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A study of the impact of agricultural credit on agro-ecological efficiency in China

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Abstract: *Agriculture is an important part of China's national economy. The rapid development of the agricultural economy in recent years and the excessive use of means of production are difficult to avoid polluting the agro-ecological environment and reducing agro-ecological efficiency. Agricultural credit can provide a source of funds for agricultural production, affecting agricultural ecological efficiency. Based on the theory of sustainable development and other theories, we explore the impact of agricultural credit on agro-ecological efficiency and the impact mechanism. The results show that the agro-ecological efficiency of 30 provinces in China varies significantly; agricultural credit plays an inhibitory role in agro-ecological efficiency; the ratio of the balance of agricultural loans reduces the agro-ecological efficiency of each province by increasing the intensity of mechanical inputs. And relevant policy suggestions are put forward accordingly.*

Keywords: *Agricultural credit; Agro-ecological efficiency; Super-efficient SBM model; Tobit model*

1. Introduction

For recent years China's agricultural economy has maintained steady growth, and food production has increased year by year. 2022 China's total agricultural output value has steadily increased by 7.8% compared with the previous year, and the total agricultural output value accounted for 6.9% of the gross domestic product (GDP). China emphasizes the building of a green agro-ecological environment while focusing on agricultural economic growth. The main problems in China's agricultural environment are agricultural surface pollution and excessive carbon emissions. Agricultural production itself has a certain degree of vulnerability, agricultural credit plays a key role in providing funds for agricultural production, supporting and guaranteeing the continuous development of agriculture to the good and strong. Few studies have considered the impact of agricultural credit on agricultural eco-efficiency.

Agro-ecological efficiency integrates both green agriculture and agricultural economics. This paper applies the super-efficient SBM modeling approach to enhance agricultural output in a less polluted environment. Appropriate input and output variables are selected for efficiency measurement and analyzed. The effect of agricultural credit on agro-ecological efficiency is explored through Tobit regression analysis.

2. Theory analysis and research hypothesis

Most of the current studies related to agricultural credit are studies on the impact of agricultural credit on the agricultural economy or green agriculture, with little consideration of the impact of agricultural credit on agro-ecological efficiency.

Most of the research on the impact of agricultural credit on the agricultural economy focuses on the design of credit products, credit guarantee linkage and so on. Bai Xiaoyan (2005) believes that China's policy-based finance to promote the agricultural economy but the progress is slow. Reasonable arrangements for the objectives and positioning of agricultural credit can realy promote the development of agricultural economy[1]. Luo Jianzhao (2023) believes that agricultural credit guarantee business should be improved and credit products should be designed according to local conditions[2]. The impact of agricultural credit on green agriculture varies according to the perspective and space.

Agro-ecological efficiency considers both the agricultural economy and green agricultural development, selected input and output variables are measured with the super-efficient SBM model, input

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variables are refined with seven indicators, desired output variables are used with the total agricultural output value, and non-desired output variables are selected to be co-constructed with two types of agricultural pollution. The current and global frontier efficiencies were measured using Dearun software and iDea Ultra software. Our current frontier agroecological efficiency values are generally low. Vertical comparison of global frontier agroecological efficiency reveals that the provinces and municipalities with large changes in average agroecological efficiency rankings before and after 2014 include Hubei, Hunan, Guizhou and Tibet Autonomous Region.

With the improvement of the rural financial system, the total scale of agricultural credit has increased. The year-on-year balance of agriculture-related loans showed a year-on-year downward trend, with a downward trend from 2011-2016, and continued to oscillate after picking up in 2017. The growth trend of total agricultural credit was stable but the growth rate slowed down slightly.

The internal structure of agricultural credit funds is unbalanced, and the proportion of agricultural science and technology loans is too small compared to other top-ranked loans, and financial institutions have insufficient financial support for agricultural science and technology.Lu Qingyao et al. (2021) found that agricultural science and technology can reduce carbon and protect the agricultural environment[3]. The total balance of agriculture-related loans has been growing steadily year by year, but the proportion of the balance of agriculture-related loans has declined significantly, and rural financial institutions need to strengthen their efforts to invest in agriculture-related loans.

The irrational use of credit funds can indirectly inhibit agro-ecological efficiency. Excessive use of land in pursuit of economic efficiency without considering the carrying capacity of land will cause agro-ecological environment deterioration. Redundancy of input factors leads to increased environmental pollution. Environmental pollution and carbon emissions cause agroecological efficiency to decline.

Structural imbalances within agricultural credit funds can also inhibit agroecological efficiency.Zhang Junwei et al. (2020) found that rural financial institutions have small loans for agricultural science and technology. Driven by commercial interests, the credit structure of rural financial institutions is increasingly showing a trend of “non-agriculturalization”, with funds flowing to non-agricultural sectors with high yields. The misalignment of the functions of rural financial institutions has prevented the development of green agriculture from gaining sustained momentum[4]. The proportion of agricultural science and technology loans is too small, and science and technology enterprises cannot obtain sufficient credit support. Therefore, the negative externality effect of excessive inputs from farmers is much higher than the positive externality effect brought by agricultural technology development.

Hypothesis H1: The ratio of agriculture-related loans will inhibit the improvement of agroecological efficiency.

