Check for updates

Efficiency measures and influencing factors for rural land outsourcing: Evidence from China, 2003–2015

Mengdi Wang[1]*, Changzheng Wang[2] and Xiaobing Peng[1]

[1]School of Public Policy and Administration, Chongqing University, Chongqing, China, [2]School of Public Policy and Administration, Chongqing Technology and Business University, Chongqing, China

In the context of China's vigorous promotion of its rural revitalization and land transfer policy, land outsourcing is a perspective worthy of attention to understand China's rural land production and agricultural development. Based on rural land outsourcing in China from 2003 to 2015, this study adopts DEA efficiency analysis and Tobit regression analysis to measure the efficiency of rural land outsourcing in China as well as discuss its influencing factors. The results show that 1) from 2003 to 2015, the efficiency of rural land outsourcing in China has risen, especially in the eastern region, where the efficiency has the best performance. Overall, technical efficiency has hindered the improvement of rural land outsourcing efficiency. 2) The development of rural land outsourcing is restricted by factors such as the newly increased arable land area in rural areas, the foreign labor force, and rural managers, while land outsourcing income cannot significantly promote the expansion of land outsourcing. 3) Large rural agricultural enterprises or cooperatives enhance the efficiency of land outsourcing. Under the food security policy, realizing the technological increment of land outsourcing and land economy can effectively promote the scale and production efficiency of land outsourcing.

KEYWORDS
rural land outsourcing, production efficiency, technical efficiency, influence factors, land development

1 Introduction

Under rapid urbanization and industrialization processes, a large number of rural laborers have flowed out and agricultural land has become idle. However, in order to make good use of idle rural land, improve the efficiency of rural land, and stabilize the rural agricultural economy, land outsourcing, a new land use model, has long been the focus of developing countries (Chen et al., 2017; Zhang et al., 2017). As the largest developing country in the world, China has made active explorations and attempts in China's agricultural growth, such as agricultural policies, agricultural trade reforms, agricultural product prices, public investment in agricultural infrastructure construction, improvements in land use, innovation in the land lease market, and agricultural cooperatives (Huang et al., 2010; Yu and Jensen, 2010; Zhang et al., 2011).

As early as the end of the 20th century, the international attention to the rural land use reform emphasized the use of rural land in the form of circulation. In underdeveloped regions such as Asia, Africa, and Latin America, more attention is paid to the status quo and efficiency of land transfer, believing that it can improve farmers' income (Jin and Jayne, 2013; Huy et al., 2016), while studies in eastern Europe pay more attention to land privatization and market transactions (Ciaian and Swinnen, 2006). As the most typical developing country and a largely agricultural country, China's land system defects, urbanization, and high planting costs have become the main driving factors affecting rural land use. At the same time, the aging labor force, the unsound transfer market, and the high transaction cost also become external factors affecting land use (Wang and Tan, 2020; Li and Shen, 2021). According to the existing research, the improvement of rural land use and land economy has become a key concern of many countries. Developing countries, in particular, face problems such as institutions, production costs, and land use methods in improving land use and land economy. Therefore, the research on the mode, efficiency, and influencing factors of China's rural land reuse can provide useful experience for other developing countries to understand and find solutions for land development.

On the basis of considering food supply and sustainable land use planning (Li et al., 2022), in the practice of rural land reuse in China, there are two new models: the agricultural production outsourcing service model and the rural land outsourcing model. In the context of promoting rural revitalization policy and land transfer policy in China, we pay attention to the efficiency of land outsourcing different from production services in the process of rural agricultural development, explore its current situation and influencing factors of development, and focus on the "land outsourcing efficiency" and "how to better land outsourcing".

Agricultural production outsourcing services promote the use of rural land in improving productivity (Chen et al., 2017; Zhang et al., 2017; Sun et al., 2018; Sheng and Chancellor, 2019; Yi et al., 2019). With the massive outflow of rural labor and the reduction of young labor, rural land may not be able to continue to be cultivated, and crop yields and agricultural profits may subsequently be affected. Agricultural production outsourcing services provide support for labor, agricultural machinery, and key agricultural production skills, such that migrant farmers or nonagricultural farmers can continue to cultivate their own land and ensure the production of crops (Yang et al., 2013; Chen et al., 2017; Zhang et al., 2017; Sheng and Chancellor, 2019; Yi et al., 2019; Deng et al., 2020). However, this model has obvious limitations in the service object, and only focuses on those agricultural production organizations with strong purchasing power. To be specific, nonagricultural employment has led to a shortage of rural labor and reduced agricultural productivity and food productivity (Wu et al., 2017). Outsourcing agricultural production services provide a way to mechanize agriculture to increase agricultural productivity. In terms of agricultural

mechanization, the Chinese government provided subsidies for farmers or agricultural cooperatives to purchase agricultural machinery in 2004, up to 30% of the purchase price. In 2008, farmers who bought large tractors with more than 100 horsepower could receive a subsidy of up to 80,000 yuan (Ministry of Agriculture and Rural Affairs of the People's Republic of China, 2020a; Ministry of Agriculture and Rural Affairs of the People's Republic of China, 2020b); however, in 2004, the per capita income of rural residents in China was only 2936.4 yuan and the Engel coefficient was 47.2% (National Bureau of Statistics of the People's Republic of China, 2020). Obviously, for individual rural families, buying agricultural machinery is a great burden and, so, such farmers are not motivated to buy or invest in agricultural machinery (Yang et al., 2013; Davis and Lopez-Carr, 2014; Zhang et al., 2018).

Furthermore, the pattern of labor cost outsourcing or labor service outsourcing in agricultural production outsourcing services provides a good research basis for land outsourcing. Agricultural production outsourcing refers to the outsourcing of agricultural production services by farmers to other individuals or professional organizations, which is an employment behavior of the owner of a land management right (Chen et al., 2017; Zhang et al., 2018; Wang and Tan, 2020) and plays a positive role. However, the reality is that the outsourcing of agricultural production by farmers may not be so effective. The outsourcing of individual peasant households is not conducive to the scale economy of the outsourcing organization, which may not be able to afford the outsourcing cost. Therefore, more peasant households have chosen to take the form of village collectives, where village organizations gather the land of peasant households for outsourcing in China. Through land subcontracting, on one hand, farmers can obtain the rent of land leases; on the other hand, outsourcing organizations that obtain land can distribute part of the profits to village organizations and redistribute them to farmers. In this way, farmers can realize their family income without participating in agricultural production and can rely on land outsourcing only, which also ensures the production of land agriculture. In addition, farmers can also be hired by outsourcing organizations to participate in agricultural production for workers, in order to obtain labor income. In 2003, China promulgated the Rural Land Contracting Law, which stipulates that farmland can be transferred to other farmers by means of leasing. With the improvement of China's rural land transfer policy, land leasing or land outsourcing has become increasingly active in China's rural areas (Huang et al., 2012; Che, 2014). According to the data from China's Ministry of Rural Agriculture, from 2012 to 2015, the annual growth rate of farmland transferred to agricultural businesses in China's rural areas exceeded by 20% (Chen, 2020) and, by the end of 2016, about 35.1% of farmland had been transferred (Tang et al., 2019). Even if the Chinese government adopts subsidies for agricultural machinery, it still adopts the leasing market to

realize land centralization and agricultural production growth (Su et al., 2018). Obviously, land outsourcing highlights a shift in land use rights, which is different from the labor cost emphasized by agricultural production outsourcing or regarded as labor outsourcing (Zhang et al., 2017; Chen, 2020). Agricultural production outsourcing focuses on the interpretation of the agricultural production process, while land outsourcing focuses on the exchange and earnings between agricultural production materials. It should be noted that this study is not a judgment on whether agricultural production outsourcing and land outsourcing are right or wrong, instead considering that they are two different perspectives we attempted to carry out research from a different perspective than that of agricultural production outsourcing. Obviously, under China's vigorous promotion of its rural revitalization and land transfer policy, we chose this perspective of land outsourcing and considered it a relatively new and noteworthy perspective.

