that administrative or economic means are used by local governments use to influence the free flow of production factors for political performance purposes, which leads to misallocation problems. However, government policies are also affected by government corruption, such as weakening environmental regulations or opening the back door for low energy efficiency companies. What role government corruption plays in the relationship between misallocation and GTFEE doesn't receive the attention of the academic community, so it is a topic worth studying. We start from the two main aspects of misallocation, capital misallocation and labor misallocation, to study what role government corruption plays in the connection between misallocation and GTFEE.

3. Method and data

3.1. Spatial econometric methods

3.1.1. Spatial weight matrix

The model in this study is a spatial model, and the selected spatial weight matrix needs to be distinguished. Among them, W_1 is the geographic distance weight matrix. In order to avoid the possible measurement error of the distance between complete sample, following Combes (2000) research, this paper sets the local spatial weight matrix with the thresholds of 400 km, 800 km, 1000 km, 1500 km, and 2000 km, which is used to exam the impact of regional corruption on GTFEE under misallocation at different distances.

According to Tobler's First Law of Geography, all things are related, but nearby things are more related than distant things (Tobler, 1970), so the spatial weight matrix is added in the spatial econometric regression model to control for the regional spatial geographical effect. Therefore, a series of spatial weight matrices (W1, W400km, W800km, W1000km, W1500km and W2000km) is utilized to measure the spatial spillover effect in this paper. At present, geographical adjacency matrix and economic weight matrix are mainly used, while spatial weight matrix with the thresholds are other choices to analyze spatial effect. Especially, under the influence of atmospheric circulation, air pollution could cross regional transmission between adjacent areas. However, the space spillover effect of air pollution may be limited by distance. When a certain distance is exceeded, this effect may not exist. Based on the above considerations, the geographic distance weight matrix and the local spatial weight matrix with the thresholds of 400 km, 800 km, 1000 km, 1500 km, and 2000 km are utilized, which could to some extent improve the robustness of the empirical findings. In practice, geographic distance is more important in the spatial spillover effect of regional air pollution. Therefore, in this study the geographic adjacency matrix is chosen as the benchmark matrix.

3.1.2. Spatial autocorrelation

In this study, it is very likely that a large number of local labors are transferred to the surrounding areas, resulting in labor misallocation. And local GTFEE is affected, which means that there may be spatial autocorrelation problems. Spatial autocorrelation refers to the correlation of the same variable at different spatial positions, and is a measure of the degree of aggregation of the attribute values of a spatial unit. Both general index and local index are used to test spatial autocorrelation uses. The general index is used to describe the overall distribution of a phenomenon and determine whether the phenomenon has agglomeration characteristics in space. The local index r is to calculate the correlation between each spatial unit and the neighboring unit with respect to a certain attribute, but whether there is aggregation in space can't be reflected. *Moran's I* is chosen to perform the spatial autocorrelation test. *Moran's I* is a correlation coefficient that generalizes the correlation coefficient to the spatial category. The similarity of the observations between spatial units can be reflected by *Moran's I*. Measuring the spatial autocorrelation can be regarded as calculating the observations correlation coefficient of the spatial lagged variable. The calculation method of *Moran's I* is shown in formula (1):

$$Moran's\ I = \sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij}(x_i-\bar{x})(x_j-\bar{x}) \Big/ S^2 \sum_{i=1}^{N}\sum_{j=1}^{N} W_{ij} \tag{1}$$

In formula (1), the global spatial autocorrelation is calculated by *Moran's I*. GTFEE of province i is represented by x_i, and N represents the total number of geographic units (the provinces in this article). The average of GTFEE is represented by $\bar{x}$, and the variance of GTFEE is represented by S^2. In addition, the Z value can be used for statistical test. The specific formula is shown in formula (2):

$$Z(Moran's\ I) = \frac{Moran's\ I - E(Moran's\ I)}{\sqrt{VAR(Moran's\ I)}}$$

$$\text{Where,} \quad E(Moran's\ I) = -\frac{1}{n-1} \tag{2}$$

3.2. Measurement model setting

In order to study the relationship between misallocation, regional corruption, and GTFEE, the following econometric model is constructed as shown in formula (3):

$$gtfee_{it} = a_0 + a_1 Wrk_{it} + a_2 Wrl_{it} + a_3 Wcor_{it} + W\sum \beta_j x_{it} + \varepsilon_{it} \tag{3}$$

The original intention of this article is to study whether the relationship between misallocation and GTFEE is affected by regional corruption. Considering that the misallocation is divided into capital misallocation and labor misallocation, based on equation (3), we add the interaction item between labor misallocation and regional corruption which is shown in formula (4). And the interaction item between capital misallocation and regional corruption is added in formula (5).

$$gtfee_{it} = a_0 + a_1 Wrk_{it} + a_2 Wrl_{it} + a_3 Wcor_{it} + a_3 Wrl_{it}cor_{it} + W\sum \beta_j x_{it} + \varepsilon_{it} \tag{4}$$

$$gtfee_{it} = a_0 + a_1 Wrk_{it} + a_2 Wrl_{it} + a_3 Wcor_{it} + a_3 Wrk_{it}cor_{it} + W\sum \beta_j x_{it} + \varepsilon_{it} \tag{5}$$

GTFEE in province i in year t is measured by $gtfee_{it}$. rk_{it} and rl_{it} respectively measure the capital misallocation and labor misallocation. In order to study the impact of regional corruption on the relationship between misallocation and GTFEE, cor_{it} is added to measure the level of regional corruption. Because GTFEE is a combination of various factors and is affected by many factors of production, this article also adds a series of control variables, which are represented by $\sum \beta_j x_{it}$. Among them, foreign direct investment (FDI) is used to measure foreign trade links. The per capita gdp (PGDP) is used to measure the level of regional economic development, and the ratio of research investment to GDP is used to measure the level of regional technology. Because GTFEE is also affected by the industrial structure, the tertiary industry's share of GDP (STR) is used to represent the industrial structure. W represents the selected spatial weight matrix.

3.3. Dynamic GMM threshold panel regression model

The generalized method of moments (GMM) approach can deal with endogeneity problem (Arellano and Bond, 1991), while the fixed-effects (hereafter FE) estimators are biased downward because of the relationship between the regressors with the unobserved fixed effects (Nickell, 1981). The dynamic threshold panel model is used in this study, which extends the static panel threshold model suggested by

Hansen (1999) through combining the existing timeseries techniques on threshold models (Chan, 1993), AH-IV model (Anderson and Hsiao, 1982) and GMM approach (Alvarez and Arellano, 2003). The potential endogenous variables are regressed against the selected instrument variables, and after that, the estimated rather than actual values of the endogenous variables are utilized to conduct the estimation. Then, the previously selected instrument variables are used by the two-step first-difference GMM estimator to estimate the coefficients of the explanatory variables. Therefore, the endogeneity problem could be well solved in this way.

Under different levels of corruption, the impact of misallocation on GTFEE may be different. To verify this idea, the dynamic GMM threshold panel model is used to test the impact of misallocation on China's GTFEE at different levels of corruption. The GMM method is used to construct moment estimation conditions, and the threshold model is embedded in the GMM model. The threshold value is determined by the grid search algorithm, thereby obtaining a dynamic GMM panel. Compared with firstly determining the threshold value by static threshold regression and then performing GMM estimation on the exogenous grouping of the sample, this method meets the requirements of thresholding endogenous grouping and can effectively solve the problem of variable endogenousness, which is better than the static threshold regression. Based on the research of Wu et al. (2019), we set the following dynamic threshold panel model. According to the core explanatory variables, they are respectively shown in formula (6) and (7):

$$gtfee_{it} = \beta_0 + \beta_1\, gtfee_{it-1} + \beta_2 rl_{it}\cdot I(cor_{it} \le C) + \beta_2 rl_{it}\cdot I(cor_{it} > C) + \gamma ctrl_{it} + \alpha_i + \varepsilon_{it} \quad (6)$$

$$gtfee_{it} = \beta_0 + \beta_1 gtfee_{it-1} + \beta_2 rk_{it}\cdot I(cor_{it} \le C) + \beta_2 rk_{it}\cdot I(cor_{it} > C) + \gamma ctrl_{it} + \alpha_i + \varepsilon_{it}. \quad (7)$$

Among them, the subscript i represents the province (i = 1, 2, 3 … 30), and t represents the time. GTFEE is represented by *gtfee*, and $gtfee_{it-1}$ is a lagging term.rl_{it}, rk_{it} respectively represents labor misallocation and capital misallocation. $cor_{it}$is selected as the threshold variable which measures regional corruption. $ctrl_{it}$ means a series of control variables that affect GTFEE, including the level of economic development of research and development investment (pgdp), technology research level (rd), foreign direct investment (fdi), and industrial structure (str). I (•) in the model represents the index function, and c is the specific threshold value. In addition, the individual fixed effect is represented by α_i, and ε_{it} represents the random disturbance term.

3.4. Variable selection

3.4.1. China's green total factor energy efficiency (GTFEE)

Energy demand growth and energy security, energy efficiency becomes the focus of governments and academia because of the global warming (Wu et al., 2019). However, there are some problems in existing energy efficiency indices, for example, wastewater discharge, exhaust emissions, and solid waste generation are computed without taking into account undesirable outputs (Shao et al., 2019). Therefore, green total factor energy efficiency (GTFEE) is calculated in this paper by following the sustainable framework and previous literatures (Li and Hu, 2012; Zhang et al., 2015; Li and Lin, 2017). Specifically, GTFEE is the variable which is the ratio of the theoretical minimum energy input to the actual input level when the undesirable output (environmental pollution) is minimized under the given desirable output conditions. There are many methods for measuring energy efficiency. Among them, energy efficiency can be divided into single factor energy efficiency and total factor energy efficiency (GTFEE) according to the number of factors examined. Single factor energy efficiency is usually measured using the ratio of economic output to energy input, and the calculation method of GTFEE is similar to total factor productivity. Similarly, various input factors in social production can be replaced with each other. It is not a single production factor that determines energy efficiency, but a combination of various production factors. Based on the measurement method of Hu and Wang (2008), we use super-efficiency DEA model to measure GTFEE in China's provinces from 2005 to 2016. The DEA model is a method to evaluate the relative effectiveness of multiple inputs and multiple outputs of decision-making units, and super-efficiency DEA can make effective decision-making units have the ability to further compare and rank.

