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Government corruption, resource misallocation, and ecological efficiency

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ABSTRACT

There is currently much discussion in China about anti-corruption, optimization of the allocation of resources, and ecological protection. This study considers data from 2006 to 2015 and uses statistical methods to examine the influence of corruption and resource misallocation on ecological efficiency. The findings show that both corruption and misallocation of resources have negative impacts on ecological efficiency, considering endogeneity. Further analysis shows that resource misallocation has mediating effects. Corruption can directly reduce ecological efficiency; however, it can also intensify resource misallocation, which leads to further decline in ecological efficiency. This research provides a helpful reference for the Chinese government to overcome its oversights, optimizing both resource allocation and ecological protection.

1. Introduction

Since the implementation of the *reform and opening up policy* in 1978, China's economy has achieved rapid growth at an average annual growth rate of 10% and became the world's second-largest economy in 2010. However, this has led to the depletion of resources and destruction of the environment (Boamah et al., 2017; Han et al., 2018). The haze problem in 2013 led to a 43% increase in the incidence of lung cancer in Beijing. Environmental protection is now imperative in China. In the report of the Nineteenth National Congress of the People's Republic of China, it is stated that China should vigorously promote the construction of ecological civilization and avoid sacrificing the environment for temporary economic growth. To measure the coordinated development of economy and environment, some scholars proposed the index of ecological efficiency (Schaltegger and Sturn, 1990). Ecological efficiency can be improved only when the economic level and environmental quality are simultaneously improved. However, ecological efficiency has always been in a declining tendency.

Improving ecological efficiency has become the focus of much research. Some scholars believe that the reduction of ecological efficiency is not due to insufficient resources, but their wastage and unreasonable allocation. The ecological efficiency can be enhanced promoting a rational allocation and effective utilization of resources (Young, 2000; Song and Jin, 2016). Since China's tax sharing system reform of 1994, the fiscal autonomy of local governments has increased significantly. Local governments, in pursuit of political achievements, are willing to violate market rules and restrict the cross-regional flow of local capital and labor (Song and Jin, 2016). This makes it difficult for the talents to be placed in important positions and the rate of capital return is low. In a country with an inherent shortage of resources, such a development model magnifies the misallocation of resources, causing unnecessary efficiency losses (Dollar and Wei, 2007; Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009; Brandt et al., 2012).

In addition to the decline in ecological efficiency caused by resource misallocation, the expansion of local financial power also causes corruption. The power to reallocate resources and make discretionary decisions tends to become the tool of government officials seeking personal gains (Shleifer and Vishny, 1993). Local government officials may set rent costs or use indirect rent extraction to induce enterprises to commit bribery, which then channels more resource allocation into non-productive activities, thereby resulting in more resource wastage (Bertrand et al., 2007; Aidt, 2016). However, some scholars believe that through corruption, government officials can identify which resources need to be distributed more than others to complete the allocation of resources on the principle of market bidding, which would improve both the allocation of resources and productivity (Méon and Weill, 2008). However, most research on the issue of resource allocation impacted by corruption is often from the rational economy perspective, which overlooks the impact of corruption on the ecological environment (Blackburn et al., 2006; Swaleheen, 2011). In fact, when considering the relationship between resource allocation and the quality of the environment, the impact of corruption on resource allocation may lead to environmental problems. For instance, some high-pollution and high-energy-consuming industries and enterprises might cover environmental costs through bribery (He et al., 2007).

Moreover, this phenomenon will continue to exist as long as the benefits that enterprises gain can offset the bribery costs. Furthermore,

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corruption may lead to an increase in the efficiency of resource allocation (Méon and Weill, 2008), which may improve the quality of the environment to some extent. Therefore, the impact of corruption on ecological efficiency needs to be further investigated.

This study will connect corruption with resource allocation and ecological efficiency. We address the following questions: (1) In China's current situation, will corruption lead to the misallocation of resources or optimization of resource allocation? (2) Will resource allocation capacity influence China's ecological efficiency? (3) Is there any possible measure to improve ecological efficiency? The structure of the paper is as follows: in the second section, the relevant literature is reviewed; the third section presents a mathematical model; the fourth section explains the index selection and measurement model; the fifth section consists of the empirical analysis; the sixth section discusses the results; and finally, the seventh section provides conclusions.

2. Literature review

2.1. Corruption and economic growth

Corruption is one of the most critical issues that governments around the world have to face. Current research holds three views about the relationship between corruption and economic growth. The first view is the "effective corruption theory." Research has found that corruption can not only increase the stock of foreign direct investment (FDI; Barassi and Zhou, 2012) but also help enterprises avoid ineffective regulations, gain some resources, and obtain competitive advantages through rent-seeking (Lien, 1986; Levy, 2007; Bologna and Ross, 2015; Dutta and Sobel, 2016). Corruption may drive economic growth, as long as the profits of rent-seeking are higher than the costs (Egger and Winner, 2005). In contrast, the supporters of the view that "corruption has harmful effects" believe that it has a negative influence on economic growth as it goes against an increase in per capita income and private investment (Mo, 2001; Swaleheen, 2011) as well as the accumulation of human capital and trade policy (Mo, 2001; Pellegrini and Gerlagh, 2004). Others hold that the relationship between corruption and economic growth is not monotonous and the impact of corruption on economic growth depends on its incidence rate (Méndez and Sepúlveda, 2006; Aidt et al., 2008; Dong and Torgler, 2010).

The impacts of corruption on economic development are still controversial. Current research always focuses on how corruption influences resource allocation. That is to say, when studying the influence of corruption, beyond taking its effects on institution and order into account, many scholars also analyze its influence on economic gain by studying the way it influences the structure of resource allocation (Leff, 1964; Dreher and Gassebrier, 2013; Bologna and Ross, 2015; Dutta and Sobel, 2016).

2.2. The impact of corruption on resource allocation

Resource misallocation, which is often divided into "connotation misallocation" and "epitaxial misallocation," lies at the core of studies on resource allocation (Hsieh and Klenow, 2009; Banerjee and Moll, 2010). The misallocation of resources may reduce not only the total factor productivity but also affect economic growth (Dollar and Wei, 2007; Ryzhenkov, 2016; David et al., 2016). As for China, under the influence of institutional distortion and market segmentation, the development of a factor capital market has obvious regional differences and a high degree of resource misallocation, which severely impacts economic development. Hsieh and Klenow (2009) discovered that China's misallocation of resources is serious, and the productivity of industrial enterprises in China is 30%–50% lower than that of American industries; 49% of this difference is caused by resource misallocation. China's total factor productivity would improve by 86%–110% if the misallocation is rectified.

Local government officials often control a large number of resources and can make discretionary decisions. Because the institutional costs are not in line with the costs presented to enterprises, there are no sufficient controls over the way in which resources are allocated, which provides some officials with a chance to broker a power-for-money deal (Pailler, 2018). Given this background, some scholars regard corruption as an effective alternative method to allocate the resources (Leff, 1964; Dreher and Gassebrier, 2013; Bologna and Ross, 2015; Dutta and Sobel, 2016). They argue that through bribery, enterprises can improve the efficiency of administrative examination and approval and preferentially obtain some rare resources (Lui, 1985; Beck and Maher, 1986; Lien, 1986), which can in turn reduce the distorted costs caused by some government policies and achieve effective resource allocation (Leff, 1964). For instance, Krammer (2013) pointed out that corruption is an effective method to introduce innovative products into the market. Also, corruption can make enterprises' financial costs congruent, and it can optimize resource allocation.