Therefore, the purpose of this study is to investigate the production efficiency of land outsourcing from the perspective of land outsourcing, as well as to further explore the circumstances under which land outsourcing is more likely to occur, or which factors affect land outsourcing and agricultural production. In addition, outsourcing means that agricultural production is transferred from inefficient farmers to efficient organizations (Wang et al., 2015), which also centralizes the farmers implementing land outsourcing and forming an organization. In China, such an organization is generally the organization of a village committee, which is a unified organization stipulated by law for the management of rural resident affairs and autonomy. Land outsourcing is a decision made by landowners (farmers). To some extent, we can say that land outsourcing is the self-choice of rural organizations (Schaller et al., 2012). It also gives us a direction to look at from an organizational perspective. Different from the existing research that has studied agricultural production from the perspective of individual characteristics, family characteristics, location characteristics, or traffic characteristics of farmers (Koirala et al., 2016; Amare and Shiferaw, 2017; Alves and Kato, 2018), we discuss the issue of land outsourcing from the perspective of an organizational characteristic formed by farmers. In other words, the existing studies have focused on the effect of outsourcing and whether the expected results are achieved, while our research interest lies in the determinants that influence outsourcing, focusing on the issues of "land outsourcing efficiency" and "how to better promote land outsourcing". From the perspective of organizational characteristics, statistical data analysis was used to evaluate the production efficiency of rural land outsourcing in China in the current period, while the main factors affecting the development of land outsourcing were sought. Finally, based on the results of our research, we put forward suggestions regarding the development of rural land outsourcing, in order to improve agricultural production efficiency. As a largely

agricultural country moving toward modernization, the explanation of China's rural land outsourcing can provide a reference for agricultural production and land use in different agricultural countries throughout the world.

2 Materials and methods

2.1 Data source

The data in this study were from the "National Rural Fixed Observation Point Survey Data" of the Ministry of Agriculture of China, consisting of two parts of data from 2000 to 2009 and from 2010 to 2015 (Rural Fixed Observation Office, 2010; Rural Fixed Observation Office, 2017). The data survey was carried out by the Rural Fixed-Observation Office and began in 1986. As of 2021 (the most recent published version was used in this study), the survey data covered 23,000 rural households and 360 administrative villages in China, with samples distributed in 31 provinces (autonomous regions and municipalities), excluding Hong Kong, Macao, and Taiwan (please see Figure 1). These continuous data were obtained through long-term follow-up surveys of fixed villages and households. As the data of each peasant household sample are not published, the data used in this study are a summary version of the officially published data; that is, after standardized processing, the data of all the surveyed peasant households and administrative villages are displayed according to the year. The data after scientific processing are still very representative and researchable, which provided a scientific, effective, and sufficient basis for data analysis in this study.

To be specific, the data reflect eight aspects: 1) the composition of family members, such as the family population, income, composition, and employment; 2) land conditions, such as cultivated land, park, forest area, and so on; 3) fixed assets; 4) production and operation conditions of farming families, such as crop production and operation, animal husbandry production, and aquaculture production; 5) sales of agricultural products, such as quantity and amount; 6) purchasing the means of production in the planting industry, such as the total amount and quantity of purchasing the means of agricultural production; 7) annual household income and expenditure, such as annual total income, annual total expenditure, capital exchanges, cumulative borrowing, grain income, and expenditure; 8) major food consumption throughout the year, major durable goods owned at the end of the year, living conditions, and so on.

Therefore, the data used in this study were all taken from the aforementioned dataset. Starting from the promulgation of the Land Contracting Law in 2003, the study analyzes the situation of rural land outsourcing in China from 2003 to 2015. "The Rural Land Contract Law" promulgated by the Chinese government in 2003 made institutional provisions on the nature and use of rural

FIGURE 1
Study area and sampling locations.
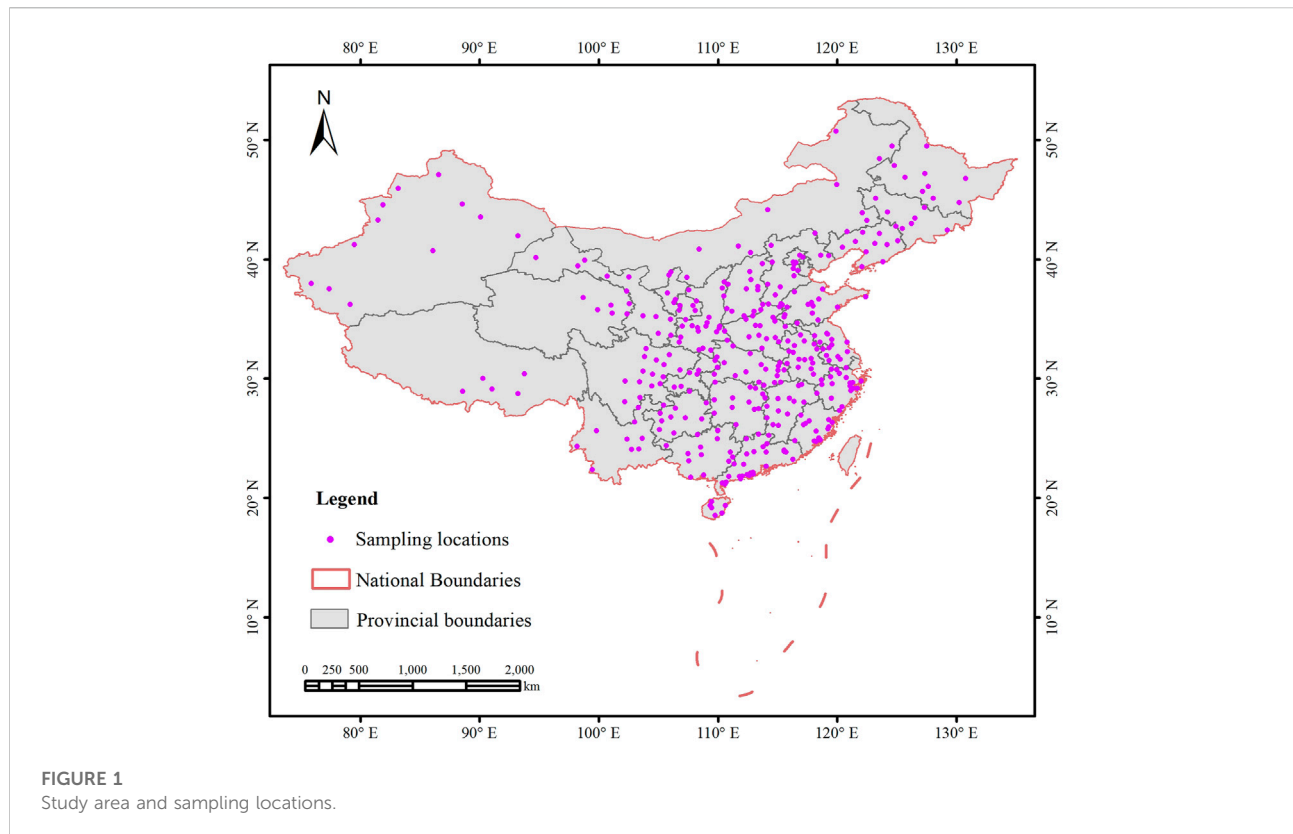
land for the first time. That gave farmers long-term and guaranteed right to the contracted management of land, fundamentally consolidating the market main body status of farmer household contract management, in accordance with the law to protect and arouse the enthusiasm of farmers, it is safe to develop agricultural production, increase agricultural inputs, in accordance with the law, norms, and orderly, right to the contracted management of land circulation forward, can safely development moderate scale management. Therefore, it was only in 2003 that the outsourcing of rural land became systemically reasonable, which is the reason why this study took this year as the starting time.