GTFEE in China is measured by inter-provincial panel data from 2005 to 2016, and the data processing of input variables, expected output and undesired output are explained as follows. Among them, it is assumed that three production factors, capital stock, labor and energy, need to be invested in the production process. The capital stock is selected from the data of the total regional fixed asset investment and the fixed asset investment price index, which is calculated by using the "perpetual inventory method". The capital stock calculation formula is shown in formula (8):

$$K_{i,t} = I_{i,t} + (1-\delta_{i,t})K_{i,t-1} \quad (8)$$

Where i is the region, t is the year, K, I, and δ are the capital stock, investment amount, and depreciation rate. For the treatment of the depreciation rate, the research of Shan (2008) is drawn to set the capital depreciation rate of each province uniformly which is 10.96%, and the data is reduced to the capital stock at constant prices in 2005. In addition, the number of employed people at the end of the year is uesed as an indicator of labor input. Expected output is expressed in the GDP of each province. Unexpected output is the discharge of industrial wastewater, the discharge of industrial waste gas, and the discharge of industrial solid waste. When there are K evaluation units, each evaluation unit uses N input factors for production, M types of desirable outputs and J types of non-desirable outputs. And the input set, desirable output set, and non-desirability of any evaluation unit respectively expressed as: $x_k = (x_{1k}, x_{2k}, \cdots, x_{Nk})$, $y_k = (y_{1k}, y_{2k}, \cdots, y_{Nk})$ and $u_k = (u_{1k}, u_{2k}, \cdots, u_{Nk})$.

The super-efficiency DEA model based on input-oriented GTFEE with constant returns to scale is shown in formula (9), and the provinces' GTFEE from 2005 to 2016 are calculated by formula (9). Among them, GTFEE levels of China's provinces in 2016 is reflected by Fig. 1.

$$gtfee^{*} = \min gtfee$$
$$s.t. \quad \sum_{k=1}^{K}\lambda_k x_{nk} \le gtfee x_n; \sum_{k=1}^{K}\lambda_k y_{mk} \ge y_m; \sum_{k=1}^{K}\lambda_k u_{jk} = u_j; \lambda \ge 0 \quad (9)$$
$$n = 1, 2, \cdots, N; m = 1, 2, \cdots, M; j = 1, 2, \cdots, J; k = 1, 2, \cdots, K$$

3.4.2. Degree of misallocation (rk/rl)

Based on the theoretical framework of scholars such as Hsieh and Klenow (2009), we assume that a factor market has a distorted competitive market, and defines the absolute distortion coefficients of capital and labor factors as formula (10):

$$\gamma_K = \frac{1}{1+\tau_{Ki}}, \quad \gamma_L = \frac{1}{1+\tau_{Li}} \quad (10)$$

The addition of factor inputs is indicated by this coefficient. Take the capital element as an example, when there is no misallocation, that is $\tau_{Ki} = 0$, which means the absolute distortion coefficient of capital is 1 and there is no distortion of capital element input bonus. When there is misallocation, that is $\tau_{Ki} \neq 0$. The input price of capital element is higher or lower than the normal level which will distort the level of capital investment. However, since the absolute distortion coefficient of the factors cannot be actually measured, the relative distortion coefficient of the capital and labor factors are further assumed, so under the premise of achieving a competitive equilibrium in the market, the relative distortion coefficient of capital and labor factors are defined as $\widehat{\gamma}_K$, $\widehat{\gamma}_L$, which is shown as formula (11):

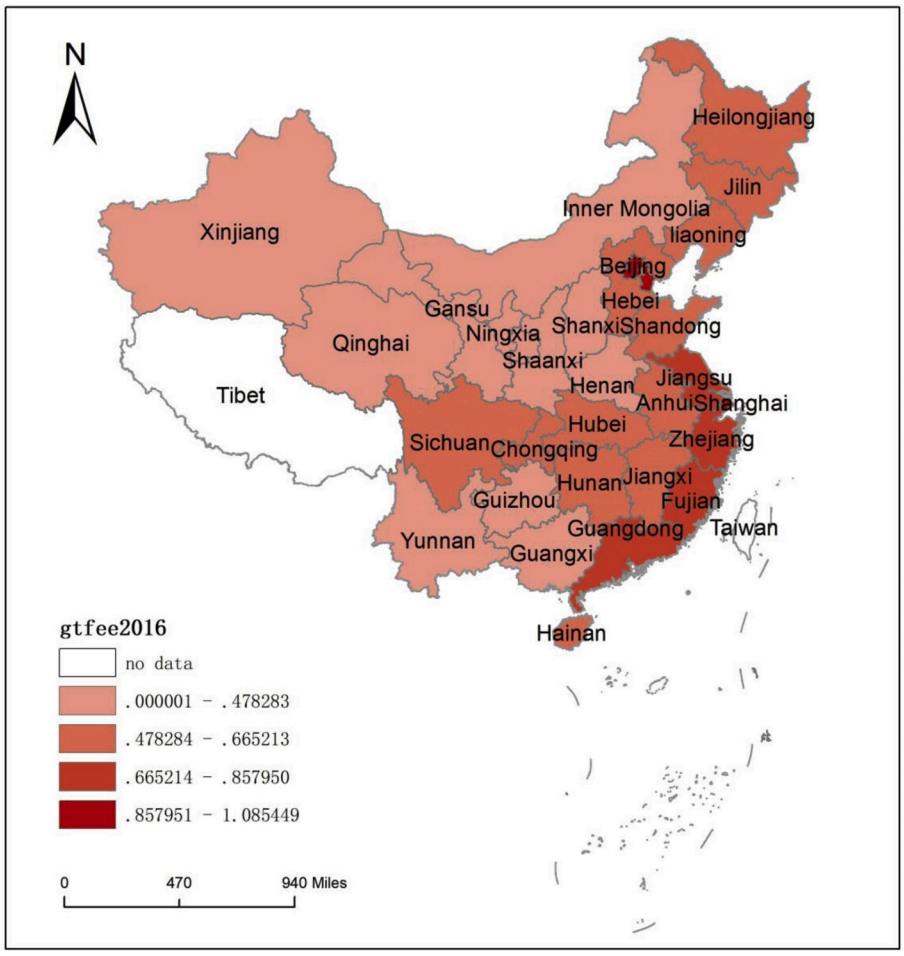

Fig. 1. The level of China's Green Total Factor Energy Efficiency in 2016 (GTFEE). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

$$\widehat{\gamma}_K = \left(\frac{K_i}{K}\right) \Big/ \left(\frac{s_i\beta_{Ki}}{\beta_K}\right), \quad \widehat{\gamma}_L = \left(\frac{L_i}{L}\right) \Big/ \left(\frac{s_i\beta_{Li}}{\beta_L}\right) \tag{11}$$

$$Y_{it} = AK_{it}^{\beta_{Ki}} L_{it}^{\beta_{Li}} \tag{12}$$

Among them, the real GDP is used as the output variable Y_{it} when 2005 is base period, the labor force input L_{it} is expressed as the average annual employment in each region, and the capital factor input K_{it} is expressed as the fixed capital stock in each region. In the calculation of fixed capital stock, the perpetual inventory method of Zhang et al. (2004) is adopted. And we supply the calculation of the 2005–2016 capital stock at constant prices in 2005 to ensure the data reasonable and comparable.

According to the Solow residual method, formula (10) is calculated, and take logarithms on both sides of the equation, which the effects of individual and time effects in the model is controlled. Sort out to get formula (13):

$$\ln(Y_{it}/L_{it}) = \ln A + \beta_{Ki} \ln(K_{it}/L_{it}) + \mu_i + \lambda_t + \varepsilon_{it} \tag{13}$$

Considering that the development levels of different regions in China are quite different, and the input-output elasticities of capital and labor factors are not the same in each region, the practice of Bai and Liu (2018) is drawn to the introduce interaction item between individual dummy variables and explanations $\ln(K_{it}/L_{it})$ in the regression equation, which constructs a variable coefficient panel model with variable intercept and variable slope properties. The elasticity of capital output β_{Ki}, β_{Li} in formula (13) is calculated. After estimating the factor output elasticity of each province, each index data is brought into formula (10) to obtain the capital misallocation index and labor misallocation index of each province. Fig. 2 and Fig. 3 respectively show the degree of labor misallocation and capital misallocation of each province in China in 2016.

3.4.3. *Government corruption (cor)*

Because of its special nature, corruption is difficult to find specific indicators to measure. The "corruption index" issued by Transparency International is an important index for assessing corruption in various countries and regions. It is a result of corruption assessment based on residents' perception of corruption, and it is a subjective observation evaluation system that reflects people's perception of corruption. Of course, in addition to the residents' perception of corruption to measure the degree of corruption, the academic community is still conceiving whether there is a more reliable method. The problem of corruption leads to poverty and social injustice. Therefore, the level of corruption is measured by considering these two factors (Foster et al., 2012). There are also scholars who calculate the level of corruption on the number of bribes accepted by officials including political contributions (Schopf, 2011), but these methods require relatively high data reliability and availability. Therefore, in this article, the number of per 10,000 public officials in corruption cases is used as a proxy for regional corruption. The larger the value, the higher the degree of corruption. Fig. 4 reflects the extent of government corruption in various regions of China in 2016.