However, most scholars believe that corruption will lead to ineffective resource allocation (Liu et al., 2015; Restuccia and Rogerson, 2017; Pailler, 2018). According to the related research, on one hand, enterprises bribe government officials because they seek less oversight and supervision (Holcombe and Boudreaux, 2015) and more returns. On the other hand, there is a possibility that officials deliberately defer administrative processes (Aidt, 2016) and induce enterprises to try to rent to gain income from corruption. Whether enterprises proactively bribe officials or are forced to seek to rent, transaction fees are expensive (Murphy et al., 1993), which will inevitably lead to cutting their productive investment and channeling more resources into non-productive activities. That is how the allocation of resources is distorted (Wadho, 2013). For example, Aidt (2016) found that more enterprises turn their business activities to less competitive industries, in which it is easier to gain corruption rent. Moreover, because corruption stems from non-productive rent-seeking (Acemoglu, 1995; Minniti, 2008; Sobel, 2008; Boudreaux et al., 2018; Sulemana, 2018), it can also induce high-quality human capital to become devoted to rent-seeking instead of creative activities, which leads to the distortion of human capital allocation.

2.3. The impact of corruption on ecological efficiency

Considering the correlation between economic growth and environmental quality, some scholars have studied the way corruption and resource allocation influence ecological efficiency during the process of economic development. Fredriksson et al. (2004), Ivanova (2010), and Sheng et al. (2016) found that corruption reduces the stringency of environmental regulation, which harms the environment and environmental protection. According to Lopez and Mitra (2000) and Masron and Subramaniam (2018), by increasing the inflection point of the Kuznets curve, corruption can intensify local pollution. Moreover, Cole (2007) pointed out that corruption would influence pollutant emission both directly and indirectly. Also, there was a positive correlation between the direct effect of pollutant emission and pollution, and there was a more significant negative correlation between the indirect effect of corruption and the emission of pollutants.

As we can see, current research has discussed the effects of corruption on ecological efficiency and analyzed how it exercises such influence. The results of these previous studies provide the background for the current research. However, existing research has produced contradictory conclusions and superficial analysis. Owing to the complexity of the relationship between corruption and economic growth, further studies should be conducted to figure out their effects on ecological efficiency. Moreover, the distortion of resource allocation caused by corruption may lead to the inefficient use of energy (Wei and Li, 2017; Yang et al., 2018) and then influence ecological efficiency. Hence, this study considers corruption, resource allocation, and ecological efficiency together, along with the causal relationships among corruption, the efficiency of resource allocation, and environmental quality, to study the impacts of corruption on ecological efficiency as well as the mediating effect of resource misallocation.

3. The theoretical model

Based on the analysis presented above, we establish a 3×2×1 model with three factors. The three factors are labor (l), capital (k), and technology (A), and the final product is Q. Concerning Peters (2013), the output function of the final product department is:

$$\ln Q = \int_0^1 \ln q_i di \tag{1}$$

We assume that any intermediate product division i has two producers (incumbent and potential entrant) that produce homogeneous product Q. Each intermediate product manufacturer inputs capital (k), labor (l), and production technology (A) and produces with constant returns to scale, whose production function is expressed as:

$$q(k, l, A) = Ak^{\alpha} l^{1-\alpha} \tag{2}$$

In the formula, α refers to the coefficient of elasticity. Intermediate product producers obtain raw materials for production through factor markets. However, because of information asymmetry, externality, or other objective reasons, market factors are not complete, and there are some distortions (Hsieh and Klenow, 2009). We assume that capital and labor prices of potential entrants are v and w respectively. As enterprises operate in the market and are parts of social production, we should not only consider the cost of production but also its impact on society, that is, environmental costs. Enterprises cannot discharge pollutants to the surrounding environment without restraint; thus, we define the ecological efficiency indicator to measure the efficiency of enterprises taking environmental factors into account. If the ecological efficiency is high, it means that the production efficiency under the constraints of environmental factors is relatively high. Thus, we assume that the ecological efficiency of potential enterprises is θ_f and there is:

$$\theta_l = t\theta_f \tag{3}$$

In this equation, θ_l represents the ecological efficiency of the incumbent enterprises. We continue to assume that, due to imperfect factor markets, capital and labor prices of incumbent firms are mv and nw; m is the degree of resource misallocation of capital; n is the degree of resource misallocation of labor, and $m, n > 1$. Since there is a resource misallocation in the market, it provides a possibility for government corruption.

We can get the demand function of intermediate products from formula (1) as below:

$$q_i = Q/p_i \tag{4}$$

p_i is the lowest price for all manufacturers. We can get the total cost function and marginal cost of the incumbent firm through calculation:

$$C(v, w, q) = qA^{-1}\alpha^{\alpha}(1-\alpha)^{1-\alpha} v^{\alpha} w^{1-\alpha} \tag{5}$$

$$MC_{(\theta_l,m,n)} = \left(\frac{wn}{1-\alpha}\right)^{1-\alpha}\left(\frac{vm}{\alpha}\right)^{\alpha}/\theta_l \tag{6}$$

Because the manufacturer is in the constant state of scale, when it implements the lowest price supply, it can seize the whole market. Hence, we can deem that when p_i exceeds the marginal cost $MC_{(\theta_f,m,n)}$, potential manufacturers can enter and seize the whole market; when $p_i < MC_{(\theta_f,m,n)}$, the profit of the incumbent firm is not maximized. Only when $p_i = MC_{(\theta_f,m,n)}$ can the enterprise profits be maximized. At this point, the equilibrium price of the incumbent firm is:

$$p_i = MC_{\theta_f} = \left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(\frac{v}{\alpha}\right)^{\alpha}/\theta_f \tag{7}$$

3.1. Decision on corruption level

In practice, however, government officials have the right to issue licenses and decide which firms can enter the market. By taking bribes from incumbent firms, government officials have prevented potential eco-efficient firms from entering the market (Amir and Burr, 2015). We assume that the bribe of the incumbent firm to the government official is equal to the price that exceeds the marginal cost, that is, $p_i - MC_{(\theta_f,m,n)}$. Corruption leads to a considerable degree of monopoly, resulting in a severe market failure under the intervention of the government. Moreover, monopoly further aggravates the breeding of corruption. To measure the degree of corruption, we use the ratio of the product price of the firm to its marginal cost for measurement, and the expression is μ. From this, we can get the corruption degree of the bribe from the incumbent firm to the government:

$$\mu(i, m, n) = p_i/MC_{(A,m,n)} = tm^{-\alpha}n^{\alpha-1} \tag{8}$$

We can see that corruption has two sources. One is the difference in enterprise ecological efficiency, the other is the resource misallocation degree in capital market m and the resource misallocation degree in labor market n. By seeking their partial derivatives, we can get:

$$\partial\mu_n = t(\alpha-1)n^{\alpha-2}m^{-\alpha}<0 \tag{9}$$

$$\partial\mu_m = -t\alpha n^{\alpha-1}m^{-\alpha-1}<0 \tag{10}$$

We can see that if an enterprise can obtain capital and labor at a lower price in the factor market, its marginal cost will be lower, and the degree of corruption will be higher. It is assumed that there is a disadvantage in the ecological efficiency of incumbent firms relative to potential entrants, that is, $t < 1$; then when $n^{1-\alpha}m^{\alpha} < t$ we can get $\mu > 1$. At this point, the misallocation of resources in the factor market makes the producers with low ecological efficiency occupy the market and hinder the potential entrants with high ecological efficiency from accessing the market. Meanwhile, corruption affects the market, which not only leads to resource misallocation among different incumbent enterprises but also may hamper more ecologically efficient enterprises from entering the market, resulting in a greater degree of resource misallocation (Banerjee and Moll, 2010).