2.2 Research design and methods

This study adopts the DEA-Tobit research method. The DEA method can deal with the efficiency evaluation of multi-input and multi-output indicators, without constructing a production function to estimate the parameters, and is not affected by dimensionality, so it can well reflect the use of resources. The data formed on this basis has the characteristics of censoring, and the Tobit regression analysis is carried out to investigate the influencing factors of land outsourcing. In order to make the framework more understandable, we

present an overview of the research methods and procedures in Figure 2.

2.2.1 Measurement of rural land outsourcing efficiency

The commonly used DEA analysis method (Hauner and Kyobe, 2010) was used to measure the outsourcing efficiency of rural land; in this method, input and output indicators need to be set. In this study, we take the outsourcing degree of rural land as the input index and the ratio of the outsourcing area of rural land to the total area of cultivated land as the input index. The output index reflects the economic growth results obtained through rural land outsourcing and, so, the ratio of outsourcing to internal production was used to select the output index. Specifically, the output index contains the most direct economic result of land outsourcing, namely, the output of economic efficiency of land outsourcing. The ratio of the income of outsourced land per unit area to the economic income of the farmer's self-run land per unit was taken as the output index, in order to reflect the contribution of land outsourcing to the farmer's economic income. Second, rural land outsourcing makes up for rural labor force shortages; thus, in this study, labor capacity was added as a second output efficiency index. The output indicators reflecting land outsourcing can achieve the degree of force and the ratio of the
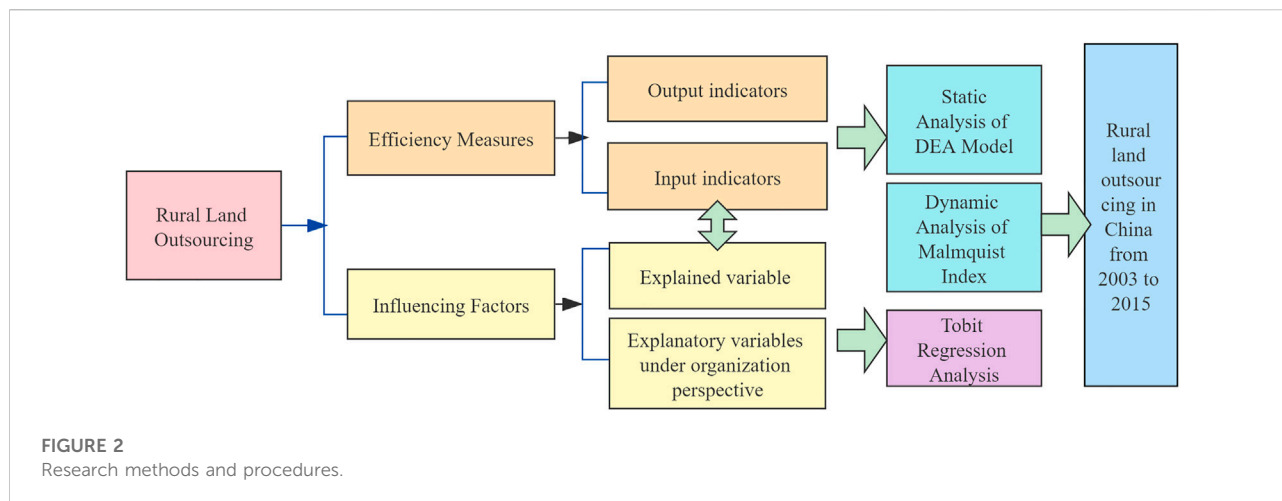
FIGURE 2
Research methods and procedures.

TABLE 1 Input and output indicators of rural land outsourcing efficiency.

Index	Name	Description
Input	Land outsourcing level	Outsourcing land area/total cultivated land area
	Economic efficiency	Outsourcing land income/farmer self-run land income
Output	Labor supplement efficiency	Income from outsourced land/labor efficiency of self-run land/quantity of outgoing labor

relationship between the organization outflow of the rural labor force, namely, how land outsourcing can achieve (measurement) the support of labor and make up for gaps in the labor force. Table 1 shows the input and output indicators of rural land outsourcing efficiency.

2.2.2 Influencing factors of rural land outsourcing

From the perspective of organizational characteristics, this study argues that different organizational characteristics have different behaviors for land outsourcing. This study regards the process of land outsourcing as an organizational unit, and the driving effects of structural characteristics, structural complexity, and core tasks within the village organization on rural land outsourcing were investigated (Boon et al., 2019).

(1) Core mission: the core task of the organization directly affects the probability of realization of rural land outsourcing. In the countryside, the basic core task is for rural organizations (or farmers) to obtain economic benefits through land outsourcing. In this study, the direct selection of rural organization outsourcing land unit gains is a core task of operation indicators. In general, under the hypothesis of a rational agent, with the outsourcing of land income, the more "profit" the rural organization (or farmers) will attempt

to gather; that is, the more likely it is to conduct land outsourcing operations, in order to obtain more economic benefits.

(2) Scale of production: the organization scale or production scale is a classic variable in the study of the "self-made/outsourcing" decision-making (Wang et al., 2021a). However, in this study, the scale is not the population or land area of the village organization, but the scale of land available for outsourcing and the scale of production conditions conducive to land outsourcing. In general, under a larger production organization and more serious labor shortages, outsourcing is more likely to be chosen (Chen et al., 2017) and, from the view of the outsourcing service provider, larger areas of land resources are likely to produce large-scale land economic returns (Deng et al., 2020). Thus, we chose the number of rural cooperatives or enterprises to measure. In addition, agricultural machinery was considered as the main factor to promote the production efficiency of rural land, as large-scale production of land outsourcing requires a large amount of farm machinery as input. The input volume of agricultural machinery was selected as another driving factor affecting land outsourcing.

(3) Complexity of the rural organizations: the complexity of rural organizations is usually the result of the

TABLE 2 Variable definition and description.

Variable	Name	Definition	Mean	Sd
Explained variables	Land_out	Area of outsourced land/total area of cultivated land	0.077	0.029
	Agri_mach	Agricultural machinery investment per unit area	0.545	0.285
	In labor	Labor inflow/total labor force	0.042	0.021
Explanatory variables	Company	Number of cooperatives or companies/number of participating villages	0.510	0.095
	Income_landout	Annual land outsourcing income/annual total income of farmers	0.369	0.134
	Age manager	Under 45 years of age/total number of management personnel in village organization	0.667	0.101

diversification of internal structures or levels of the organizations (Boon et al., 2019); that is, the diversification of different factors that may affect land outsourcing. In rural organizations, one of the key factors driving the formation of land outsourcing is labor force shortages. At the same time, we also found that, with labor outflow, there is also labor inflow—foreign labor may enter to make up for the original labor force structure in village organizations, thus alleviating the demand for labor. Therefore, we consider foreign labor as one of the forms of rural complexity and, so, as one of the factors that affect land outsourcing. In the reality of foreign labor force inflow, the contribution of the supplement of this labor force to land outsourcing needs to be further verified. Labor force inflow requires employment and income, where there are two modes of employment: agricultural and nonagricultural employment. Therefore, we took the number of enterprises and cooperatives in rural areas as the manifestation of off-farm employment, in order to form another influencing factor of rural land outsourcing.