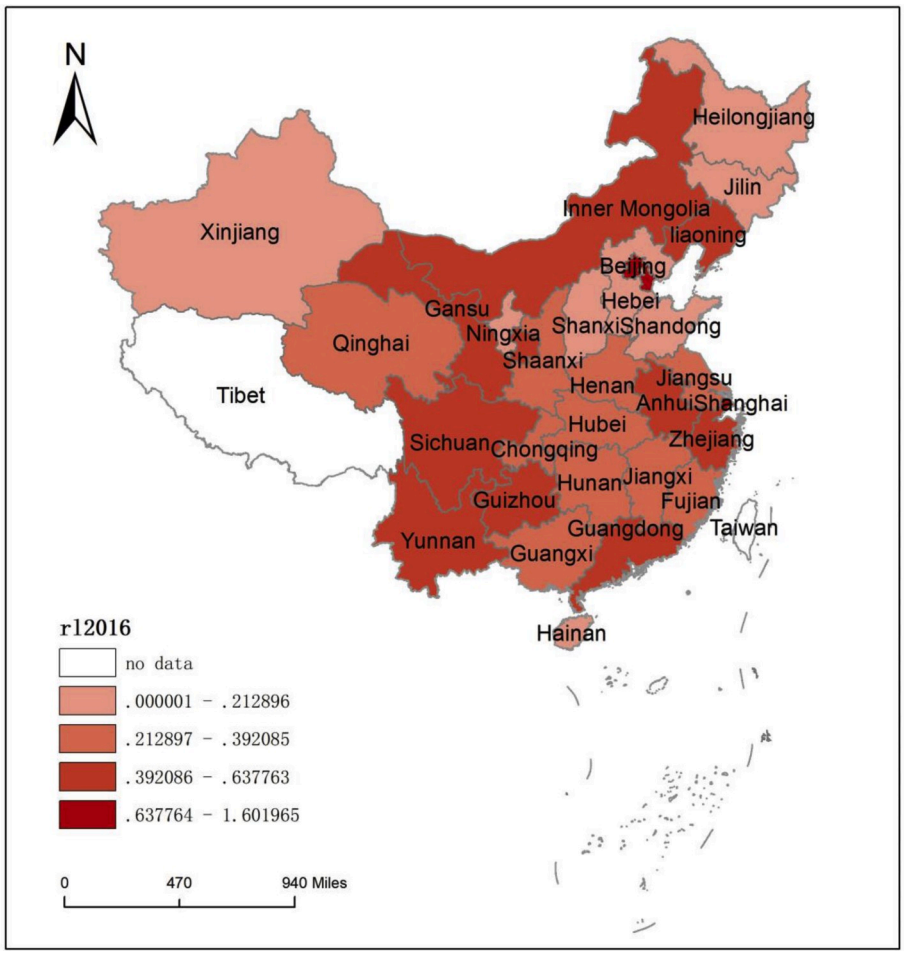

Fig. 2. The level of labor misallocation in China in 2016 (rl).

3.4.4. Other variables

(1) Economic development level. The per capita GDP is used to measure the level of regional economic development (Lluís Carrion-i-Silvestre et al., 2005). The link between the level of regional economic development and GTFEE is inseparable.
(2) Development level of foreign trade. Foreign direct investment (FDI) is used to measure foreign trade links. According to the "pollution paradise" theory (Hao et al., 2019), regions with higher pollution levels are more likely to attract foreign direct investment, and these regions tend to have higher levels of corruption. Since environmental regulations are poor and GTFEE is low, this variable was included in this study.
(3) Regional technical level. The ratio of research investment to GDP is used to measure the level of regional technology (Fogel, 1994). The technical level is closely related to GTFEE, and adding this variable can better reflect the changes in GTFEE.
(4) Industrial structure. The proportion of the tertiary industry to GDP (STR) is used to represent the industrial structure (Wu et al., 2019). Since the secondary industry is a large energy user, and the primary and tertiary industries consume a very low proportion of energy, the industrial structure will also affect GTFEE. This is the original intention of adding this variable.

3.5. Data sources and data processing

The sample interval of this study is from 2005 to 2016. The main data comes from China Statistical Yearbook, China Science and Technology Statistics Yearbook, China High-Tech Industry Statistical Yearbook, China Energy Statistics Yearbook, Wind Database, and the official website of the National Bureau of Statistics. Considering the lack of data in Tibet and the availability of data in Hong Kong, Macau, and Taiwan, the research objects are 30 provinces except Tibet, Hong Kong, Macau, and Taiwan. In order to ensure the comparability of the data, this article bases the relevant nominal data on the 2005 basal period. In view of the lack of data for some statistical indicators in some years, this article uses the mean method to make up. The descriptive statistics of the data are shown in Table 1.

4. Empirical results

4.1. Spatial autocorrelation test

The geographical distance weight matrix and the local spatial weight matrix established based on the five thresholds are used to calculate the local Moran index of GTFEE in 30 provinces in China from 2005 to 2016. The Z-distribution is used to check the calculation results. First, the Moran index is analyzed by using the geographic distance weight matrix. The specific results are shown in the first column of Table 2. From 2006 to 2015, GTFEE in 30 provinces in China is significant at 5% significance level. Furthermore, it can be found that the spillover effect of GTFEE in the local area on the GTFEE of the surrounding area is positive, which means that the GTFEE of each province has a significant positive promotion effect on the GTFEE of the surrounding area, but the spillover effect shows a U-shaped trend, which first decreases and then rise. The turning point is between 2011 and 2012, which means that after 2012, the positive spillover effect of the regional GTFEE is continuously increasing, which is closely related to the smoother and freer flow of

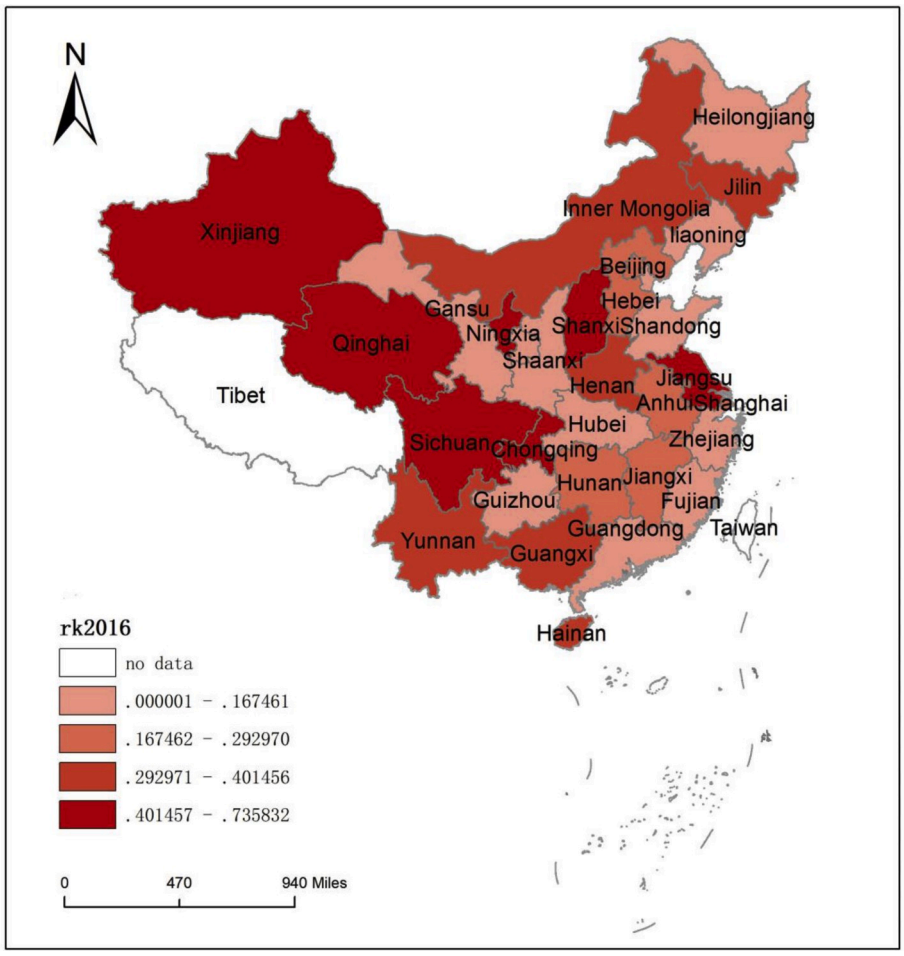

Fig. 3. The level of capital misallocation in China in 2016 (rk).

factors between provinces.

Similar to the calculation results of the geographic weight matrix, under the spatial weight matrix calculated at four thresholds of 800 km, 1000 km, 1500 km, and 2000 km, the regional GTFEE also has a positive spillover effect on similar indicators in the surrounding area. And it also performs U-trend. However, under the spatial weight matrix calculated by the 400 km threshold, although the Moran's I index is also positively significant, it continues to increase year by year. This means the positive promotion effect of regional GTFEE on surrounding GTFEE is constantly increasing, which indicates that GTFEE gradually increases the spillover effect.

Compared with Moran index analysis, whether there is a statistical relationship between related variables can be better reflected by Moran scatter plots. In addition, in order to better judge globally whether GTFEE has spatial aggregation characteristics, so the global Moran index scatter plots for the first and last years is analyzed, as shown in Figs. 5 and 6, which analyzes 30 provinces in China in 2005 and 2016 respectively.

The Moran scatter plot has four quadrants, each of which represents a different meaning. Falling into the first quadrant, it indicates that the spatial relationship between the high-observed regional units are surrounded by the high-observed regional units, which means that the GTFEE of neighboring provinces is at a high level. The second quadrant indicates that the province with lower GTFEE is surrounded by the province with higher GTFEE; the third quadrant indicates the aggregation of regions with low observation values, which means that the GTFEE between adjacent provinces is at a low level. The observations in the fourth quadrant represent exactly the opposite of the second quadrant. Both the first and third quadrants represent typical positive spatial correlations, while the second and fourth quadrants represent typical negative correlations.