3.2. Government corruption, resource misallocation, and ecological efficiency

To verify the relationships among government corruption, resource misallocation, and ecological efficiency, we combine formulae (4), (7) to obtain:

$$k = \alpha Q/\mu vm \tag{11}$$

$$l = (1-\alpha)Q/\mu wn \tag{12}$$

By substituting formula (2), we can yield the output of the incumbent firm as below:

$$y = \theta_l Q\mu^{-1}(\alpha/mv)^{\alpha}((1-\alpha)/nw)^{1-\alpha} \tag{13}$$

The marginal output of capital is $mv\mu$; the marginal output of labor is $nv\mu$. We can see that the product price is related to three factors: the price of a factor in the whole market, the degree of resource misallocation in the factor market, and the degree of government corruption.

We can get the total social capital and the total labor input as below:

$$K = \int_0^1 \frac{\alpha Q}{\mu v(1+m)} di \tag{14}$$

and

$$L = \int_0^1 \frac{(1-\alpha)Q}{\mu w(1+n)} di \tag{15}$$

If the enterprise produces according to formula (2) and the whole society regards the improvement of ecological efficiency as the embodiment of social and technological progress, there will be:

$$Q = \theta \times \left(\int_0^1 (\alpha Q/mv\mu) di\right)^{\alpha} \left(\int_0^1 ((1-\alpha)Q/nw\mu) di\right)^{1-\alpha} \tag{16}$$

On the other hand, by combining the formula (1) and the enterprise output formula (13), we can also get the expression of ecological efficiency as below:

$$\theta = \exp\left(\int_0^1 \ln\theta_l di\right) \times \frac{-\exp\int_0^1 \ln t di}{\left(\int_0^1 t^{-1}(m/n)^{\alpha-1} di\right)^{\alpha}\left(\int_0^1 t^{-1}(m/n)^{\alpha} di\right)^{1-\alpha}} = \theta_M \times M \tag{17}$$

In the formula, θ_M represents the weighted average of the ecological efficiency of the incumbent firms, and M indicates the resource misallocation index. By combining formulae (9) and (10), we can know that ecological efficiency is closely related to the degree of resource misallocation of economic factors and government corruption.

4. Selection and explanation of the variables

4.1. Degree of corruption (cor)

As corruption tends to be concealed, it is difficult to measure the degree of corruption. Breen and Gillanders (2012) used the Transparency International (TI) corruption survey data to analyze the effects of corruption and institutions on business regulation, but such indicators have strong subjectivity and are not representative of the real situation. Dong and Torgler (2013) and Duan et al. (2018) used the number of civil servants who abused their power to measure the extent of corruption in the United States, but this indicator ignored the impact of regional population size. Castro et al. (2015) used the number of corruption cases per one million public officials but ignored the differences among the provinces. Therefore, we combine the approaches of Duan et al. (2018) and Castro et al. (2015), that is, we measure the degree of inter-provincial corruption by selecting the number of corruption cases per one million public officials from 2006 to 2015. The greater the value of this index, the higher the degree of corruption. The relevant data have been obtained from the official website of the state data and Procuratorial Yearbook of China (http://www.stats.gov.cn/).

It should be noted that due to the influence of the statistical yearbook data, the data on corruption cases in some provinces in 2014 and 2015 are missing. Considering the stability of relevant data, the annual mean value is selected to supplement the missing values.

4.2. Resource misallocation (rm)

The relative difference between the development degree of the factor market and the highest development degree of factor market in each region is used to measure the level of resource misallocation. The specific calculation method is as follows:

$$rm_{it} = \frac{\max(factor_{it}) - factor_{it}}{\max(factor_{it})}, (i = 1, \ldots, 29; t = 2006, \ldots, 2015) \tag{18}$$

The factor market development index is calculated by four score values according to their weights. The data are extracted from the National Bureau of Statistics and the annual China City Statistical Yearbook from 2007 to 2016.

$$factor_{it} = 0.311 score_1 + 0.218\, score_2 + 0.203\, score_3 + 0.268\, score_4 \tag{19}$$

According to the marketization index compiled by Wang et al. (2016), the factor market development index includes four parts: the marketization of financial industry, degree of foreign investment, mobility of labor force, and marketization of technological achievements. According to these four parts, this study chooses "the proportion of regional financial institutions' loan balance to GDP," "the actual amount of foreign capital used in that year (converted by the annual average price of CNY to USD exchange rate) to GDP," "the proportion of urban population," and "the ratio of amount of the technical contract transaction to the full-time equivalent regional research and experimental development personnel," respectively, to calculate the index score values. Moreover, the score of every part is obtained using the formula (20):

$$score_k = 10 \times \frac{V_{\max} - V_k}{V_{\max} - V_{\min}}, (k = 1, 2, 3, 4) \tag{20}$$

4.3. Ecological efficiency (efe)

According to the definition of OECD (Organization for Economic Cooperation and Development) (1998), eco-efficiency refers to "the efficiency of ecological resources to meet human needs," that is, the relationship between the input and output of resources and the environment that human beings rely on to meet their needs. Research on the calculation of ecological efficiency began in the 1990s. Schaltegger and Sturn (1990) first proposed how to calculate ecological efficiency, while Fussler (1995) expanded it. Most existing studies measure ecological efficiency based on the DEA method (Ángeles et al., 2017; Liu et al., 2015), which better reflects the relationship between input and output of ecological efficiency. However, the traditional DEA method is not suitable for the situation where there is an undesirable output (Choi et al., 2018). Therefore, this studyrefers to the idea of Choi et al. (2018) and uses the SBM model, considering the undesirable output to calculate the ecological efficiency of various provinces in China. Based on neoclassical economic theories and the main aims of this study, this study selects labor force, capital, and land as input indexes, and economic development and undesirable output as output indexes.

Table 1
Definition of the study's variables.