(4) Age of the manager: the organization manager plays a key role in the organization's behavior and decision-making. In agricultural production outsourcing, previous studies have investigated the individual characteristics of farmers who take outsourcing actions and found that factors such as age, education level, and political status can affect the outsourcing behavior of farmers (Koirala et al., 2016; Amare and Shiferaw, 2017). However, some studies have pointed out that the decision of outsourcing has no relationship with the education level, political status, and other factors, but has a negative relationship with the age of farmers; that is, the younger the farmers are, the more likely they are to choose outsourcing (Chen et al., 2017). Age is a consistent factor in the individual characteristics of farmers in agricultural production outsourcing research. In this study, rural organizations are originally aggregations of farmers. So, by referring to the aforementioned research results, managers of rural organizations (generally, members of village committees)

are more likely to choose land outsourcing actions when they are younger, but this hypothesis still needs to be further verified. In particular, youth is a relative concept in this study. In this study, managers in rural organizations were divided into four age groups (defined as 35, 46, and 55 years old). Considering that the maximum retirement age of civil servant cadres in China is 60 years old (60 years old for males and 55 years old for females), we calculated the proportion of young managers in the management group by taking managers under 45 years old as the standard.

2.2.3 Empirical model of influencing factors of rural land outsourcing

Based on an analysis of the influencing factors of rural land outsourcing, this study sets relevant variables and presents them in Table 2. Furthermore, we empirically studied the degree of influence of these drivers on rural land outsourcing (land_out).

Considering that the land outsourcing (land_out) calculated by DEA was greater than 0, it has the property of truncation. Therefore, the Tobit model, which follows the concept of the maximum likelihood method, was adopted for further analysis. The Tobit model can analyze both continuous numerical variables and virtual variables. This study uses the Tobit model for empirical analysis. To compare the influences between different drivers, we adopted the method of adding variables step by step, successively adding (agri_mach), (in_labor), (company), (income_landout), and (age_manager), and constructed seven respective models, among which model 5 is expressed as follows. For the convenience of expression, the aforementioned variables are marked as X1–X5, successively:

$$land\_out_{jt} = \alpha_0 + \alpha_1 X1_{jt} + \alpha_2 X2_{jt} + \alpha_3 X3_{jt} + \alpha_4 X4_{jt} + \alpha_5 X5_{jt} + \epsilon_{jt},$$

where α_i is the parameter to be estimated and ϵ_{jt} is a random error term following $\epsilon_j \sim N\ (0,\ \sigma^2)$.

TABLE 3 Efficiency values of rural land outsourcing in China in 2003 and 2015.

Frim	2003				2015			
	Crste	Vrste	Scale		Crste	Vrste	Scale	
1 (eastern)	0.549	0.612	0.896	irs	1	1	1	-
2 (central)	0.205	1	0.205	irs	0.167	0.469	0.357	irs
3 (western)	1	1	I	—	0.916	1	0.916	irs
Mean	0.585	0.871	0.700		0.694	0.823	0.757	

crste means the technical efficiency from CRS DEA; vrste means the technical efficiency from VRS DEA; scale means scale efficiency = crstelvrste.

3 Results

3.1 Results of rural land outsourcing efficiency accounting based on the DEA method

3.1.1 Static analysis of the DEA model

Drawing lessons from the evaluation method of urban circular economy efficiency (Wang et al., 2021a), DEAP 2.1 software was used to analyze the input–output indicators of eastern, western, and central China in 2003 and 2015, where the comprehensive efficiency value, pure technical efficiency value, and scale efficiency value of rural land outsourcing efficiency could be obtained.

According to the comprehensive technical efficiency index (crste) of China's land outsourcing efficiency shown in Table 3, the efficiency of China's rural land outsourcing in 2003 and 2015 was 0.585 and 0.694, respectively, showing an overall rising trend; however, there is still a large gap to reach the production frontier conditions. Among the three regions, only the western region reached the production frontier conditions (with index value 1), indicating that the rural land outsourcing input in the western region achieved optimal allocation, the structure of land outsourcing quantity and income was reasonable, and the input and output achieved the best effect. The central region had the lowest index value, indicating that the central region had less input and a lower degree of land outsourcing.

Furthermore, in terms of the pure technical efficiency index (vrste), the outsourcing efficiency of rural land in China was basically flat in the western region, indicating that there has been no significant improvement and progress in technology or management in the process of rural land outsourcing in China over the past 13 years. The eastern and central regions showed a reversal. In 2015, the northeast region reached production frontier conditions, while the central region dropped from the production frontier to 0.469. Specifically, in 2015, under the pure technical efficiency index, both eastern and western regions reached the DEA effective value (index 1), indicating that the management or technical level in these

regions was relatively advanced and maximization of output was achieved. In particular, the technological efficiency growth of the northeast region was the most obvious. However, the pure technical efficiency index of the central region showed a decreasing trend, which reflected that the technical level of the central region could not adapt to the production and development of regional land outsourcing. Of course, it should be noted that, in this study, technical efficiency is more reflected by the compensation of land outsourcing for farmer incomes and rural farming labor resources, which is regarded as a form of technology that can be transformed and, thus, improves or changes agricultural productivity in rural areas.

The scale efficiency index (scale) can reflect whether rural land outsourcing is at the optimal scale. From 2003 to 2015, the scale efficiency index showed an upward trend, indicating that China's rural land outsourcing gradually moved toward the optimal scale. The growth in the eastern region was 0.104 and that of the central region was 0.152, indicating that the scale advantage of rural land outsourcing in the central region was relatively prominent. However, we cannot ignore the large gap between the scale efficiency and production frontier conditions.

From the comparison between 2003 and 2015, it can be seen that production frontier conditions were reached in the central region in 2003 but were lost in 2015. Fortunately, the scale return of the central region showed an increasing trend in 2015, indicating that the outsourced land invested by the central region was well-utilized without obvious efficiency loss. This reflects that the central region can obtain more outputs by improving its technical level of land outsourcing and, thus, improving the efficiency of land outsourcing in this region again. Nevertheless, the central region was at a low level of input–output efficiency of land outsourcing. In general, the input–output efficiency of China's rural land outsourcing had an upward trend but was also accompanied by fluctuations in different regions.

Based on the measurement of land outsourcing efficiency in eastern, western, and central regions from 2003 to 2015 in China, it can be found that the western region has a low scale

TABLE 4 Malmquist index of rural land outsourcing efficiency in China from 2003 to 2015.

Year	Effch	Techch	Pech	Sech	Tfpch
2003–2004	1.300	0.773	1.149	1.131	1.005
2004–2005	1.036	1.106	0.979	1.057	1.146
2005–2006	0.782	1.444	1.016	0.769	1.129
2006–2007	0.932	1.032	0.868	1.073	0.962
2007–2008	1.146	0.856	0.986	1.163	0.982
2008–2009	1.109	1.202	1.060	1.046	1.333
2009–2010	1.027	0.686	0.959	1.071	0.705
2010–2011	0.928	1.055	1.020	0.909	0.978
2011–2012	0.978	0.925	0.947	1.033	0.905
2012–2013	0.956	1.138	0.995	0.961	1.088
2013–2014	0.945	0.975	0.955	0.989	0.921
2014–2015	0.847	1.264	1.034	0.819	1.071
Mean	0.990	1.017	0.995	0.995	1.008

TABLE 5 Malmquist index of rural land outsourcing efficiency in different regions of China.

Firm	Effch	Techch	Pech	Sech	Tfpch
1 (eastern)	1.051	1.020	1.042	1.009	1.073
2 (central)	0.960	1.016	0.946	1.015	0.975
3 (western)	0.962	1.016	1	0.962	0.978
Mean	0.990	1.017	0.995	0.995	1.008

efficiency and a high saturation degree due to the limited land available for outsourcing. The central region has the highest scale efficiency of rural land outsourcing in China, but compared with the Eastern region, its pure technical efficiency needs to be improved. In other words, the central region will be an important part of rural land outsourcing in China, and more attention should be paid to the technology and management of land outsourcing.