From Fig. 5, we can observe that in the 30 provinces observed in 2005, most of the provinces are located in the first and third quadrants, and only a few provinces are located in the second and fourth quadrants, which meets the positive correlations. Compared with Figs. 5 and 6 has changed. First, the global index has changed from 0.04 in 2005 to 0.07 in 2016, which means that the space gathering has increased and the spatial agglomeration of China's GTFEE has increased. In addition, many provinces located in the second quadrant moved to the first and third quadrants, and the low-high value distribution or high-low value distribution decreased. The total number of observations in the second and fourth quadrants is decreasing, which also proves that space gathering is increasing.

4.2. *Basic regression of misallocation, corruption and GTFEE*

This section examines the factors which affect GTFEE. It focuses on the impact of regional corruption and misallocation on GTFEE. The results are shown in Table 3. According to the results in Table 3: ①The degree of corruption in the local area does not have a significant effect on the GTFEE in the local area, and the degree of corruption in the surrounding area does not have a significant effect on the local GTFEE. Whether the geographic distance weight matrix or the threshold weight matrix is used, the calculations are all the same, which means that GTFEE doesn't be affected by regional corruption on statistical significance. ②The relation between local GTFEE and the local labor misallocation is significantly negative, which means that the higher the local labor misallocation, the lower the local GTFEE. But local GTFEE is not

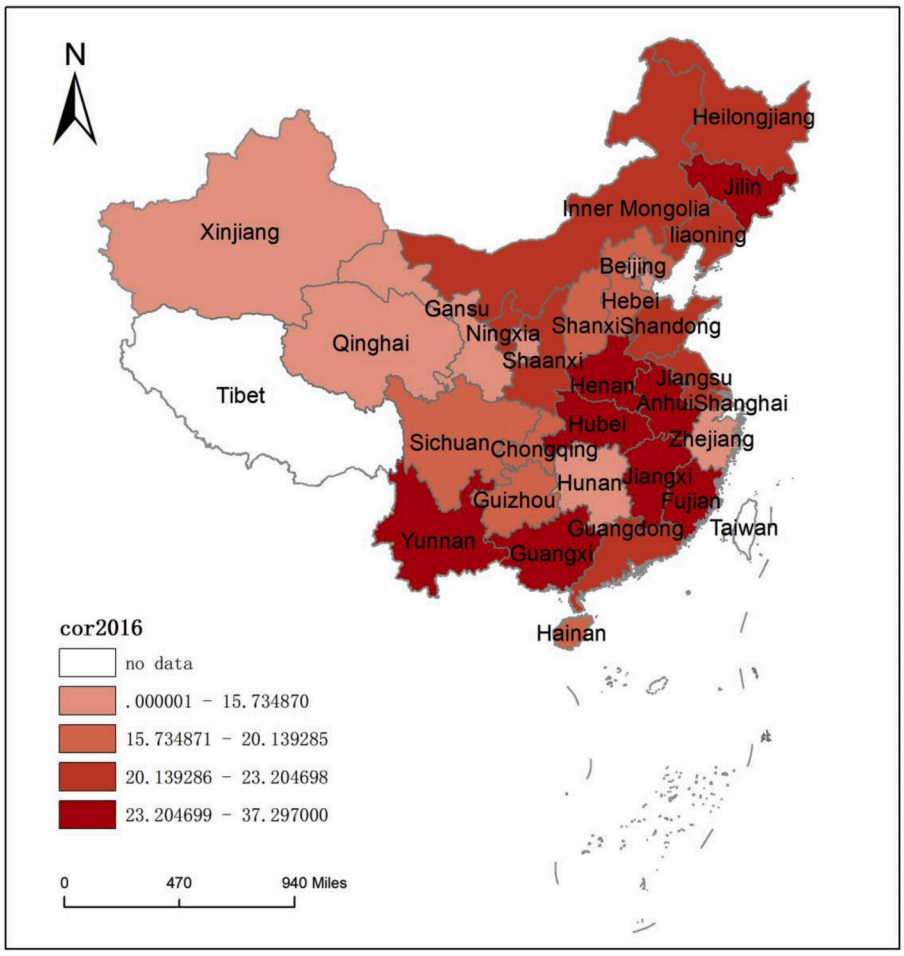

Fig. 4. The level of corruption in China in 2016 (cor).

Table 1
Descriptive statistics.

Variable	Unit	Obs	Mean	Std. Dev.	Min	Max
gtfee	–	360	0.548	0.173	0.235	1.085
fdi	Billion dollars	360	0.029	0.033	0.000	0.181
pgdp	Ten thousand yuan	360	3.682	2.279	0.505	11.820
str	%	360	0.421	0.088	0.283	0.802
rk	–	360	0.249	0.168	0.000	0.736
rl	–	360	0.518	0.528	0.005	2.683
rd	%	360	1.505	1.080	0.210	6.080
cor	Cases/10,000 officials	360	24.713	6.883	7.875	46.322

affected by the labor misallocation in surrounding areas, which means that the configuration of relevant elements in the local area isn't affected by neighbor labor misallocation. ③Unlike labor misallocation, although the capital misallocation in the local area is negatively related to local GTFEE, it is not significant, while the capital misallocation in the surrounding area is significantly negatively related to GTFEE in the local area. Generally speaking, there is a negative correlation between capital misallocation and GTFEE. ④Among other variables, only the relationship between the economic level of the local area and GTFEE is significantly positive, while the industrial structure and technological level of the local area and adjacent areas play a significant role in GTFEE only in a few specific spatial ranges.

4.3. Does corruption affect the inhibition effect of misallocation on GTFEE?

The interaction item between corruption and labor misallocation and the interaction item between corruption and capital misallocation are added to investigate whether regional corruption affects the inhibitory effect of misallocation on GTFEE. Specific empirical results are shown in Table 4 and Table 5.

In Table 4, we consider whether the inhibitory effect of labor mismatch on GTFEE is affected by the regional corruption. The results show that this effect does exist. The interaction item's coefficient between the local corruption and labor misallocation is significantly negative, which means that the inhibitory effect of local area labor mismatch on GTFEE will be enhanced by corruption in the local area. When examining neighbor situation, the interaction item's coefficient is significant only in the geographic matrix, 1500 km and 2000 km range. But the overall is negative which can also indicate that the inhibitory effect of neighbor labor misallocation on local GTFEE will be aggravated by the neighbor corruption. The coefficients of pgdp, str, and rd in the local area are all significantly positive, indicating that these three variables play a role in promoting GTFEE. The coefficient of fdi isn't significant, indicating that GTFEE doesn't have relationships with fdi. And the local GTFEE isn't affected by other variables of neighbor.

Whether the corruption affects the inhibitory effect of capital misallocation on GTFEE is shown in Table 5. Neither the local area nor the neighbor area, the interaction item's coefficient between the corruption and the capital misallocation are significant, and the coefficient is close to zero, which indicates that the inhibitory effect of capital misallocation on GTFEE isn't affected by regional corruption. In

Table 2
GTFEE local Moran's I index of 30 provinces in China from 2005 to 2016.

Year	Moran's I	W_1	W_{400}	W_{800}	W_{1000}	W_{1500}	W_{2000}
2005	Moran's I	0.040**	0.235*	0.193**	0.185***	0.159***	0.108***
	P-value	(0.009)	(0.071)	(0.020)	(0.004)	(0.001)	(0.001)
2006	Moran's I	0.038**	0.254*	0.181**	0.171***	0.146***	0.099***
	P-value	(0.011)	(0.058)	(0.025)	(0.007)	(0.001)	(0.001)
2007	Moran's I	0.039**	0.290**	0.177**	0.164***	0.140***	0.096***
	P-value	(0.012	(0.041)	(0.030)	(0.009)	(0.002)	(0.002)
2008	Moran's I	0.037**	0.305**	0.160**	0.148**	0.128***	0.087***
	P-value	(0.015)	(0.036)	(0.044)	(0.016)	(0.004)	(0.004)
2009	Moran's I	0.033**	0.306**	0.145**	0.133**	0.118***	0.079***
	P-value	(0.020)	(0.036)	(0.057)	(0.025)	(0.007)	(0.007)
2010	Moran's I	0.030**	0.301**	0.135*	0.121**	0.108**	0.073***
	P-value	(0.025)	(0.038)	(0.068)	(0.034)	(0.010)	(0.009)
2011	Moran's I	0.029**	0.302**	0.129*	0.121**	0.106**	0.074***
	P-value	(0.026)	(0.038)	(0.076)	(0.034)	(0.011)	(0.009)
2012	Moran's I	0.034**	0.313**	0.135*	0.133**	0.118***	0.083***
	P-value	(0.020)	(0.035)	(0.070)	(0.026)	(0.007)	(0.006)
2013	Moran's I	0.035**	0.309**	0.139*	0.138**	0.130***	0.091***
	P-value	(0.019)	(0.037)	(0.066)	(0.024)	(0.004)	(0.003)
2014	Moran's I	0.042**	0.328**	0.155*	0.155**	0.148***	0.104***
	P-value	(0.011)	(0.030)	(0.051)	(0.015)	(0.002)	(0.002)
2015	Moran's I	0.043**	0.338**	0.159**	0.158**	0.148***	0.105***
	P-value	(0.011)	(0.027)	(0.048)	(0.014)	(0.002)	(0.001)
2016	Moran's I	0.070***	0.503***	0.217**	0.201***	0.183***	0.133***
	P-value	(0.001)	(0.003)	(0.015)	(0.004)	(0.000)	(0.000)