Symbol	Definition
efe	Ecological efficiency level
rm	Resource misallocation degree
cor	Number of corruption cases per million public officers
for	Foreign capital dependence (proportion of actually utilized foreign direct investment in GDP)
env	Environmental pollution degree (proportion of investment in environmental pollution control in GDP)
gfe1	Government regulation 1 (proportion of general local financial expenditure in GDP)
gfe2	Government regulation 2 (proportion of general government revenue in GDP)
tur	Logistics level (per capita goods turnover)
str	Industrial structure (proportion of secondary industry output value in GDP)

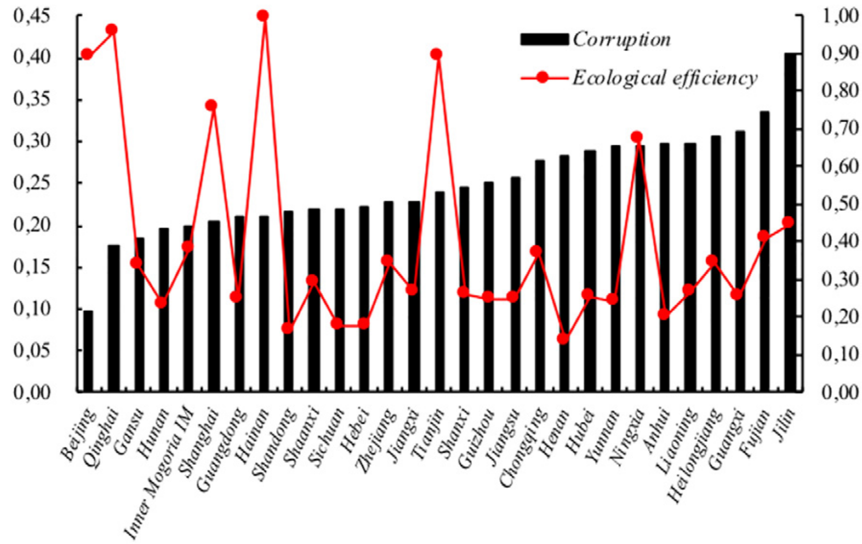

Fig. 1. Government corruption and resource misallocation scatter diagram.

4.3.1. Input index

(1) Labor force. This study adopts the year-end number of employees to measure the labor factor. The year-end number of employees reflects all employees engaged in production and business activities at the end of the year, which can better reflect the level of labor input. These data for each province or city are taken from the China City Statistical Yearbook.
(2) Capital. From the perspective of economics, capital factors mainly include capital stock composed of various resources and fixed asset investment in the current year. Therefore, this study chooses the fixed asset investment of the whole society as the investment index to measure the capital factors and calculate the annual ecological efficiency of each province or city. The relevant data were obtained from the website of the National Bureau of Statistics (http://www.stats.gov.cn/).
(3) Land. This study uses ecological footprint to measure the input of land factors. Ecological footprint refers to the area of ecological productive land required for the consumption of all resources and absorption of all waste in the production area. Most natural resources that people require are obtained from land. Thus, the ecological footprint can be used to describe people's demand for land. In the research process, the ecological footprint is further divided into the agricultural footprint, energy footprint, and pollution footprint, among which agricultural footprint and energy footprint are taken as inputs of ecological efficiency, while pollution footprint is the output.

The ecological footprint considered in this study consist of six types of biological productive land: cultivated land, woodland, grassland, construction land, fossil energy land, and water area. In the calculation process, this study calculates the land consumption per capita and an average output of each type of land by classification. The specific formula is:

$$EF = N \times ef = N \times \sum_{j=1}^{6} \sum_{i=1}^{n} (r_j \times c_i / p_i) \tag{21}$$

Here, i refers to the type of consumption item; EF refers to the total regional ecological footprint; ef refers to the regional ecological footprint per capita; N refers to the total regional population; r_j is the balance factor of the jth ecologically productive land; c_i refers to the yield of the ith consumption item per capita, and p_i refers to the average global yield of the ith consumption item per capita. The balance factor (r_j) is the ratio of the type of biogenic land in the region to the average productivity of all productive lands in the region. According to the research results of Wackernagel et al. (2004), Living Planet Report (2000, 2002, 2004), and the China Ecological Footprint and Sustainable Consumption Research Report, the equilibrium factors of the six types of land did not change much in the last forty years. Therefore, the mean value of each factor is used for calculation in this study.[1] Additionally, as each region produces different agricultural products and fossil fuels, the types of consumption vary from region to region. For example, the outputs of cultivated land include rice, wheat, corn, sorghum, beans, potatoes, cotton, oil, sugar, eggs, tobacco, and vegetables. The outputs of woodland include fruit, raw lacquer, oilseed, tea seed, palm slice, bamboo shoot, etc. Grassland outputs include pork, beef, mutton, milk, wool, cashmere, and honey, and water areas mainly produce all kinds of aquatic products.

Based on the global average output data of agricultural products released by the United Nations Food and Agriculture Organization (FAO), the ecological footprint is calculated by combining products and consumption types in different regions. As FAO has not released the average output data of agricultural products in 2015, considering that the annual output of the same type of products changes slightly, the average data of the same type of products in 2014 and 2016 are used to replace the missing 2015 data. Yang et al. (2018) pointed out that the yield of woodland and grassland did not change much, and the average yield data provided by Wackernagel et al. (2004) is used to replace the data of uncounted animal products in FAO. As some families of biological accounts (such as walnut, Sichuan pepper, poultry egg, cashmere, raw lacquer, and palm sheet) are not included in the statistical families of FAO, relevant statistical data reported by Chinese scholars are selected to account for the missing data (Xie et al., 2008; Yang et al., 2018).[2] Accordingly, the energy footprint is calculated in this study according to the national energy consumption projects, which mainly include coal, coke, crude oil, gasoline, kerosene, diesel, fuel oil, natural gas, electricity, and so on. Among them, the forests and pastures for absorbing the

[1] The mean values of each factor are: cultivated land = 2.34, woodland = 1.64, grassland = 0.48, water area = 0.32, construction land = 2.34, and fossil energy land = 1.64.

[2] The average yield of walnut is 2150 kg/ha, poultry egg 2760 kg/ha, Chinese prickly ash 385 kg/ha, raw lacquer and palm slice 3732 kg/ha, cashmere 1 kg/ha.

Table 2
Descriptive statistics.

Index	Mean value	Standard deviation	Minimum value	Maximum value
efe	0.3962	0.2569	0.1222	1.0000
rmt	0.6786	0.2172	0.0000	0.9693
cor	0.2480	0.0662	0.0788	0.4632
for	0.0254	0.0186	0.0003	0.0819
env	0.0133	0.0060	0.0040	0.0363
gfe1	0.2116	0.0926	0.0837	0.6269
gfe2	0.1002	0.0312	0.0541	0.2197
tur	1.2347	1.8026	0.1186	13.7121
str	0.4752	0.0790	0.1974	0.5905

greenhouse gas emissions of fossil energy are calculated based on the statistical data of Chinese scholars (Xie et al., 2008).[3]

4.3.2. Output index

(1) Economic development condition. Considering the availability of data and the comprehensiveness of economic development, this study adopts GNP to measure economic development.
(2) Undesirable output. Under the concept of green development, environmental conditions should be considered. Some environmental pollution will be caused by humans in productive activities, and the pollution and its treatment will occupy the biological productive land area. Thus, this study adds the pollution absorption area when observing ecological land to measure the biological productive land area (that is, the pollution footprint), which is needed for pollution discharge. Pollution emissions need biological productive land area (that is, the pollution footprint) and, as the expected output, indicators to measure the ecological efficiency. The pollution footprint refers to the ecological footprint of land that is directly or indirectly occupied by polluting substances, including wastewater, waste gas, and solid waste. The calculation standards of occupied land area for sewage discharge are as follows: the land area occupied by wastewater discharge is converted according to the standard 3704 t/ha of the sewage treatment test project of Shenzhen Bainikeng artificial wetland; the woodland area occupied by waste gas discharge is converted according to the average SO_2 and soot absorption capacity of broad-leaved forest, which is 88.65 kg/ha and 10.11 t/ha, respectively. In addition, since solid waste is generally treated by sanitary landfill and compost, the occupied land area is converted according to the standard of 10.19 t /ha. Based on the above indexes and standards, this study calculates the ecological efficiencies of 29 Chinese provinces from 2006 to 2015.