3.1.2 Dynamic analysis of the Malmquist index

The Malmquist index can reflect the changing trend of rural land outsourcing efficiency in China. Therefore, DEA2.1 software was used to analyze the rural land outsourcing data of the three regions in China from 2003 to 2015. The dynamic change of total factor productivity was then investigated.

In Table 4, from the perspective of overall efficiency changes, the average input productivity index of China's rural land outsourcing from 2003 to 2015 was 1.008, showing an overall rising trend. However, due to the fluctuation of the productivity index in different time periods, the overall trend showed a fluctuating rising trend. In terms of decomposition, the

average technological progress (techch) increased by 1.7%, indicating that the technology or management level of China's rural land outsourcing plays a major role in improving the efficiency of land outsourcing. In addition, the indices of technical efficiency (effch), the pure technical efficiency (pech), and the scale efficiency (sech) were less than 1, showing that technical efficiency limits the outsourcing of land use efficiency and the effect of technological progress, pure technical efficiency inhibits technology to improve production and capacity, and scale efficiency reflects the need to improve technology, production capacity and promote land utilization. This is basically consistent with the results of the DEA static analysis in this study.

In Table 5, the three regional efficiency changes are shown, from which it can be found that, between 2003 and 2015 in the east, the rural land outsourcing productivity index (tfpch) was greater than 1, showing that the efficiency of the regional rural land outsourcing development situation was good. The four indices had different degrees of growth, with the static DEA analysis of the eastern region in 2015 leading to consistent efficiency conclusions. However, the productivity indices in the central and western regions fell. The main reason for this is that, for the central region, the technical efficiency and pure technical efficiency indices were 0.960 and 0.946, respectively, showing a trend of decline; this suggests that the land outsourcing technological progress in the central region did not improve land use efficiency. The efficiency loss and low technological level in production capacity at the same time also inhibited the scale efficiency and production efficiency. The same problem existed in the western region; that is, the inhibition of land use efficiency by technological progress. The difference is that the scale efficiency of the western region limited the transformation of technology into production capacity, which affected the overall production efficiency of the western region. This is consistent with the common knowledge that plateau, basin, desert, and other terrain types in western China cannot form a resource-based large-scale economy (Yang et al., 2021). This also reflects the regional differences, resource misallocation, and the differences between land efficiency and ecological efficiency in China (Wang et al., 2021b).

3.2 Analysis of influencing factors of rural land outsourcing

Before the regression analysis of rural land outsourcing from 2003 to 2015, through a correlation analysis among various variables (please see Table 6 for details). According to the existing research on the critical value of correlation coefficient (Carsten et al., 2013), the colinearity analysis was carried out on all variables, and it was found that the variance

TABLE 6 Correlation analysis of all variables.

Land out	Income-t	Age ma--r	Company	In labb-r	Agri m-h
Land out	1				
Income land	−0.149	1			
Age_man	−0.318	−0.857**	1		
Company	0.628*	−0.251	−0.234	1	
In labor	−0.411	0.587*	−0.785**	−0.389	1
Agri_mach	−0.406	−0.201	0.364	−0.614*	−0.228	1

***$p < 0.01$, " $p < 0.05$, $p < 0.1$.

TABLE 7 Tobit regression analysis results of influencing factors of rural land outsourcing in China.

Variable	(1) Model	(2) Model	(3) Model	(4) Model	(5) Model
Income_landout	0.368	0.859**	0.678**	0.707**	0.679**
	(1.249)	(3.158)	(2.819)	(2.830)	(2.819)
Age_manager		0.220**	0.165**	0.194*	0.217*
		(3.133)	(2.592)	(1.985)	(2.249)
Company			0.004*	0.004*	0.002
			(2.352)	(2.390)	(0.746)
In labor				0.161	0.037
				(0.399)	(0.092)
Agri_mach					−0.030
					(−1.058)
Constant	0.049*	−0.135*	−0.156**	−0.188*	−0.140
	(2.083)	(−2.203)	(−2.999)	(−1.971)	(−1.365)
Observations	13	13	13	13	13
McFadden R2	−0.026	−0.157	−0.240	−0.243	−0.262

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

inflation factor (VIF) of all variables was below 5, indicating that there was a small possibility of multicolinearity among all variables. On this basis, the Tobit regression analysis was performed using Stata17.0 software.

The most direct reflection of the degree of land outsourcing is the change in land outsourcing income. The proportion of land outsourcing income in the total income of farmers (income_landout) is taken as the benchmark for the regression analysis of rural land outsourcing to form model 1. Then, considering that the increase in income will attract the attention of managers, drive enterprises or agricultural cooperation organizations, and cause a change of production costs such as labor and farming equipment, model 2 and model 3 are constructed by gradually joining the proportion of youth under 45 years old in the rural management team (age_Manager), rural enterprises, or cooperative organizations (company). Finally, the inflow labor (in_labor) and agricultural equipment input (agri_Mach) of rural land production costs are added to the model to form model 4 and model 5.

From Table 7, through the Tobit regression analysis of the driving factors of land outsourcing behaviors adopted by rural organizations in China from 2003 to 2015, the following results were obtained:

(1) In model 1, the increase in the proportion of land outsourcing income in the total income of farmers does not have a significant impact on the degree of land outsourcing. This indirectly reflects that, in the total income of farmers in the current period, the impact of land outsourcing income may be low, that is, the land economic income obtained by farmers relying on land outsourcing is not ideal.

(2) The estimation results of model 2 show that young managers in rural organizations have a significant role in promoting rural land outsourcing, and land outsourcing income also has a positive and significant role in promoting the degree of land outsourcing. This shows that the younger the managers of rural organizations, the higher the degree of land outsourcing, and their dependence on land outsourcing income is much greater.

(3) The increase in the number of rural enterprises and cooperatives will promote the expansion of land outsourcing. In model 3, the elasticity coefficients of enterprises and cooperatives in rural areas are 0.004, which indicates that the number of enterprises and cooperatives in rural areas has a promoting effect on the level of rural land outsourcing.

(4) The inflow of labor does not promote the outsourcing of land. In model 4, the inflow of the rural labor force has a positive effect on the level of rural land outsourcing, but it does not pass the significance test. Similarly, in model 5, the input of farming equipment also fails to pass the significance test, which reflects that the production cost of land outsourcing has no obvious effect on the degree of land outsourcing.

4 Discussion

The driving force of production scale and the constraint of input resource efficiency affect the overall efficiency of land outsourcing in China. In terms of the overall efficiency of rural land outsourcing in China from 2003 to 2015, the overall trend was upward and the return on the scale has increased. These results are similar to those of Yue (2010) and Larson (2013), especially in the eastern coastal areas of China, where agricultural productivity is very high (Yue et al., 2010; Larson, 2013), while the inland areas, such as the central and western regions, still have huge development potential in terms of land use efficiency, technological production efficiency, and agricultural productivity improvement, in agreement with the results of Long (2010) (Long and Zou, 2010).

However, behind this seemingly good development trend, the performance is driven by the production scale and the suppression of input resource efficiency. In particular, from 2003 to 2015, the scale of rural land outsourcing in China has continuously expanded; however, due to the current technical level and the production efficiency of land outsourcing, the use efficiency of land outsourcing has been lost. From 2003 to 2015, China's rural land outsourcing efficiency technological progress index rose by 1.7%, but the rest of the indices experienced a relatively small decline. This further clarifies that the efficiency of land outsourcing mainly relies on technological progress, which cannot be converted into technical efficiency and enhance land use efficiency or scale efficiency, and may not meet or play a role in the current land outsourcing production efficiency and the scale of production.