Note: () means P value; *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

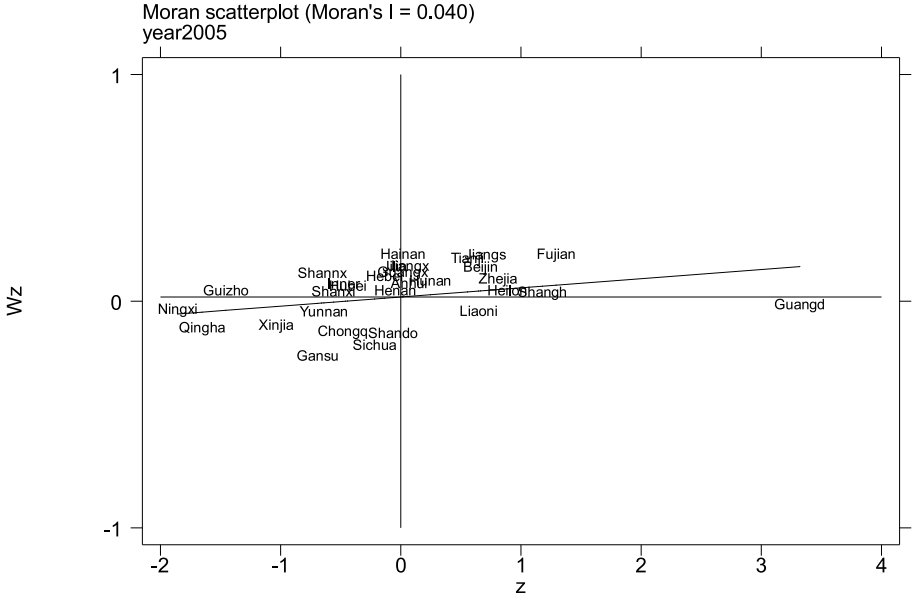

Fig. 5. Global Moran scatter plot of GTFEE in 30 provinces of China in 2005.

addition, unlike Table 3, in Table 5, the coefficient of capital misallocation in neighboring provinces and within a range of 2000 km is only significant at significance level of 10%, which means that when considering the problem of neighbor corruption, GTFEE in the local area isn't affected by neighbor capital misallocation. Similarly, the coefficients of local pgdp, str, and rd are all significantly positive. And fdi in the local area is not related to GTFEE. There is no significant relationship between other neighbor variables and local GTFEE. These are same as Table 4, which means that the results are consistent and the empirical analysis results of this paper are credible.

4.4. Dynamic threshold panel regression

The self-sampling results of the dynamic threshold effect is shown in Table 6. The dynamic threshold models with corruption (cor) as the threshold variable significantly reject the null hypothesis that there isn't threshold effect, so this variable can be used as the threshold variable for threshold regression analysis. The thresholds and their confidence intervals are shown in Table 6. The threshold effect estimation results are shown in Table 7. The improvement of GTFEE is significantly inhibited by the labor misallocation and capital misallocation. However, due to the different levels of corruption in different regions, this inhibitory effect exhibits significant asymmetric characteristics. In areas with high levels of corruption, the labor misallocation and capital misallocation have a greater inhibitory effect on the GTFEE, and in areas with low corruption, this inhibition effect is relatively small. Through dynamic threshold regression, the relationship between misallocation, corruption and GTFEE is further proved that the inhibitory effect of misallocation on GTFEE is affected by the corruption.

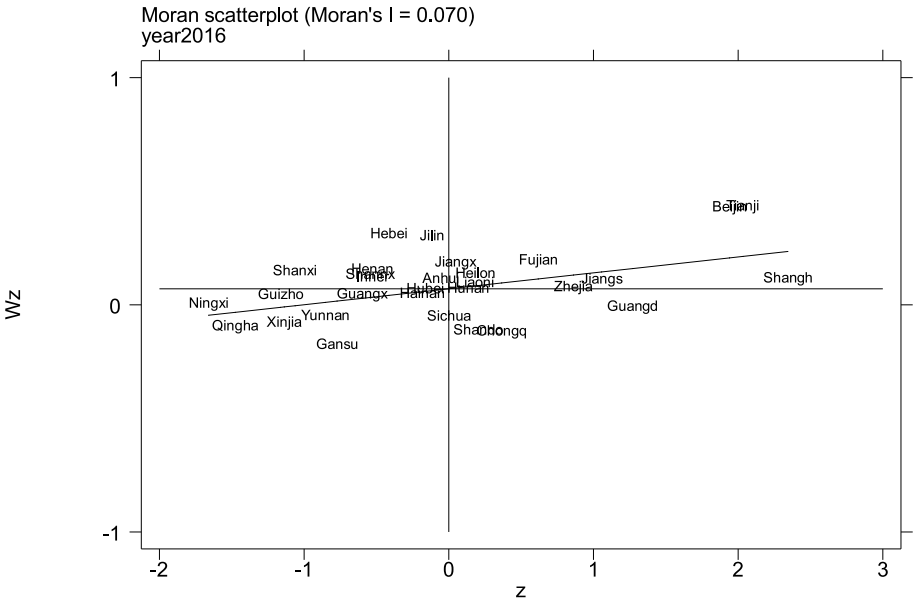

Fig. 6. Global Moran scatter plot of GTFEE in 30 provinces of China in 2016.

Table 3
Misallocation, corruption and GTFEE.

Variable		W_1	W_{400km}	W_{800km}	W_{1000km}	W_{1500km}	W_{2000km}
Main effect	cor	0.000	-0.001	-0.000	-0.000	0.000	0.000
		(0.907)	(-0.821)	(-0.230)	(-0.124)	(0.487)	(0.770)
	rl	-0.161***	-0.174***	-0.160***	-0.149***	-0.171***	-0.166***
		(-6.834)	(-3.663)	(-4.360)	(-4.150)	(-6.189)	(-6.988)
	rk	-0.019	-0.034	-0.065	-0.060	-0.025	-0.022
		(-0.196)	(-0.318)	(-0.592)	(-0.539)	(-0.243)	(-0.215)
	fdi	-0.304	-0.014	-0.180	-0.155	-0.267	-0.299
		(-1.547)	(-0.063)	(-0.862)	(-0.752)	(-1.375)	(-1.512)
	pgdp	0.036***	0.015***	0.026***	0.027***	0.034***	0.036***
		(6.861)	(2.856)	(3.806)	(3.672)	(6.130)	(6.595)
	str	0.285**	0.084	0.286**	0.290**	0.349***	0.299**
		(2.314)	(0.680)	(2.050)	(2.225)	(2.938)	(2.455)
	rd	0.018*	0.020**	0.021**	0.020**	0.019**	0.018*
		(1.709)	(2.093)	(2.291)	(2.090)	(2.007)	(1.749)
Spatial effect (Wx)	cor	-0.001	-0.000	-0.000	-0.001	-0.002	-0.002
		(-0.611)	(-0.310)	(-0.056)	(-1.066)	(-1.285)	(-1.174)
	rl	0.162	-0.030	0.094	0.173	-0.132	-0.053
		(0.629)	(-0.259)	(0.779)	(1.099)	(-0.685)	(-0.309)
	rk	-1.177***	-0.140	-0.276**	-0.438***	-0.455***	-0.830***
		(-2.877)	(-1.029)	(-2.044)	(-2.696)	(-2.610)	(-3.079)
	fdi	0.689	0.671***	0.386	0.709	0.078	0.435
		(0.445)	(2.913)	(0.702)	(0.969)	(0.264)	(1.153)
	pgdp	0.005	-0.015**	-0.012	-0.007	-0.027**	-0.014
		(0.265)	(-2.439)	(-1.595)	(-0.734)	(-2.462)	(-1.346)
	str	0.384	0.353**	0.089	0.259	0.041	0.239
		(1.614)	(2.245)	(0.396)	(1.157)	(0.175)	(1.052)
	rd	-0.019	-0.027*	-0.028**	-0.028**	-0.015	-0.020
		(-1.491)	(-1.756)	(-2.202)	(-2.385)	(-1.264)	(-1.541)
Spatial rho		-0.642**	-0.005	-0.139	-0.252	-0.305	-0.459*
		(-2.327)	(-0.051)	(-1.068)	(-1.464)	(-1.327)	(-1.858)
Variance sigma2_e		0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
		(4.250)	(4.724)	(4.709)	(4.642)	(4.560)	(4.267)
	N	360	360	360	360	360	360

t statistics in parentheses; $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5. Discussion

The relationship between misallocation, regional corruption and GTFEE can be found through the empirical analysis in the previous section. Unlike Table 3, the interactive items between misallocation and regional corruption are added in Table 4 and 5 which are used to investigate whether the inhibitory effect of misallocation on GTFEE corruption. So why are there empirical links between misallocation, corruption, and GTFEE? This section will discuss the inner connections between the three.

When the interaction item is not considered, we can find that the GTFEE in the local area isn't impacted by local corruption level or the

Table 4
The impact of regional corruption on labor misallocation and GTFEE.