4.4. Control variables

Previous studies have found that government guidance, factor flow, foreign capital utilization capacity, economic structure, environmental protection, and other factors are likely to affect the degree of resource misallocation and ecological efficiency (Hao and Lu, 2018; Bai and Liu, 2018). Therefore, factors such as government intervention, logistics level, foreign capital dependence, industrial structure, and environmental pollution are selected as control variables in the paper. The definition of each control variable is shown in Table 1.

[3] Land area occupied by 1 ton of fossil energy is: petroleum 0.3382 ha; diesel 0.3496 ha, crude oil 0.3340 ha, natural gas 0.1882 ha, raw coal 0.2269 ha; cultivated land occupied by 1kwh electric power: thermal power $1.1251 \times 10{-}4$ ha; hydroelectricity $2.1448 \times 10{-}6$ ha.

5. Analysis and results

5.1. Descriptive statistics

Fig. 1 shows that among the 29 regions in China included in the survey, the average eco-efficiency values of Hainan, Qinghai, Beijing, and Tianjin are relatively high, all above 0.8, and the average eco-efficiency values of other regions are relatively low. Except for the average ecological efficiency of Shanghai and Ningxia Hui Autonomous Region, between 0.6 and 0.7, the average ecological efficiency of other regions remains below 0.5, indicating that the overall ecological efficiency is not ideal. In addition, Fig. 1 shows that Beijing has the lowest level of corruption, while the Northeast (Liaoning, Heilongjiang, and Jilin provinces) has the highest level of corruption.

As shown in Table 2, ecological efficiency has an average of 0.396 with standard deviation of 0.257, which shows the distinct difference of eco-efficiency in different provinces. The degree of resource mismatch has an average of 0.679 with standard deviation of 0.217, which indicates that the degree of average resources mismatch in China is comparatively high with obvious regional differences. The average of number of corruption cases per million public officers is 0.248, and the standard deviation is 0.0662, which demonstrates that corruption is still an issue that the Chinese Government needs to consider carefully. In addition, as is shown in Table 2, the level of development of logistics differs highly, while the fluctuating degree of external dependence, environmental pollution, the intervention of the government and industry structure is relatively low.

5.2. Analysis of the regression results

5.2.1. Analysis of the regression results of corruption and resource mismatch

In order to verify the connection between corruption and resource mismatch, this study built the following regression model:

$$rm_{i,t} = \alpha_0 + \alpha_1 rm_{i,t\text{-}1} + \alpha cor_{i,t} + \sum \eta_i X_{i,t} + \varepsilon_{i,t} \tag{22}$$

In this formula, *rm* stands for the degree of resource mismatch; *cor* is the corruption degree; *X* is the degree of FDI independence (*for*), government intervention (*gfe1, gfe2*), the development level of logistics (*tur*), the level of environmental pollution (*env*); *i* stands for regions; *t* means time. This study applied the comparative regression verification on the connection between corruption and resource mismatch by using the OLS, FE, and GMM models to relieve the endogeneity problems and guarantee the reliability of the result. See Table 3 for the regression results.

Table 3 shows that in the OLS model, the coefficient of *cor* is 0.072, which is distinctive at the level of 10%, indicating that the higher the degree of corruption, the greater the degree of resource mismatch. Correspondingly, in the FE model, the coefficient of *cor* is 0.070, which does not pass the distinctiveness test. From the regression results, the coefficients of the hysteresis in the OLS and FE models are 0.894 and 0.451, respectively, while the coefficients in the GMM model are 0.572. Both pass the test at the 1% distinctiveness level, which proves that the estimated results of GMM model are valid. At this time, the coefficient of *cor* is 0.220, and the distinctiveness test at the level of 10% indicates that the level of corruption is positively correlated with the degree of resource mismatch.

5.3. The impact of the degree of corruption and resource misallocation on regional ecological efficiency

According to the previous mathematical deduction, this study argues that the degree of corruption and mismatch of resources can impact ecological efficiency. To verify the relationship between the three, this

Table 3
Initial inspection on the connection between corruption and resources mismatch. Notes: The number in coefficient brackets is t; *, **, *** are distinctive at 10%, 5%, and 1%, respectively. The Hausman Test line shows the Hausman inspection results. Line AR(1) and AR(2) respectively show the sequence-related test results; Line Sargan Test demonstrates the test results of the tool variables. The test results support the exogeneity of the tool variables.

Variable	OLS	FE	GMM
rm(−1)	0.894***	0.451***	0.571***
	(29.28)	(5.15)	(7.51)
cor	0.072*	0.070	0.216*
	(1.66)	(0.96)	(1.70)
tur	−0.001	−0.004***	−0.008**
	(−0.39)	(−3.22)	(−2.00)
gfe2	−0.347*	−0.801**	−0.234
	(−1.76)	(−2.37)	(−0.21)
gfe1	−0.064	−0.061	0.174
	(−1.10)	(−0.27)	(1.04)
for	−0.578**	−2.248	−1.234***
	(−2.24)	(−8.76)	(−3.67)
env	−0.7174	−0.889	−1.593***
	(−1.29)	(−1.63)	(−4.69)
Cons	0.129***	0.524***	0.380***
	(3.39)	(9.29)	(5.57)
Hausman test		69.95***	
AR(1)			−2.097**
AR(2)			−1.944*
Sargan test			27.274
Num. of tool variable			60

study constructed the following regression model:

$$efe_{i,t} = \beta_0 + \beta_1 efe_{i,t\text{-}1} + \beta rm_{i,t} + \chi cor_{i,t} + \sum \mu_i X_{i,t} + \varepsilon_{i,t} \tag{23}$$

5.3.1. Preliminary examination and path analysis of corruption degree, resource misallocation, and regional eco-efficiency

Considering the existence of endogenous problems, this study continued to use the GMM method to test the relationship between corruption degree, resource mismatch, and regional ecological efficiency, and the regression results are shown in Table 4. As seen in Table 4, after considering endogenous problems, the coefficients of *cor* and *rm* are −0.082 and −0.077 respectively, which are significant at the level of 5% and 1%. This indicates that the corruption level and resource mismatch have a negative effect on ecological efficiency. That is, the higher the level of corruption, the greater the degree of mismatch of resources, and the lower the ecological efficiency. It should be pointed out that, based on the above theoretical analysis and empirical test, this study has verified that corruption will aggravate the degree of resource misallocation, and both corruption and resource misallocation will lead to the reduction of regional ecological efficiency. Therefore, does this mean that resource mismatch play an intermediary role in the mechanism of corruption affecting regional ecological efficiency? To analyze and verify this problem, this study constructed the following model to test

Table 4
Degree of corruption, misallocation of resources, eco-efficiency test, and mediation Effect test. Notes: The number in coefficient brackets is t; *, **, *** are distinctive at 10%, 5%, and 1%, respectively. Line AR(1) and AR(2) respectively show the sequence-related test results; Line Sargan Test demonstrates the test results of the tool variables. The test results support the exogeneity of the tool variables.