In addition, this study examines the influencing factors of rural land outsourcing. At its most fundamental, protective production of land for grain cultivation in rural areas is the main reason for guaranteeing the scale of cultivated land and food security. Rural land outsourcing has been used to explain the decrease in arable land and the increase in food production due to the shortage of the rural labor force. In 2012, 8,318,190.6 ha of China's rural outsourced land were used for grain cultivation (accounting for 55%), while 15, 268, 278 ha were used for grain cultivation in 2015, accounting for 57% (China Agricultural Yearbook Editorial Board; China Agricultural Yearbook Editorial Board, 2015). From 2012 to 2015, the area of grain cultivation increased by 84%. It has been found that the proportion of grain planting area in the national outsourced land is maintained at about 55%, and with the growth of grain planting area, the grain output generated by this proportion will also increase substantially. This reflects China's protective production of rural arable land. The basic protection of China's farmland policy is very effective and has had a profound impact on China's land use and food security (Liu et al., 2014). For example, the Chinese government has launched a national arable land preservation program, known as the "Green Food" program, to protect high-quality arable land as basic farmland, in order to

meet the survival needs of local people (Wang et al., 2007). This protective policy ensures that the total amount of basic arable land and its quality will not be reduced, which is the key to rural food production and land cultivation.

Rural land outsourcing gradually flows from farmers to large-scale agricultural enterprises or rural cooperatives. The income of farmers in land outsourcing is not significant, which reflects that land outsourcing does not flow into the hands of farmers, and grain output is not created by farmers. From the correlation analysis of the variables affecting land outsourcing, we found that there was a strong positive relationship between grain output and land outsourcing. In other words, the increase in land outsourcing will be accompanied by an increase in grain output. However, in the analysis of influencing factors, the income of farmers in land outsourcing was not significant, which reflects that land outsourcing profits do not flow into the hands of farmers and that the grain output is not created by farmers. In the analysis of the driving factors of land outsourcing, the entry of enterprises and cooperatives promoted land outsourcing. This is consistent with reality. In China's rural farming land contracts in 2012, the cultivated land area operated by peasant households was 10, 277, 357.1 hactares, accounting for 68% of the total contracted area that year. However, by 2015, this proportion had decreased to 58% (China Agricultural Yearbook Editorial Board; China Agricultural Yearbook Editorial Board, 2015). During this period, the cultivated land area flowing into peasant households increased by 58%. Li (2020) also pointed out that, from 2003 to 2011, the per capita demand for arable land of rural residents decreased from 1984 to 1,501 square meters (Li et al., 2020). In contrast, the proportion of arable land flowing into enterprises and cooperatives increased from 21% in 2012 to 32% in 2015, with a growth rate of 156% (China Agricultural Yearbook Editorial Board; China Agricultural Yearbook Editorial Board, 2015), much higher than the growth rate of farmers. The reason for this is that the increased cost of the rural labor force promotes large-scale machinery production or services outsourcing as the main engine (Zhang et al., 2017), while for farmers, expanding their funds to the scale needed is beyond their capacity (Chen, 2020). All these lead to the rural land in the hands of farmers being less likely to achieve large-scale production, leading to outsourcing and, thus, the land depending on large-scale agricultural enterprises and rural cooperatives. This conclusion is consistent with that of Deng (2020) (Deng et al., 2020). However, the growth of cooperatives has had two different results.

On the one hand, the choice of nonagricultural employment and the growth of nonagricultural land in rural areas have squeezed the scale of land outsourcing. In the study of the factors influencing the efficiency of rural land outsourcing, the migrant labor force as the production cost does not promote the outsourcing of rural land. Rural land outsourcing solves the problem of rural labor shortages, but the inflow of labor does not promote land outsourcing. This is an interesting finding; we think the likely reason for this is labor gains. On one hand, we found that the increase in land outsourcing income could not

promote the land outsourcing of rural organizations. The economic benefits of rural land outsourcing are not obvious, but there is no basic condition for labor force supplementation. It also means that even considering the environmental costs, the labor cost increase effect limits employment (Wang et al., 2022). On the other hand, in order to obtain more income, the labor force flowing into the countryside will not choose land with relatively low income for farming but, instead, will flow to nonagricultural enterprises, whose development serves to reduce the efficiency of land outsourcing. According to the study by Song (2020), a large number of off-farm agricultural workers have higher income, reducing their dependence on rural land and agricultural income (Song et al., 2020), verifying the choice of migrant workers for off-farm employment. In addition, nonagricultural land also exists in the use of rural land. In 2012, the acreage leased to factories and enterprises in China accounted for 27% of the total cultivated land area. In 2015, the proportion reached 33% (an increase of 117%), forming the fastest growing form of land outflow in China. However, the proportion of land outsourced decreased from 51 to 47% over the period 2012–2015. Nonagricultural land may also affect food production at the same time. In 2015, crop production directly related to nonagricultural land increased by 28% over the annual increase of the 2013–2014 national crop yield while, between 1990 and 2015, the expansion of nonagricultural land use problems, such as pollution from crop losses, caused close to 9% of the total crop production in China (Zhang et al., 2020a).

On the other hand, agricultural production outsourcing services can realize the technical value-added of rural land outsourcing. The technological efficiency of rural land outsourcing affects the transformation of technological production capacity and the efficiency of land use. Realizing the technological increment of land outsourcing needs to be changed from the effective use of the invested outsourced land resources at the current technological level. The study of Huang and Ding (2016) was aimed at promoting the establishment of service centers of land circulation, as farmland circulation leads to an increase in the agricultural scale (Huang and Ding, 2016). Yang (2013) and Yi (2019) also believe that, relative to large-scale farms or agricultural professional organizations, China's small farmers cannot buy machinery; this kind of restrictive nature cannot achieve technical efficiency changes for farmers (Yang et al., 2013; Yi et al., 2019). However, such agricultural machinery or professional services can replace household labor in agricultural production, thus improving labor productivity (Zhang et al., 2020b). In other words, the realization of technical efficiency of rural land outsourcing must rely on large-scale production scales or agricultural professional service organizations, in order to realize the support for rural land production efficiency under labor shortages, which is also the technical value-added of rural land outsourcing. This further reflects the connection between the two perspectives of rural production outsourcing services and land outsourcing proposed in the introduction.

Of course, our investigation of the managers of rural organizations has also found and verified the pursuit of a "land economy" by the rural managers. Young managers in rural organizations play a significant role in promoting rural land outsourcing. Under the background of China's policy of promoting rural revitalization, managers hope that more and more farmers can stay in the countryside and earn a living income there, differing from the idea of farmers who go out to work. Young managers pay more attention to the concepts and policies of rural development, and are more inclined to make up for the labor force shortage and promote agricultural production by other means (e.g., calling for returning home to start businesses, attracting investments, promoting ecological agriculture, and so on). From relevant studies (Wang and Tan, 2020), we suspect that managers are more inclined to obtain more income-generating opportunities through the pursuit of the "land economy", further converting it into public facilities or environmental improvements needed for rural development. The land has become an important tool for local governments to achieve their economic development goals (Yang et al., 2022).

5 Conclusion

In this study, the DEA efficiency analysis and the Tobit model were used to analyze the efficiency and influencing factors of rural land outsourcing in China. The results showed that the overall efficiency of rural land outsourcing in China is on the rise; however, the inhibiting effect of technical efficiency is prominent. The results of the current survey and the existing literature clearly indicate that the production efficiency of rural land outsourcing has become an important issue in rural land production. The production efficiency of land outsourcing is affected by agricultural enterprises, agricultural cooperatives, nonagricultural land, and the economic pursuits of managers, among other reasons. Although land outsourcing can boost grain output, its role and contribution to China's food security are no longer a primary concern due to China's protective policies on rural arable land and grain production. How to improve the production efficiency of land outsourcing is an important issue in the study of land outsourcing.