Variable		W_1	W_{400km}	W_{800km}	W_{1000km}	W_{1500km}	W_{2000km}
Main effect	cor	0.002***	0.001	0.001*	0.001*	0.002**	0.002**
		(2.623)	(1.250)	(1.681)	(1.815)	(2.250)	(2.504)
	rl	-0.119***	-0.114*	-0.112**	-0.103**	-0.122***	-0.120***
		(-4.554)	(-1.887)	(-2.524)	(-2.434)	(-3.365)	(-3.967)
	rk	-0.014	-0.025	-0.059	-0.055	-0.019	-0.017
		(-0.144)	(-0.231)	(-0.542)	(-0.492)	(-0.182)	(-0.164)
	cor_rl	-0.002***	-0.003***	-0.002***	-0.002***	-0.002***	-0.002***
		(-3.727)	(-2.779)	(-2.980)	(-2.861)	(-3.275)	(-3.926)
	fdi	-0.268	0.038	-0.125	-0.111	-0.227	-0.269
		(-1.394)	(0.169)	(-0.583)	(-0.530)	(-1.184)	(-1.401)
	pgdp	0.035***	0.014***	0.025***	0.026***	0.032***	0.034***
		(6.638)	(2.871)	(3.691)	(3.582)	(6.176)	(6.527)
	str	0.265**	0.055	0.273**	0.277**	0.327***	0.279**
		(2.237)	(0.485)	(2.034)	(2.182)	(2.868)	(2.361)
	rd	0.019*	0.021**	0.023**	0.022**	0.022**	0.020*
		(1.831)	(2.231)	(2.387)	(2.134)	(2.221)	(1.902)
Spatial effect (Wx)	cor	-0.000	0.001	0.001	-0.000	-0.001	-0.001
		(-0.072)	(0.763)	(0.395)	(-0.223)	(-0.499)	(-0.375)
	rl	0.190	0.023	0.100	0.184	-0.069	0.020
		(0.798)	(0.222)	(0.847)	(1.123)	(-0.397)	(0.122)
	rk	-1.163***	-0.142	-0.256*	-0.421***	-0.436**	-0.825***
		(-2.935)	(-1.088)	(-1.897)	(-2.611)	(-2.541)	(-3.149)
	cor_rl	-0.004**	-0.005	-0.002	-0.003	-0.004*	-0.005*
		(-2.207)	(-1.507)	(-1.049)	(-1.112)	(-1.777)	(-1.823)
	fdi	0.948	0.662***	0.520	0.855	0.147	0.509
		(0.646)	(3.255)	(1.012)	(1.265)	(0.488)	(1.409)
	pgdp	0.003	-0.016***	-0.012	-0.008	-0.028***	-0.014
		(0.178)	(-2.655)	(-1.574)	(-0.833)	(-2.594)	(-1.400)
	str	0.373*	0.362**	0.067	0.226	0.060	0.247
		(1.673)	(2.539)	(0.321)	(1.073)	(0.278)	(1.169)
	rd	-0.014	-0.026*	-0.025**	-0.023*	-0.011	-0.016
		(-1.101)	(-1.703)	(-2.053)	(-1.762)	(-0.858)	(-1.208)
Spatial rho		-0.706***	-0.043	-0.163	-0.302*	-0.385*	-0.543**
		(-2.622)	(-0.527)	(-1.359)	(-1.948)	(-1.896)	(-2.341)
Variance sigma2_e		0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
		(4.248)	(4.744)	(4.688)	(4.643)	(4.553)	(4.253)
	N	360	360	360	360	360	360

t statistics in parentheses; $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

neighbor corruption. This is because GTFEE is determined by various combinations of factors of production, and the combination of factors of production isn't directly affected by corruption. But misallocation can have a direct impact on GTFEE, the labor misallocation of local area has a significantly negative effect on GTFEE in local area, which means that the higher the degree of labor misallocation, the lower the GTFEE in local area, but the GTFEE in local area is not affected by labor misallocation in the surrounding areas. Because except for a few provinces, the labor required in most regional industries is mainly from the local area (Wang et al., 2019a,b). The allocation of relevant elements in the local area isn't affected by the labor misallocation of neighbor. As an important production factor, labor force will reduce GTFEE when it is mismatched (Hu and Wang, 2006). Unlike labor misallocation, the capital misallocation in the local area is negatively related to GTFEE, but it is not significant, while the capital misallocation of neighbor is significantly negatively related to GTFEE of local area. This is because compared to labor, the liquidity of capital is stronger, so that the local area GTFEE is affected by the capital misallocation in the surrounding areas (Li and Hu, 2012). The allocation of other factors of production is impacted by the allocation of capital resources which also impacts GTFEE. Therefore, when the capital misallocation occurs, GTFEE is significantly inhibited (Wang et al., 2012). In addition to the two important production factors of capital and labor, the technical level also plays an important role in GTFEE. When the local area's technical level is higher, the use of factors may be more reasonable, and the GTFEE is improved. However, GTFEE is inhibited by the technological level of neighbor area (Chang and Hu, 2010). This is because when the technological level of neighboring areas improves, technological advantages is formed, and the production factors in the local area is attracted to the outside, which affects the allocation of production factors in the local area (Wang et al., 2020). In addition, the relationship between the economic level of the local area and GTFEE is significantly positive. The higher the regional economic level, the region has more ample production factors, the superstructure is more complete, and the more reasonable the combination of production factors, which make the GTFEE higher. But GTFEE in the local area isn't significant impacted by the economic level of neighboring areas (Zhang et al., 2015). For the two variables of foreign direct investment and industrial structure, whether it is local area or neighbor, there is a significant positive correlation only on a certain distance matrix. And on the whole, there is not relationship between then and GTFEE. Because foreign direct investment directly affects the enterprise and does not directly affect the allocation of production factors, so GTFEE isn't directly impacted. At present, most provinces in China are still dominated by the secondary industry. Although the proportion of the tertiary industry continues to increase, it is still in a weak position, so it doesn't have much impact on GTFEE (Yuan et al., 2009).

Although GTFEE isn't directly impacted by the corruption, it may have an impact on GTFEE by affecting the misallocation. To this end, the interaction item between labor misallocation and corruption, and capital misallocation and corruption are affiliated, which are used to confirm our ideas. Because the interaction item between the misallocation and corruption indicates whether the inhibitory effect of misallocation on GTFEE is enhanced by corruption (Li et al., 2019). Firstly, we

Table 5
The impact of regional corruption on capital misallocation and GTFEE.

Variable		W_1	W_{400km}	W_{800km}	W_{1000km}	W_{1500km}	W_{2000km}
Main effect	cor	0.000	-0.001	-0.001	-0.000	0.000	0.000
		(0.224)	(-0.634)	(-0.432)	(-0.306)	(0.006)	(0.190)
	rl	-0.160***	-0.179***	-0.159***	-0.151***	-0.170***	-0.165***
		(-6.559)	(-3.725)	(-4.292)	(-4.282)	(-5.925)	(-6.704)
	rk	-0.049	-0.042	-0.110	-0.093	-0.058	-0.050
		(-0.307)	(-0.223)	(-0.553)	(-0.482)	(-0.330)	(-0.294)
	cor_rk	0.001	0.000	0.002	0.002	0.001	0.001
		(0.355)	(0.095)	(0.404)	(0.343)	(0.339)	(0.297)
	fdi	-0.307	-0.003	-0.178	-0.163	-0.267	-0.304
		(-1.570)	(-0.013)	(-0.862)	(-0.786)	(-1.374)	(-1.548)
	pgdp	0.036***	0.015***	0.026***	0.027***	0.034***	0.035***
		(6.897)	(2.795)	(3.813)	(3.722)	(6.211)	(6.652)
	str	0.285**	0.070	0.293**	0.307**	0.354***	0.297**
		(2.337)	(0.560)	(2.095)	(2.385)	(3.034)	(2.508)
	rd	0.018*	0.020**	0.021**	0.020**	0.020**	0.018*
		(1.747)	(2.043)	(2.418)	(2.169)	(2.071)	(1.798)
Spatial effect (Wx)	cor	-0.002	-0.002	-0.000	0.000	-0.001	-0.003
		(-0.710)	(-1.132)	(-0.221)	(0.114)	(-0.555)	(-0.883)
	rl	0.192	-0.001	0.098	0.157	-0.129	-0.026
		(0.629)	(-0.008)	(0.785)	(1.007)	(-0.642)	(-0.136)
	rk	-1.388*	-0.453	-0.321	-0.214	-0.436	-1.023*
		(-1.715)	(-1.571)	(-0.988)	(-0.535)	(-1.126)	(-1.800)
	cor_rk	0.007	0.012	0.002	-0.009	-0.001	0.007
		(0.419)	(1.184)	(0.161)	(-0.755)	(-0.068)	(0.443)
	fdi	0.692	0.633***	0.397	0.775	0.081	0.409
		(0.451)	(3.490)	(0.745)	(1.123)	(0.281)	(1.060)
	pgdp	0.006	-0.014**	-0.012	-0.007	-0.027**	-0.013
		(0.295)	(-2.164)	(-1.535)	(-0.760)	(-2.460)	(-1.167)
	str	0.407	0.382**	0.087	0.239	0.042	0.265
		(1.565)	(2.310)	(0.390)	(1.074)	(0.183)	(1.147)
	rd	-0.017	-0.024	-0.027**	-0.031***	-0.015	-0.018
		(-1.171)	(-1.547)	(-2.204)	(-2.758)	(-1.173)	(-1.250)
Spatial_rho		-0.628**	0.017	-0.133	-0.275*	-0.308	-0.455*
		(-2.361)	(0.194)	(-1.060)	(-1.758)	(-1.368)	(-1.877)
Variance sigma2_e		0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
		(4.256)	(4.816)	(4.746)	(4.658)	(4.582)	(4.286)
	N	360	360	360	360	360	360

t statistics in parentheses; $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

Table 6
The self-sampling test of dynamic threshold effect.

Core interpretation variables	Threshold value	Wald statistics	P value	BS times	Confidence interval
rl	17.418***	158.582	0.000	1000	[14.227,37.985]
rk	34.271***	100.831	0.000	1000	[14.227,37.985]

analyze the results of adding labor misallocation and regional corruption interaction item. Empirical research shows that the inhibitory effect of local labor misallocation on GTFEE is enhanced by local corruption. On the one hand, people are more antipathy to corruption and may move elsewhere because of corruption, which enhances labor misallocation (Zhao et al., 2014). On the other hand, companies bribe the government to obtain a tilt in government policy, which further exacerbates labor misallocation (Honma and Hu, 2014). When considering whether the inhibitory effect of capital misallocation on GTFEE is affected by the corruption, it is found that the corruption in local area hardly affects the connection between capital misallocation and GTFEE. Because local governments adopt administrative measures for the purpose of pursuing GDP, economic means is used to concentrate capital to support key industries which are often heavy chemical industries, large energy consumers and large polluters (Niu et al., 2018). These companies do not need to bribe the government to obtain policy support (Wang and Zhou, 2008). When the problem of neighbor corruption intensifies, the government will provide financial facilities for corporate production, which will exacerbate local capital misallocation (Zhang and Wang, 2019). These policies will also attract capital resources in the local area and impact the combination of factors in the local area, so the inhibitory effect of neighbor capital misallocation on local GTFEE is enhanced (Özkara and Atak, 2015). Regardless of which interaction item is considered, the level of local economic development, industrial structure, and technology all play a significant role in promoting local GTFEE. The level of economic development is the most direct manifestation of social productivity, and the factor of production is another manifestation of productivity, so there is a positive relationship between the level of economic and GTFEE (Wu et al., 2017). The energy demand of the tertiary industry is much lower than that of the secondary industry. A higher proportion of the tertiary industry means that the industrial structure is closer to modernization and more reasonable, which effectively improves GTFEE (Lin and Tan, 2016). Higher technical level improves the utilization efficiency of various production factors, so all three have a positive relationship with GTFEE.