Variable	Mediation effect test			
	(23)	(24)	(22)	(25)
efe(1)	0.935***	0.953***		0.940***
	(36.52)	(48.64)		(28.54)
rm(−1)			0.571***	
			(7.51)	
cor	−0.082**	−0.123***	0.216*	
	(−2.15)	(−3.31)	(1.70)	
rm	−0.077***			−0.096***
	(−2.93)			(−2.65)
tur	0.005**	0.005**	−0.008**	0.005
	(2.09)	(1.98)	(−2.00)	(1.25)
env	0.721	0.770	−0.234	0.390
	(1.27)	(1.46)	(−0.21)	(0.45)
for	−0.880***	−0.506*	0.174	−1.038***
	(−2.96)	(−1.92)	(1.04)	(−4.16)
gfe1	−0.095	−0.130 *	−1.234***	−0.074
	(−1.48)	(−1.83)	(−3.67)	(−1.21)
gfe2	0.095	0.257***	−1.593***	0.085
	(0.79)	(2.62)	(−4.69)	(0.40)
Cons	0.121***	0.054***	0.380***	0.118***
	(3.60)	(2.64)	(5.57)	(3.00)
AR(1)	−1.987**	−1.997**	−2.097**	−1.981**
AR(2)	1.092	1.087	−1.944*	1.049
Sargan test	26.460	26.833	27.274	28.370
Num. of Tool Variable	85	84	60	68

Table 5
Robustness test for the relationship among corruption, misallocation of resources, and ecological efficiency. Notes: The number in coefficient brackets is t; *, **, *** are distinctive at 10%, 5%, and 1%, respectively. Line AR(1) and AR(2) respectively show the sequence-related test results; Line Sargan Test demonstrates the test results of the tool variables. The test results support the exogeneity of the tool variables.

Rm	(1)	(2)	(3)	(4)	(5)
rm(−1)	0.814***	0.744***	0.691***	0.547***	0.571***
	(15.50)	(9.68)	(15.08)	(7.38)	(7.51)
cor	0.308*	0.222*	0.200*	0.267**	0.216*
	(1.68)	(1.65)	(1.85)	(2.11)	(1.70)
tur	−0.013**	−0.012***	−0.009**	−0.007 *	−0.008**
	(−2.19)	(−2.56)	(−2.30)	(−1.78)	(−2.00)
gfe2		−0.655***	−1.329***	−1.300***	−0.234
		(−3.22)	(−5.77)	(−5.87)	(−0.21)
gfe1			0.384***	0.228	0.174
			(2.62)	(1.60)	(1.04)
for				−2.023***	−1.234***
				(−2.83)	(−3.67)
env					−1.593***
					(−4.69)
Cons	0.067	0.202**	0.225***	0.385***	0.380***
	(1.00)	(2.34)	(6.44)	(6.20)	(5.57)
AR(1)	−2.274**	−2.227**	−2.212**	−2.130**	−2.097**
AR(2)	−1.720*	−1.833*	−1.857*	−1.943*	−1.944*
Sargan test	28.057	27.110	27.562	26.944	27.274
Num. of tool variable	34	35	36	37	60

the mediation effect:

$$efe_{i,t} = \theta_0 + \theta_1 efe_{i,t\text{-}1} + \gamma cor_{i,t} + \sum \lambda_i X_{i,t} + \varepsilon_{i,t} \quad (24)$$

$$efe_{i,t} = \rho_0 + \rho_1 efe_{i,t\text{-}1} + \delta rm_{i,t} + \sum \xi_i X_{i,t} + \varepsilon_{i,t} \quad (25)$$

According to the test results of the mediation effect in Table 4, we can find that *cor* and *efe* are negatively correlated at 1% level (coefficient is −0.123); *cor* and *rm* are positively correlated at the 10% level (coefficient is 0.216); *rm* and *efe* are negatively correlated at 1% level (coefficient is −0.096); and *cor* and *rm* are negatively correlated with *efe* at 5% and 1%, respectively (coefficient are −0.082 and −0.077, respectively). This shows that resource mismatch does have a mediating effect on the relationship between corruption level and ecological efficiency, and resource mismatch is a partial mediator variable. That is, there are two ways to influence the ecological efficiency through corruption. One is to directly affect the ecological efficiency, leading to the deterioration of the ecological environment; the other is to reduce the ecological efficiency by intensifying the mismatch of resources, and ultimately aggravating ecological destruction.

5.4. Robustness test

To verify the reliability of the regression results, a robustness test on the relationship between corruption, resource mismatch, and ecological efficiency, as well as some mediating effects of resource mismatch was conducted. First, the relationship between corruption, resource mismatch, and ecological efficiency was investigated by gradually introducing control variables. The results of the robustness test are shown in Table 5. Second, considering the impact of the industrial structure on its ecological efficiency, this study introduced the industrial structure

Table 6
Test of degree of corruption, misallocation of resources, and testing of ecological efficiency. Notes: The number in coefficient brackets is t; *, **, *** are distinctive at 10%, 5%, and 1%, respectively. Line AR(1) and AR(2) respectively show the sequence-related test results; Line Sargan Test demonstrates the test results of the tool variables. The test results support the exogeneity of the tool variables.

EFE	(6)	(7)	(8)	(9)	(10)
efe(−1)	0.877***	0.903***	0.921***	0.934***	0.935***
	(22.45)	(50.15)	(53.16)	(50.06)	(36.52)
cor	−0.110**	−0.099***	−0.106**	−0.086**	−0.082**
	(−2.31)	(−2.95)	(−2.17)	(−2.28)	(−2.15)
rm	−0.087***	−0.064***	−0.087***	−0.089***	−0.077***
	(−2.94)	(−3.55)	(−4.06)	(−4.63)	(−2.93)
tur	0.004	0.004	0.005**	0.005**	0.005**
	(1.44)	(1.47)	(2.01)	(2.14)	(2.09)
env		0.405	0.272	0.681	0.721
		(0.98)	(0.51)	(1.18)	(1.27)
for			−0.662***	−0.872***	−0.880***
			(−3.63)	(−3.07)	(−2.96)
gfe1				−0.072	−0.095
				(−1.00)	(−1.48)
gfe2					0.095
					(0.79)
Cons	0.137***	0.103***	0.130***	0.136***	0.121***
	(3.30)	(5.32)	(5.74)	(5.47)	(3.60)
AR(1)	−1.977**	−1.978**	−1.995**	−1.988**	−1.987**
AR(2)	1.037	1.022	1.061	1.083	1.092
Sargan test	27.115	26.669	27.118	26.457	26.460
Num. of tool variable	51	67	83	84	85

Table 7
Robustness test for the mediation effect. Notes: The number in coefficient brackets is t; *, **, *** are distinctive at 10%, 5%, and 1%, respectively. Line AR(1) and AR(2) respectively show the sequence-related test results; Line Sargan Test demonstrates the test results of the tool variables. The test results support the exogeneity of the tool variables.