Of course, the measurement and analysis of land outsourcing efficiency in this study also make us have a clearer understanding of the practical value of rural production service outsourcing. Rural production service outsourcing focuses on the transfer of production costs, while land outsourcing focuses on the use of production materials. Land outsourcing is an indispensable link in the development of modern agriculture, and production service outsourcing is an important innovative form in the process of land outsourcing and land use, which can promote rural land outsourcing and promote the rural land economy.

Based on the results of our research, we propose suggestions from three aspects. First of all, the rural land outsourcing of "post-production" should be emphasized. Post-productivism points out that rural production should be diversified, rather than specialized (Hay and Hay, 2017). The use of rural land outsourcing also changes from a single food production function to diversified functions, covering environmental protection, entertainment experiences, and agricultural consumption, among others, thus optimizing and improving the efficiency of outsourced land use. Second, the outsourcing or trusteeship of large-scale agricultural production should be strengthened. The establishment of an effective agricultural social service system, a well-trained labor market, and access to mechanized services and technical services will also increase the number and capital employed in agriculture and popularize agricultural production techniques, thus improving the quality and efficiency of China's agricultural production. Finally, policy resources must be used. In the context of the construction of civilization and rural revitalization, the Chinese government has implemented land transfer and outsourcing policies to improve land resource utilization efficiency and optimize land use structure and layout (Zhou and Cao, 2020). At the same time, land resources should be allocated, differentiated environmental development policies should be formulated, and efficiency, scale, and technology should be improved (Wang et al., 2021c). This is a favorable policy direction for the scale and efficiency improvement of China's land outsourcing, which can obtain more resource support through such policies.

This study has some drawbacks. Due to the availability of the data, we did not include data after 2015 in the research data and only used relevant research or data from the literature for explanations. At the same time, due to the characteristics of the data, we did not analyze the social and economic characteristics of individual farmers. From the perspective of rural organizations formed by farmers, we selected the influencing factors of land outsourcing. Therefore, in future studies, we will focus on the socio-economic characteristics of farmers and the latest data to analyze and verify the efficiency and influencing factors of rural land outsourcing. In addition, we plan to further study the optimization and development of the production efficiency of rural land outsourcing.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding author.

Author contributions

Conceptualization: MW and CW; data curation: MW and XP; formal analysis: MW, CW, and XP; supervision: MW and CW; validation: MW and XP; visualization: MW and CW; writing—original draft: MW and XP; and writing—review and editing: MW, CW, and XP. All authors have read and approved the final manuscript. All authors have read and agreed to the published version of the manuscript.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors, and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Alves, L. B. D. O., and Kato, H. (2018). Transportation and land property rights: Economic impacts on agricultural productivity. *Transp. Res. Rec.* 2672, 1–11. doi:10.1177/0361198118775868

Amare, M., and Shiferaw, B. (2017). Nonfarm employment, agricultural intensification, and productivity change: Empirical findings from Uganda. *Agric. Econ.* 48, 59–72. doi:10.1111/agec.12386

Boon, J., Verhoest, K., and De Borger, B. (2019). Hiving off the non-essential: Analysing which public organizations outsource administrative overhead. *Int. Rev. Adm. Sci.* 85, 228–246. doi:10.1177/0020852317692137

Carsten, F. D., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carre, G., et al. (2013). Collinearity: A review of methods to deal with it and a simulation study evaluating their performance. *Ecography* 36, 27–46. doi:10.1111/j.1600-0587.2012.07348.x

Che, Y. (2014). Mismatch: Land reallocations, recovery land rental and land rental market development in rural China. China. *China Agric. Econ. Rev.* 6, 229–247. doi:10.1108/caer-06-2012-0070

Chen, J., Guo, H., Jin, S., and Yang, J. (2017). Outsourcing agricultural production: Evidence from rice farmers in Zhejiang province. *PLoS ONE* 12, e0170861. doi:10.1371/journal.pone.0170861

Chen, Y. (2020). Land outsourcing and labour contracting: Labour management in China's capitalist farms. *J. Agrar. Change* 20, 238–254. doi:10.1111/joac.12353

China Agricultural Yearbook Editorial Board (2012). *Chinese agricultural Yearbook*. Beijing, China: China Agriculture Press, 348–349. (in chinese).

China Agricultural Yearbook Editorial Board (2015). *Chinese agricultural Yearbook*. Beijing, China: China Agriculture Press, 398–399. (in chinese).

Ciaian, P., and Swinnen, J. (2006). Land market imperfections and agricultural policy impacts in the new eu member states: A partial equilibrium analysis. *Am. J. Agric. Econ.* 88, 799–815. doi:10.1111/j.1467-8276.2006.00899.x

Davis, J., and Lopez-Carr, D. (2014). Migration, remittances and smallholder decision-making: Implications for land use and livelihood change in Central America. *Land Use Policy* 36, 319–329. doi:10.1016/j.landusepol.2013.09.001

Deng, X., Xu, D., Zeng, M., and Qi, Y. (2020). Does outsourcing affect agricultural productivity of farmer households? Evidence from China. *China Agric. Econ. Rev.* 12, 673–688. doi:10.1108/caer-12-2018-0236

Hauner, D., and Kyobe, A. (2010). Determinants of government efficiency. *World Dev.* 38, 1527–1542. doi:10.1016/j.worlddev.2010.04.004

Hay, A., and Hay, J. (2017). Indicators of post-productivism in South Africa's "platteland": A second home case study of rosendal, eastern free state. *Bull. Geogr. Socio-economic Ser.* 37, 35–49. doi:10.1515/bog-2017-0023

Huang, J., and Ding, J. (2016). Institutional innovation and policy support to facilitate small-scale farming transformation in China. *Agric. Econ.* 47, 227–237. doi:10.1111/agec.12309

Huang, J., Gao, L., and Rozelle, S. (2012). The effect of off-farm employment on the decisions of households to rent out and rent in cultivated land in China. *China Agric. Econ. Rev.* 4, 5–17. doi:10.1108/17561371211196748

Huang, J., Yang, J., and Rozelle, S. (2010). China's agriculture: Drivers of change and implications for China and the rest of world. *Agric. Econ.* 41, 47–55. doi:10.1111/j.1574-0862.2010.00487.x

Huy, H. T., Lyne, M., Ratna, N., and Nuthall, P. (2016). Drivers of transaction costs affecting participation in the rental market for cropland in Vietnam. *Aust. J. Agric. Resour. Econ.* 60, 476–492. doi:10.1111/1467-8489.12149

Jin, S., and Jayne, T. (2013). Land rental markets in Kenya: Implications for efficiency, equity, household income, and poverty. *Land Econ.* 89, 246–271. doi:10.3368/le.89.2.246

Koirala, K. H., Mishra, A., and Mohanty, S. (2016). Impact of land ownership on productivity and efficiency of rice farmers: The case of the Philippines. *Land Use Policy* 50, 371–378. doi:10.1016/j.landusepol.2015.10.001

Larson, C. (2013). Losing arable land, China faces Stark choice: Adapt or go hungry. *Science* 339, 644–645. doi:10.1126/science.339.6120.644

Li, B., and Shen, Y. (2021). Effects of land transfer quality on the application of organic fertilizer by large-scale farmers in China. *Land Use Policy* 100, 105124. doi:10.1016/j.landusepol.2020.105124

Li, J., Shan, G., Wang, G., Kan, S., and Jiang, H. (2020). Changes in agricultural land requirements for food provision in China 2003-2011: A comparison between urban and rural residents. *Sci. Total Environ.* 725, 138293. doi:10.1016/j.scitotenv.2020.138293

Li, Y., Zeng, C., Liu, Z., Cai, B., and Zhang, Y. (2022). Integrating landscape pattern into characterising and optimising ecosystem services for regional sustainable development. *Land* 11, 140. doi:10.3390/land11010140

Liu, Y., Fang, F., and Li, Y. (2014). Key issues of land use in China and implications for policy making. *Land Use Policy* 40, 6–12. doi:10.1016/j.landusepol.2013.03.013

Long, H., and Zou, J. (2010). Grain production driven by variations in farmland use in China: An analysis of security patterns. *J. Resour. Ecol.* 1, 60–67.