Under different levels of corruption, the impact of misallocation on GTFEE may vary. Through threshold regression analysis, it is found that in areas with high levels of corruption, whether it is labor misallocation or capital misallocation, the inhibitory effect on GTFEE will be exacerbated. And in areas with lesser corruption, this inhibition effect is weakened. This is basically consistent with our previous conclusions. This is because in areas with high levels of corruption, the government often colludes with enterprises to take care of talent policies and financial policies for companies that pay political capital contribution, which aggravates the misallocation in the region (Zhang and Li, 2019).

Table 7
Dynamic threshold regression results.

Variables	Formula (6)	Formula (7)
L.gtfe	0.439***	0.495***
	[20.19]	[53.28]
fdi	-0.223***	-0.351***
	[-7.59]	[-7.87]
pgdp	0.001	0.007***
	[1.24]	[8.93]
str	0.160***	0.215***
	[9.48]	[11.26]
rd	0.0002	-0.002***
	[0.38]	[-4.18]
rl· $I(cor \leq C)$	-0.008	
	[-0.62]	
rl· $I(cor > C)$	-0.059***	
	[-4.04]	
rk· $I(cor \leq C)$		-0.137***
		[-4.86]
rk· $I(cor > C)$		-0.214***
		[-6.04]
AR(1)	-1.29	-0.95
	(0.198)	(0.343)
AR(2)	1.38	1.16
	(0.168)	(0.246)
Hansen test	25.84	27.67
	(0.634)	(0.536)
Wald statistics	158.582***	100.831***
	(0.000)	(0.000)
N	300	300

Note: [] means Z value, () means P value.
t statistics in parentheses; $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.

In the above process, the combination of factors is not optimal, which leads to a decline in GTFEE (Prendergast, 1999). At the same time, when the corruption is intensified, production factors such as labor and capital will flee the local area. The structural irrationality of the local factor allocation combination is further exacerbated and the regional GTFEE is further reduced (Oladapo, 2014). Through a series of studies, we find that there is an inextricable link between misallocation, corruption and GTFEE.

6. Conclusions and policy implications

The spatial measurement method is used to analyze panel data of 30 provinces in China from 2005 to 2016 to explore links between misallocation, corruption and GTFEE. It is found that: ①GTFEE has positive spatial autocorrelation and spatial agglomeration is constantly strengthening. ②When corruption is not considered, GTFEE is significant negative impacted by the local labor misallocation, while GTFEE isn't affected by the labor misallocation of neighbor. The capital misallocation is just the opposite, the capital misallocation of neighbor affects GTFEE, while the capital misallocation of local area will not. In addition, GTFEE isn't affected by the corruption of local area or neighbor. ③When considering the interference of regional corruption, the negative impact of the local area labor misallocation on GTFEE is increased by the corruption in the local area, but the impact of the degree of neighbor labor misallocation on the local GTFEE isn't inhibited. In addition, no matter the local area or the neighbor, corruption issues is not interfered with the impact of capital misallocation on the local GTFEE. ④In areas with high levels of corruption, the labor misallocation and capital misallocation have a greater inhibitory effect on GTFEE, and in areas with low corruption, this inhibitory effect becomes smaller. According to the research results of this article, the following three policy suggestions are proposed for China to solve the problem of misallocation, improve the efficiency of GTFEE, and thus achieve a smooth transition of the economic structure:

(1) The employment mechanism of the regional population should be established and improved, which is used to solve the problem of the difficulty of employment of some enterprises. Firstly, the local talent introduction mechanism to solve the problem of enterprise technical talent gaps should be improved by the government. Secondly, fair and equitable employment policies for enterprises should be formulated by the government, instead of focusing on other industries and focusing on some industries. Furthermore, appropriate recruitment subsidies should be provided by the government alleviate the difficulty of recruitment due to pay differences. In addition, labor mobility barriers are also an important reason for labor misallocation. The current household registration system and social security system prevent labor from flowing freely between regions and sectors. Therefore, removing the various institutional barriers that hinder the cross-sectoral movement of labor is an important content to unlock the future growth potential of China. On the one hand, the dual urban-rural mechanism is broken by the continuous development of industrialization and urbanization. On the other hand, the residence permit system based on employment and stable residence should also established. Finally, the wage gap caused by sector monopolies should be solved by the government. And government should break the institutional barriers that restrict economic development and social progress, which can actively introduce market competitive forces, and break all forms of industrial monopolies.
(2) Government should improve regional capital flow mechanisms and reduce capital flow costs. Due to natural endowment and different government policies, capital allocation in different regions is not the same. The government should guide capital allocation according to local conditions which doesn't interfere with market mechanisms or interfere with normal capital market order. And capital should be avoided only clustered in a few industries. At the same time, financial enterprises and commercial banks should also assume certain social responsibilities, the credit system of small and medium-sized enterprises should be established and improved. And they can take advantage of the situation to work with the government to solve the problem of capital mismatch. Increasing and broadening access to private capital and reduce sector and industry monopolies are duties of government. An important reason for the emergence of the capital misallocation in China is that the government's promulgation of financial policies is obvious. Monopoly industries such as large state-owned enterprises benefit the most. These monopoly industries are inaccessible to private capital, which prevents capital resources from flowing freely. Therefore, in order to solve the problem of capital misallocation and improve the utilization efficiency of capital resources, the access mechanism should be relaxed to allow all kinds of capital to compete fairly, activate the real economy, and optimize the allocation structure of private and public capital.
(3) Government should vigorously carry out anti-corruption work and strive to solve the problem of corruption. Government departments can start from the following aspects. First of all, people should strengthen political identity, strengthen the sense of responsibility, and effectively promote the implementation of work. The implementation of the responsibility system for party style should be strengthen and government construction should be cleaned by government. The effective working mechanism should be established by clarifying tasks, implementing responsibilities, strengthening supervision, and strict assessment to make government construction become a strong constraint mechanism. Secondly, to improve the restriction system, the open system of power list should be carried out by government, which is used to clarify the scope of power and operational procedures and improve the power restriction. Government should increase

transparency and openness to the people and ordinary party members and cadres, and clearly expose the process and results of power operation to ensure that power operates in the sun. It is necessary to focus on areas of high governance risks. In addition, it is necessary for government to strengthen the accountability system. For those who have serious corruption, they should be held accountable for the leaders and main leaders while holding the direct responsibilities. Strong accountability measures is used to lead cadres forcing to perform their duties. At the same time, government should constantly improve the fault tolerance and correction mechanism. It is also necessary for government to adhere to the combination of strict management and love, and give equal weight to incentives and constraints, and establish an incentive mechanism.

Although this article has made some achievements in studying the relationship between environmental decentralization, government corruption and air pollution, there are still some limitations, which could also be future research directions. It is noteworthy that this study is purely empirical, but the mechanisms for the existence of nonlinear relationship between environmental decentralization and air pollution is also important. Therefore, the follow-up studies could try to build theoretical models to thoroughly explain the empirical findings of this research. Moreover, environmental management rights may be delegated to cities, the nexus of environmental decentralization and air pollution could be more accurately when city-level data are available in the future. The utilization of city-level data could enhance the explanatory power due to the significant increase in the sample size.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Yu Hao: Conceptualization, Methodology, Funding acquisition, Supervision. **Zhiqiang Gai:** Software, Visualization, Writing - original draft, Writing - review & editing, Formal analysis. **Haitao Wu:** Conceptualization, Project administration, Formal analysis, Writing - review & editing.