Variable	(24)	(22)	(25)	(23)
efe(−1)	0.975***		0.957***	0.949***
	(36.77)		(27.04)	(34.24)
rm			−0.120***	−0.091***
			(−3.62)	(−2.88)
rm(−1)		0.633***		
		(17.20)		
cor	−0.110**	0.184*		−0.071*
	(−2.06)	(1.75)		(−1.72)
tur	0.003	−0.005*	0.003	0.004*
	(1.43)	(−1.64)	(1.21)	(1.66)
env	0.208	1.363	−0.689	0.016
	(0.26)	(1.30)	(−0.66)	(0.02)
for	−0.750***	−0.939 **	−1.444***	−1.172***
	(−3.10)	(−2.06)	(−5.64)	(−5.19)
str	0.147***	−0.279	0.199***	0.181***
	(2.53)	(−1.25)	(3.40)	(3.37)
gfe1	−0.156***	0.205	−0.097	−0.118*
	(−2.50)	(1.57)	(−1.57)	(−1.70)
gfe2	0.439***	−1.625***	0.267	0.311*
	(3.45)	(−6.42)	(1.46)	(1.84)
Cons	−0.026	0.470 ***	0.046	0.039
	(−0.62)	(3.62)	(0.99)	(0.99)
AR(1)	−1.970**	−2.266**	−1.966**	−1.963**
AR(2)	1.197	−1.829*	1.166	1.225
Sargan test	27.214	25.688	26.905	27.090
Num. of tool variable	85	69	69	86

(STR), a key control variable, for the robustness test when investigating the mediating effect of resource mismatch. The regression results are shown in Table 6. According to the robustness test results, the conclusions of this study are reliable. (See Table 7.)

6. Conclusions

Based on the statistical data from 2006 to 2015, this study analyzed the relationship between corruption, resource mismatch, and ecological efficiency based on a variety of statistical methods. The results show that after considering the influence of endogenous problems, both the level of corruption and the degree of resource mismatch have a negative impact on ecological efficiency. That is, the higher the level of corruption, the greater the degree of resource mismatch, and the lower the ecological efficiency. Moreover, the negative relationship between the corruption level of resource mismatch and ecological efficiency has partial mediating effects, showing that, corruption does not only lead directly to the decrease of ecological efficiency but also to the decrease of ecological efficiency by intensifying the resource mismatch.

The shortcoming of this paper is that the premise of the model is too robust. We set the production function of enterprises as a C-D production function and considered the production of the enterprise on the premise of constant return on a production scale. In future studies, we need to soften the model hypothesis to ensure a more realistic conclusion. We think that government corruption is an exogenous factor, and has an insignificant relationship with other factors. However, we can see from the empirical results that corruption and misallocation of resources are interactional. Therefore, in future studies, we should try to endogenize government corruption and build a complete model of government corruption and resource misallocation. Finally, considering the availability and accuracy of the data, we only tested the data from 2006 to 2015. Extending the analysis period would make it possible to obtain more accurate conclusions. In particular, since President Xi came to power in 2015, the government corruption problem has been severely targeted. Selecting data after 2015 for the robustness test would be a very good comparative experiment, thus making our conclusions more convincing.

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References

Acemoglu, D., 1995. Reward structures and the allocation of talent. Eur. Econ. Rev. 39 (1), 17–33.
Aidt, T.S., 2016. Rent seeking and the economics of corruption. Constitut. Polit. Econ. 27 (2), 142–157.
Aidt, T.S., Dutta, J., Sena, V., 2008. Governance regimes, corruption and growth: theory and evidence. J. Comp. Econ. 36, 195–220.
Amir, R., Burr, C., 2015. Corruption and socially optimal entry. J. Public Econ. 123, 30–41.
Ángeles, G.D., Emilio, G.G., Juan, C.P.M., Laura, P.M., 2017. Assessing eco-efficiency and the determinants of horticultural family-farming in southeast Spain. J. Environ. Manag. 204 (1), 594–604.
Bai, J., Liu, Y., 2018. Can foreign direct investment improve China's resource mismatch. Chin Ind Econ. (01), 60–78 (in Chinese).
Banerjee, A.V., Moll, B., 2010. Why does misallocation persist? Am. Econ. J. Macroecon. 2 (1), 189–206.
Barassi, M.R., Zhou, Y., 2012. The effect of corruption on FDI: a parametric and non-parametric analysis. Eur. J. Polit. Econ. 28 (3), 302–312.
Beck, P.J., Maher, M.W., 1986. A comparison of bribery and bidding in thin markets. Econ. Lett. 20, 1–5.
Bertrand, M., Djankov, S., Hanna, R., Mullainathan, S., 2007. Obtaining a driver's license in India: an experimental approach to studying corruption. Q. J. Econ. 1639–1676.
Blackburn, K., Bose, N., Haque, M.E., 2006. The incidence and persistence of corruption in economic development. J. Econ. Dyn. Control. 30, 2447–2467.
Boamah, K.B., Du, J.G., Boamah, A.J., Applah, K., 2017. A study on the causal effect of urban population growth and international trade on environmental pollution: evidence from China. Environ. Sci. Pollut. Res. 25 (6), 5862–5874.
Bologna, J., Ross, A., 2015. Corruption and entrepreneurship: evidence from Brazilian municipalities. Publ. Choice. 165 (1–2), 59–77.
Boudreaux, C.J., Nikolaev, B.N., Holcombe, R.G., 2018. Corruption and destructive entrepreneurship. Small Bus. Econ. 51 (1), 181–202.
Brandt, L.J., Biesebroeck, V., Zhang, Y., 2012. Creative accounting or creative destruction? Firm–level productivity growth in Chinese manufacturing. J. Dev. Econ. 97 (2), 339–351.
Breen, M., Gillanders, R., 2012. Corruption, institutions and regulation. Econ. Govern. 13 (3), 263–285.
Castro, M.F., Guccio, C., Pignataro, G., Rizzo, I., 2015. Is competition able to counteract the inefficiency of corruption? The case of Italian public works. Economia e Politica Industriale. 8 (3), 1–30.