Ministry of Agriculture and Rural Affairs of the People's Republic of China (2020a). Ministry of agriculture and rural affairs of the People's republic of China.

Available at: http://www.moa.gov.cn/nybgb/2004/dwuq/201806/t20180623_6152978.htm (Accessed on September 11, 2020).

Ministry of Agriculture and Rural Affairs of the People's Republic of China (2020b). Ministry of agriculture and rural affairs of the People's republic of China. Available at: http://www.moa.gov.cn/xw/zwdt/200802/t20080228_981606.htm (Accessed on September 11, 2020).

National Bureau of Statistics of the People's Republic of China (2020). National Bureau of statistics of the People's republic of China. Available at: http://www.stats.gov.cn/tjsj/ndsj/2005/indexch.htm (Accessed on September 11, 2020).

Rural Fixed Observation Office (2010). *National rural fixed observation point survey data (2000-2009)*. Beijing, China: China Agriculture Press, 10–23. (in chinese).

Rural Fixed Observation Office (2017). *National rural fixed observation point survey data (2010-2015)*. Beijing, China: China Agriculture Press, 124–138. (in chinese).

Schaller, N., Lazrak, E. G., Martin, P., Mari, J. F. Aubry, C., and Benoit, M. (2012). Combining farmers' decision rules and landscape stochastic regularities for landscape modeling. *Landsc. Ecol.* 27, 433–446. doi:10.1007/s10980-011-9691-2

Sheng, Y., and Chancellor, W. (2019). Exploring the relationship between farm size and productivity: Evidence from the Australian grains industry. *Food Policy* 84, 196–204. doi:10.1016/j.foodpol.2018.03.012

Song, M., Wu, Y., and Chen, L. (2020). Does the land titling program promote rural housing land transfer in China? Evidence from household surveys in hubei province. *Land Use Policy* 97, 104701. doi:10.1016/j.landusepol.2020.104701

Su, W., Eriksson, T., and Zhang, L. (2018). Off-farm employment, land renting and concentration of farmland in the process of urbanization: Chinese evidence. *China Agric. Econ. Rev.* 10, 338–350. doi:10.1108/caer-10-2016-0169

Sun, D., Rickaille, M., and Xu, Z. (2018). Determinants and impacts of outsourcing pest and disease management: Evidence from China's rice production. *China Agric. Econ. Rev.* 10, 443–461. doi:10.1108/caer-01-2017-0011

Tang, L., Ma, X., Zhou, Y., Shi, X., and Ma, J. (2019). Social relations, public interventions and land rent deviation: Evidence from Jiangsu Province in China. *Land Use Policy* 86, 406–420. doi:10.1016/j.landusepol.2019.05.025

Wang, H., Riedinger, J., and Jin, S. (2015). Land documents, tenure security and land rental development: Panel evidence from China. *China Econ. Rev.* 36, 220–235. doi:10.1016/j.chieco.2015.09.005

Wang, R., and Tan, R. (2020). Patterns of revenue distribution in rural residential land consolidation in contemporary China: The perspective of property rights delineation. *Land Use Policy* 97, 104742. doi:10.1016/j.landusepol.2020.104742

Wang, S., Chen, H., and Yin, K. (2022). The employment effect of Chinese industrial enterprises embedded in environmental cost-adjusted global value chains. *Environ. Sci. Pollut. Res.* 29, 18160–18176. doi:10.1007/s11356-021-17118-w

Wang, S., Chen, S., and Zhan, H. (2021). Effect of income and energy efficiency on natural capital demand. *Environ. Sci. Pollut. Res.* 28, 45402–45413. doi:10.1007/s11356-021-13971-x

Wang, S., Liang, L., and Lu, X. (2021). Urban circular economy performance evaluation: A novel fully fuzzy data envelopment analysis with large datasets. *J. Clean. Prod.* 324, 129214. doi:10.1016/j.jclepro.2021.129214

Wang, S., Sun, X., and Song, M. (2021). Environmental regulation, resource misallocation, and ecological efficiency. *Emerg. Mark. Finance Trade* 57, 410–429. doi:10.1080/1540496x.2018.1529560

Wang, X., Lu, C., Fang, J., and Shen, Y. (2007). Implications for development of grain-for-green policy based on cropland suitability evaluation in desertification-affected north China. *Land Use Policy* 24, 417–424. doi:10.1016/j.landusepol.2006.05.005

Wu, L., Hu, Q., Wang, J., and Zhu, D. (2017). Empirical analysis of the main factors influencing rice harvest losses based on sampling survey data of ten provinces in China. *China Agric. Econ. Rev.* 9, 287–302. doi:10.1108/caer-03-2016-0036

Yang, J., Huang, Z., Zhang, X., and Reardon, T. (2013). The rapid rise of cross-regional agricultural mechanization services in China. *Am. J. Agric. Econ.* 95, 1245–1251. doi:10.1093/ajae/aat027

Yang, X., Wang, W., Su, X., Ren, S., Ran, Q., Wang, J., et al. (2022). Analysis of the influence of land finance on haze pollution: An empirical study based on 269 prefecture-level cities in China. *Growth Change A J. Urban Regional Policy*, 1–34.

Yang, X., Wang, W., Wu, H., Wang, J., Ran, Q., and Ren, S. (2021). The impact of the new energy demonstration city policy on the green total factor

productivity of resource-based cities: Empirical evidence from a quasi-natural experiment in China. *J. Environ. Plan. Manag.*, 1–34. doi:10.1080/09640568.2021.1988529

Yi, Q., Chen, M., Sheng, Y., and Huang, J. (2019). Mechanization services, farm productivity and institutional innovation in China. *China Agric. Econ. Rev.* 11, 536–554. doi:10.1108/caer-12-2018-0244

Yu, W., and Jensen, H. (2010). China's agricultural policy transition: Impacts of recent reforms and future scenarios. *J. Agric. Econ.* 61, 343–368. doi:10.1111/j.1477-9552.2010.00242.x

Yue, T., Wang, Q., Lu, Y., Xin, X., Zhang, H., and Wu, S. (2010). Change trends of food provisions in China. *Glob. Planet. Change* 72, 118–130. doi:10.1016/j.gloplacha.2010.01.023

Zhang, C., Kuang, W., Wu, J., Liu, J., and Tian, H. (2020). Industrial land expansion in rural China threatens environmental securities. *Front. Environ. Sci. Eng.* 15, 29. doi:10.1007/s11783-020-1321-2

Zhang, J., Mishra, A. K., Zhu, P., and Li, X. (2020). Land rental market and agricultural labor productivity in rural China: A mediation analysis. *World Dev.* 135, 105089. doi:10.1016/j.worlddev.2020.105089

Zhang, Q., Yan, B., and Huo, X. (2018). What are the effects of participation in production outsourcing? Evidence from Chinese apple farmers. *Sustainability* 10, 4525. doi:10.3390/su10124525

Zhang, X., Yang, J., and Reardon, T. (2017). Mechanization outsourcing clusters and division of labor in Chinese agriculture. *China Econ. Rev.* 43, 184–195. doi:10.1016/j.chieco.2017.01.012

Zhang, Y., Wang, X., Glauben, T., and Brummer, B. (2011). The impact of land reallocation on technical efficiency: Evidence from China. *Agric. Econ.* 42, 495–507. doi:10.1111/j.1574-0862.2010.00532.x

Zhou, J., and Cao, X. (2020). What is the policy improvement of China's land consolidation? Evidence from completed land consolidation projects in shaanxi province. *Land Use Policy* 99, 104847. doi:10.1016/j.landusepol.2020.104847