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References

Alvarez, J., Arellano, M., 2003. The time series and cross-section asymptotics of dynamic panel data estimators. Econometrica 71 (4), 1121–1159.
Anderson, T.W., Hsiao, C., 1982. Formulation and estimation of dynamic models using panel data. J. Econom. 18 (1), 47–82.
Arellano, M., Bond, S., 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev. Econ. Stud. 58 (2), 277–297.
Bai, Junhong, Liu, Yuying, 2018. Can FDI improve misallocation in China. China Ind. Econ. 1, 60–78.
Bandyopadhyay, D., King, I., Tang, X., 2019. Human capital misallocation, redistributive policies, and TFP. J. Macroecon. 60, 309–324.
Bian, Y., Song, K., Bai, J., 2019. Market segmentation, resource misallocation and environmental pollution. J. Clean. Prod. 228, 376–387.
Caggese, A., Cuñat, V., Metzger, D., 2019. Firing the wrong workers: financing constraints and labor misallocation. J. Financ. Econ. 133 (3), 589–607.
Chan, K.S., 1993. Consistency and limiting distribution of the least squares estimator of a threshold autoregressive model. Ann. Stat. 21 (1), 520–533.
Chang, T.P., Hu, J.L., 2010. Total-factor energy productivity growth, technical progress, and efficiency change: an empirical study of China. Appl. Energy 87 (10), 3262–3270.
Chen, J., Wang, S., Zhou, C., Li, M., 2019a. Does the path of technological progress matter in mitigating China's PM2.5 concentrations? Evidence from three urban agglomerations in China. Environ. Pollut. 254, 113012.
Chen, S., Zhang, Y., Zhang, Y., Liu, Z., 2019b. The relationship between industrial restructuring and China's regional haze pollution: a spatial spillover perspective. J. Clean. Prod. 239, 115808.
Cheng, Z., Li, L., Liu, J., 2018. Industrial structure, technical progress and carbon intensity in China's provinces. Renew. Sustain. Energy Rev. 81, 2935–2946.
Cubizol, D., 2018. Transition and capital misallocation: the Chinese case. J. Int. Money Finance 81, 88–115.
Cunat, V., Metzger, D., Caggese, A., 2017. Firing the wrong workers: financing constraints and labor misallocation. In: 2017 Meeting Papers (No. 632). Society for Economic Dynamics.
Dai, X., Cheng, L., 2019. Aggregate productivity losses from factor misallocation across Chinese manufacturing firms. Econ. Syst. 43 (1), 30–41.
David, J.M., Venkateswaran, V., 2019. The sources of capital misallocation. Am. Econ. Rev. 109 (7), 2531–2567.
Ek, C., Wu, G.L., 2018. Investment-cash flow sensitivities and capital misallocation. J. Dev. Econ. 133, 220–230.
Fogel, R.W., 1994. Economic Growth, Population Theory, and Physiology: the Bearing of Long-Term Processes on the Making of Economic Policy (No. W4638). National Bureau of Economic Research.
Fontagné, L., Santoni, G., 2019. Agglomeration economies and firm-level labor misallocation. J. Econ. Geogr. 19 (1), 251–272.
Foster, J.E., Horowitz, A.W., Méndez, F., 2012. An axiomatic approach to the measurement of corruption: theory and applications. World Bank Econ. Rev. 26 (2), 217–235.
Freeman, R., 2019. Doubling the global workforce: the challenges of integrating China, India, and the former Soviet block into the world economy. Doubling the Global Work Force.
Hansen, B.E., 1999. Threshold effects in non-dynamic panels: estimation, testing, and inference. J. Econom. 93 (2), 345–368.
Hao, Y., Wu, Y., Wu, H., Ren, S., 2019. How do FDI and technical innovation affect environmental quality? Evidence from China. Environ. Sci. Pollut. Control Ser. 1–16.
Hirakata, N., Sunakawa, T., 2019. Financial frictions, capital misallocation and structural change. J. Macroecon. 103127.
Honma, S., Hu, J.L., 2014. Industry-level total-factor energy efficiency in developed countries: a Japan-centered analysis. Appl. Energy 119, 67–78.
Hsieh, C.T., Klenow, P.J., 2009. Misallocation and manufacturing TFP in China and India. Q. J. Econ. 124 (4), 1403–1448.
Hu, J.L., Wang, S.C., 2006. Total-factor energy efficiency of regions in China. Energy Pol. 34 (17), 3206–3217.
Kaymak, B., Schott, I., 2019. Loss-offset provisions in the corporate tax code and misallocation of capital. J. Monetary Econ. 105, 1–20.
Li, L.B., Hu, J.L., 2012. Ecological total-factor energy efficiency of regions in China. Energy Pol. 46, 216–224.
Li, J., Lin, B., 2017. Ecological total-factor energy efficiency of China's heavy and light industries: which performs better? Renew. Sustain. Energy Rev. 72, 83–94.
Li, G., Shao, S., Zhang, L., 2019. Green supply chain behavior and business performance: evidence from China. Technol. Forecast. Soc. Change 144, 445–455.
Lin, B., Tan, R., 2016. Ecological total-factor energy efficiency of China's energy intensive industries. Ecol. Indicat. 70, 480–497.
Lluís Carrion-i-Silvestre, J., Del Barrio-Castro, T., López-Bazo, E., 2005. Breaking the panels: an application to the GDP per capita. Econom. J. 8 (2), 159–175.
Moll, B., 2014. Productivity losses from financial frictions: can self-financing undo capital misallocation? Am. Econ. Rev. 104 (10), 3186–3221.
Munshi, K., Rosenzweig, M., 2016. Networks and misallocation: insurance, migration, and the rural-urban wage gap. Am. Econ. Rev. 106 (1), 46–98.
Murphy, K.M., Shleifer, A., Vishny, R.W., 1991. The allocation of talent: implications for growth. Q. J. Econ. 106 (2), 503–530.
Neumark, D., 2018. Experimental research on labor market discrimination. J. Econ. Lit. 56 (3), 799–866.
Nickell, S., 1981. Biases in dynamic models with fixed effects. Econometrica: J. Econ. Soc. 1417–1426.
Niu, T., Yao, X., Shao, S., Li, D., Wang, W., 2018. Environmental tax shocks and carbon emissions: an estimated DSGE model. Struct. Change Econ. Dynam. 47, 9–17.
Oladapo, Z.A., 2014. Impact of Economic and Financial Crime Commission on the Economic Development of Nigeria.
Özkara, Y., Atak, M., 2015. Regional total-factor energy efficiency and electricity saving potential of manufacturing industry in Turkey. Energy 93, 495–510.
Piao, Z., Jia, J., Shen, F., Chen, R., 2016. Research of microcosmic affection factors on capital misallocation: a case of Chinese listed companies. Math. Probl Eng. 2016.
Prendergast, C., 1999. Investigating Corruption. The World Bank.
Ryzhenkov, M., 2016. Resource misallocation and manufacturing productivity: the case of Ukraine. J. Comp. Econ. 44 (1), 41–55.
Schopf, J.C., 2011. Following the money to determine the effects of democracy on corruption: the case of Korea. J. East Asian Stud. 11 (1), 1–39.
Shan, Haojie, 2008. Re-estimation of China's capital stock K: 1952 ~ 2006. Res. Quant. Econ. Tech. Econ. 25 (10), 17–31.

Shao, S., Yang, Z., Yang, L., Ma, S., 2019. Can China's energy intensity constraint policy promote total factor energy efficiency? Evidence from the industrial sector. Energy J. 40 (4).
Shi, H., Li, X., Zhang, H., Liu, X., Li, T., Zhong, Z., 2019. Global difference in the relationships between tourism, economic growth, CO2 emissions, and primary energy consumption. Curr. Issues Tourism 1–16.
Sun, C., Zhan, Y., Du, G., 2020. Can value-added tax incentives of new energy industry increase firm's profitability? Evidence from financial data of China's listed companies. Energy Econ. 104654.
Tobler, W.R., 1970. A computer movie simulating urban growth in the Detroit region. Econ. Geogr. 46 (Suppl. 1), 234–240.
Wang, Q.W., Zhou, D.Q., 2008. An empirical study on the change of total factor energy efficiency in China. Syst. Eng. 7.
Wang, Z.H., Zeng, H.L., Wei, Y.M., Zhang, Y.X., 2012. Regional total factor energy efficiency: an empirical analysis of industrial sector in China. Appl. Energy 97, 115–123.
Wang, J., Wang, K., Shi, X., Wei, Y.M., 2019a. Spatial heterogeneity and driving forces of environmental productivity growth in China: would it help to switch pollutant discharge fees to environmental taxes? J. Clean. Prod. 223, 36–44.
Wang, S., Li, C., Zhou, H., 2019b. Impact of China's economic growth and energy consumption structure on atmospheric pollutants: based on a panel threshold model. J. Clean. Prod. 236, 117694.
Wang, D., Liu, Y., Wang, Y., Shi, X., Song, X., 2020. Allocation of coal de-capacity quota among provinces in China: a bi-level multi-objective combinatorial optimization approach. Energy Econ. 87, 104709.
Wu, G.L., 2018. Capital misallocation in China: financial frictions or policy distortions? J. Dev. Econ. 130, 203–223.
Wu, J., Xiong, B., An, Q., Sun, J., Wu, H., 2017. Total-factor energy efficiency evaluation of Chinese industry by using two-stage DEA model with shared inputs. Ann. Oper. Res. 255 (1–2), 257–276.
Wu, H., Hao, Y., Weng, J.H., 2019. How does energy consumption affect China's urbanization? New evidence from dynamic threshold panel models. Energy Pol. 127, 24–38.
Wu, H., Gai, Z., Guo, Y., Li, Y., Hao, Y., Lu, Z.N., 2020. Does environmental pollution inhibit urbanization in China? A new perspective through residents' medical and health costs. Environ. Res. 109128.
Yang, S., Shi, X., 2018. Intangible capital and sectoral energy intensity: evidence from 40 economies between 1995 and 2007. Energy Pol. 122, 118–128.
Yian, C., 2019. Misallocation of human capital and productivity: evidence from China. Econ. Res. Ekon. Istraživanja 32 (1), 3342–3359.
Yuan, X.L., Zhang, B.S., Yang, W.P., 2009. The total factor energy efficiency measurement of China based on environmental pollution. China Ind. Econ. 2, 76–86.
Zhang, Y.J., Li, S.H., 2019. The impact of investor sentiment on crude oil market risks: evidence from the wavelet approach. Quant. Finance 19 (8), 1357–1371.
Zhang, Y.J., Wang, J.L., 2019. Do high-frequency stock market data help forecast crude oil prices? Evidence from the MIDAS models. Energy Econ. 78, 192–201.
Zhang, Jun, Wu, Guiying, Zhang, Jipeng, 2004. Estimates of China's inter-provincial physical capital stock: 1952-2000. Econ. Res. 10 (35), 4.
Zhang, X.P., Cheng, X.M., Yuan, J.H., Gao, X.J., 2011. Total-factor energy efficiency in developing countries. Energy Pol. 39 (2), 644–650.
Zhang, N., Kong, F., Yu, Y., 2015. Measuring ecological total-factor energy efficiency incorporating regional heterogeneities in China. Ecol. Indicat. 51, 165–172.
Zhao, X., Liu, C., Sun, C., Yang, M., 2020. Does stringent environmental regulation lead to a carbon haven effect? Evidence from carbon-intensive industries in China. Energy Econ. 86, 104631.
Zhou, Q., Zhang, X., Shao, Q., Wang, X., 2019. The non-linear effect of environmental regulation on haze pollution: empirical evidence for 277 Chinese cities during 2002–2010. J. Environ. Manag. 248, 109274.
Zhu, L., Hao, Y., Lu, Z.N., Wu, H., Ran, Q., 2019. Do economic activities cause air pollution? Evidence from China's major cities. Sustain. Cities Soc. 49, 101593.