Choi, Y., Yu, Y., Lee, H., 2018. A study on the sustainable performance of the steel industry in Korea based on SBM-DEA. Sustainability. 10 (1), 173.
Cole, M.A., 2007. Corruption, income and the environment: an empirical analysis. Ecol. Econ. 62 (3), 637–647.
David, J.M., Hopenhayn, H.A., Venkateswaran, V., 2016. Information, misallocation and aggregate productivity. Q. J. Econ. 131 (2), 943–1005.
Dollar, D., Wei, S.J., 2007. Das (wasted) capital: firm ownership and investment efficiency in China. NBER Working Paper No. 7 (13103).
Dong, B., Torgler, B., 2010. The Consequences of Corruption: Evidence From China, CREMA, Center for Research in Economics. Working Paper No. 2010-06.
Dong, B., Torgler, B., 2013. Causes of corruption: evidence from China. China Econ. Rev. 26, 152–169.
Dreher, A., Gassebrier, M., 2013. Greasing the wheels? The impact of regulation and corruption on firm entry. Publ. Choice. 155 (3–4), 413–432.
Duan, H., Snyder, T., Yuan, W., 2018. Corruption, economic development, and auto loan delinquency: evidence from China. J. Econ. Bus. 99, 28–38.
Dutta, N., Sobel, R., 2016. Does corruption ever help entrepreneurship? Small Bus. Econ. 1–21.
Egger, P., Winner, H., 2005. Evidence on corruption as an incentive for foreign direct investment. Eur. J. Polit. Econ. 21, 932–952.
Fredriksson, P.G., Vollebergh, H.R., Dijkgraaf, E., 2004. Corruption and energy efficiency in OECD countries: theory and evidence. J. Environ. Econ. Manag. 47 (2), 207–231.
Fussler, C., 1995. The development of industrial eco-efficiency. Industry and Environment 17 (4), 71–74.
Han, J., Du, T.Y., Zhang, C., Qian, X.P., 2018. Correlation analysis of CO_2 emissions, material stocks and economic growth nexus: evidence from Chinese provinces. J. Clean. Prod. 180, 395–406.
Hao, Y., Lu, J., 2018. The impact of government intervention on corporate investment allocations and efficiency: evidence from China. Financ. Manage. 47 (2), 383–419.
He, J., Makdissi, P., Wodon, Q., 2007. Corruption Inequality and Environmental Regulation. Working Paper No. 07-13.
Holcombe, R.G., Boudreaux, C.J., 2015. Regulation and corruption. Publ. Choice. 164 (1–2), 75–85.
Hsieh, C.T., Klenow, P.J., 2009. Misallocation and manufacturing TFP in China and India. Q. J. Econ. 124 (4), 1403–1448.
Ivanova, K., 2010. Corruption and air pollution in Europe. Oxf. Econ. Paper. 63 (1), 49–70.
Krammer, S., 2013. Greasing the Wheels of Change: The Impact of Corruption on Firms' Innovation in Transition Economics. 35th DRUID Celebration Conference, Working Paper.
Leff, N., 1964. Economics development through bureaucratic corruption. Am. Behav. Sci. 8, 8–14.
Levy, D., 2007. Price adjustment under the table: evidence on efficiency-enhancing corruption. Eur. J. Polit. Econ. 23, 423–447.
Lien, D.H.D., 1986. A note on competitive bribery games. Econ. Lett. 22 (4), 337–341.
Liu, Q., Lu, R.S., Ma, X.J., 2015. Corruption, financial resources and exports. Rev. Int. Econ. 23 (5), 1023–1043.
Lopez, R., Mitra, S., 2000. Corruption, pollution, and the Kuznets environment curve. J Environ Econ Manag. 40 (2), 137–150.
Lui, F., 1985. An equilibrium queuing model of bribery. J. Polit. Econ. 93 (4), 760–781.
Masron, T.A., Subramaniam, Y., 2018. The environmental Kuznets curve in the presence of corruption in developing countries. Environ. Sci. Pollut. Res. 25 (13), 12491–12506.
Méndez, F., Sepúlveda, F., 2006. Corruption, growth and political regimes: cross-country evidence. Eur. J. Polit. Econ. 22, 82–98.
Méon, P.G., Weill, L., 2008. Is Corruption an Efficient Grease. Bank of Finland, Institute for Economics in Transition. BOFIT Discussion Papers. 20.
Minniti, M., 2008. The role of government policy on entrepreneurial activity: productive, unproductive, or destructive? Entrep Theory Pract. 32 (5), 779–790.
Mo, P.H., 2001. Corruption and economic growth. J. Comp. Econ. 29, 66–79.
Murphy, K., Shleifer, A., Vishny, R., 1993. Why is rent-seeking so costly to growth? Am. Econ. Rev. 83 (2), 409–414.
Pailler, S., 2018. Re-election incentives and deforestation cycles in the Brazilian Amazon. J. Environ. Econ. Manag. 88, 345–365.
Pellegrini, L., Gerlagh, R., 2004. Corruption's effect on growth and its transmission channels. Kyklos. 57, 429–456.
Peters, M., 2013. Heterogeneous Mark-ups, Growth and Endogenous Misallocation. Working Paper.
Restuccia, D., Rogerson, R., 2008. Policy distortions and aggregate productivity with heterogeneous establishments. Rev. Econ. Dynam. 11, 707–720.
Restuccia, D., Rogerson, R., 2017. The causes and costs of misallocation. J. Econ. Perspect. 31 (3), 151–174.
Ryzhenkov, M., 2016. Resource misallocation and manufacturing productivity: the case of Ukraine. J. Comp. Econ. 44 (1), 41–55.
Schaltegger, S., Sturn, A., 1990. Ecological rationality: starting points for the design of ecology-oriented management tools. The company 44 (4), 273–290.
Sheng, J., Han, X., Zhou, H., Miao, Z., 2016. Effects of corruption on performance: evidence from the UN-REDD Programme. Land Use Policy 59 (11), 344–350.
Shleifer, A., Vishny, R.W., 1993. Corruption. Q. J. Econ. 108 (3), 599–617.
Sobel, R.S., 2008. Testing Baumol: institutional quality and the productivity of entrepreneurship. J. Bus. Venturing. 23 (6), 641–655.
Song, M., Jin, P., 2016. Local protection, resource misallocation and environmental welfare performance. Econ. Istraz. 12 (1), 47–61 (in Chinese).
Sulemana, I., 2018. The effect of trust and corruption on public preferences for cash transfers from oil revenues in Ghana. J. Asian Afr. Stud. 53 (4), 553–570.
Swaleheen, M., 2011. Economic growth with endogenous corruption: an empirical study. Publ. Choice. 146, 23–41.
Wackernagel, M., Monfreda, C., Schulz, N. B., Erb, K. H., Haberl, H., Krausmann, F., 2004. Calculating national and global ecological footprint time series: resolving conceptual challenges. Land Use Policy 21(3), 0–278.
Wadho, W.A., 2013. Control rights, bureaucratic corruption and the allocation of resources. Eur. J. Law Econ. 35 (1), 41–59.
Wang, X., Fan, G., Yu, J., 2016. Marketization Index of China's Province: NERI REPORT 2016.
Wei, C., Li, C.Z., 2017. Resource misallocation in Chinese manufacturing enterprises: evidence from firm-level data. J. Clean. Prod. 142 (2), 837–845.
Xie, H., Chen, X., Lin, K., Hu, A., 2008. Fossil energy and electric power ecological footprint based on carbon cycle. J. Ecol. 4, 1729–1735 (in Chinese).
Yang, M.A., Yang, F.X., Sun, C.W., 2018. Factor market distortion correction, resource reallocation and potential productivity gains: an empirical study on China's heavy industry sector. Energ. Econ. 69, 270–279.
Young, A., 2000. The razor's edge: distortions and incremental reform in the people's republic of China. Q. J. Econ. 115 (4), 1091–1135.