Farmers who receive loans are more likely to invest in the purchase of agricultural machinery. However, the loans are rarely used to upgrade green technologies in agriculture. According to Li Bo (2011) the factors of carbon emission in agriculture are agricultural tilling, agricultural irrigation and so on. According to the theory of sustainable development the input use of agricultural machinery causes carbon emission pollution[5]. Input factor redundancy and increase in non-desired output reduces the value of agricultural eco-efficiency. The intensity of agricultural machinery inputs can both increase the efficiency of agricultural production and increase the amount of agricultural carbon emissions and pollution, which in general shows a negative effect due to excessive negative externalities. According to externality theory farmers do not have to bear the negative externalities caused by agricultural pollution. Therefore they will pursue higher agricultural yields and invest more in factors of production. Excessive input of agricultural machinery causes negative externalities increase the redundancy of non-desired output and reduce agro-ecological efficiency.

Hypothesis H2: Agricultural credit reduces agroecological efficiency by increasing the intensity of machinery inputs.

3. Measurement Model Setting and Data

3.1. Methodology

This paper uses a random effects Tobit model. Our baseline model specification used to test our hypothesis is as follows:

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$$Y_{it}^{*} = \alpha_i + \sum \beta_j * X_{jit} + u_i + \varepsilon_{it} \quad (1)$$

$$Y_{it} = \begin{cases} Y_{it}^{*}, Y_{it}^{*} \geq 0 \\ 0, Y_{it}^{*} < 0 \end{cases}$$

Where Y_{it} is the truncated variable of agroecological efficiency at moment t in province i. Y_{it}^{*} is the latent variable. α_i is the intercept, ε_{it} is the random perturbation term. u_i is the individual effect.

The mediated effects model is as follows:

$$Z_{it}^{*} = \alpha_i + \sum \beta_j * X_{jit} + u_i + \varepsilon_{it} \quad (2)$$

$$Z_{it} = \begin{cases} Z_{it}^{*}, Z_{it}^{*} \geq 0 \\ 0, Z_{it}^{*} < 0 \end{cases}$$

Z_{it} is the input of agricultural machinery in province i at moment t.

3.2. Variables and data sources

3.2.1. Explained variables

Agro-ecological efficiency is analysed with global agro-ecological efficiency with constant returns to scale by considering both agricultural economic development and green agricultural development in each province.

3.2.2. Core explanatory variables

The ratio of agriculture-related loan balance indicates the support of each financial institution in rural areas to agricultural activities, which is the balance of agriculture-related loans/total loan balance in each region.

3.2.3. Control and mediating variables

The control variables include agricultural disaster, the level of financial support for agriculture, the per capita disposable income of rural residents, the level of large-scale agricultural operation, and the intensity of fertiliser use. The mediating variable, agricultural machinery input, reflects the level of agricultural mechanisation, which is the total power of agricultural machinery/crop sowing area.

The main variables in this paper are defined as shown in Table 1.

Table 1: Variable definitions.

Category	Varible	Name	Definition
Explained variable	Efficiency	Agro-ecological efficiency	Calculated by the super-efficient SBM model
proxy variable for agricultural credit	Loanrate	Ratio of agriculture-related loan balance	Agricultural loan balance/total loan balance by region
Control variables	Disaster	Agricultural disaster	Area affected by crops/area sown with crops
	Finance	Level of financial support for agriculture	Fiscal agriculture, forestry and water affairs/total fiscal expenditure
	Dpi	Per capita disposable income of rural residents	Directly obtained by the National Bureau of Statistics
	Scale	Level of large-scale agricultural operation	Crop Sown Area/Agricultural Employees
	Fertilizer	Intensity of Fertiliser Use	Fertiliser application/crop sown area
Mediating variable	Mechanic	Intensity of agricultural machinery input	Total power of agricultural machinery/area sown with crops

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3.2.4. Data description

Considering data availability, individual provinces lack data and have different statistical calibres. A total of 300 sample data from 30 provinces during 2010-2019 are selected for the study. Data source National Bureau of Statistics, wind database.

4. Empirical test and result analysis

4.1. Baseline analysis results.

The results of the baseline analysis are shown in Table 2, the baseline regression passes the Wald test, and the ratio of agricultural loan balances negatively affects agro-ecological efficiency and passes the significance test at the 1% level. The effect is always negative when the control variable increases indicating some stability in the conclusion. In the year when the ratio of agriculture-related loan balance increases, most of the credit funds flow to agriculture, forestry, fishery and animal husbandry loans, and too much credit funds are invested in factors of production, resulting in redundancy of input factors, which reduces the value of agro-ecological efficiency. At the same time, the proportion of agricultural science and technology loans is too small, according to the theory of externality, the flow of credit funds to agricultural production of the negative externality is much larger than the positive externality, the overall view of the ratio of the balance of agriculturally related loans inhibit agro-ecological efficiency, and the hypothesis is consistent with the H1.

Table 2: Baselin regression.

	(1)	(2)	(3)	(4)	(5)	(6)
	efficiency	efficiency	efficiency	efficiency	efficiency	efficiency
loanrate	-0.936***	-0.790***	-1.021***	-0.483***	-0.451***	-0.449***
	(-5.22)	(-4.53)	(-5.04)	(-3.00)	(-2.85)	(-2.84)
disaster		-0.505***	-0.504***	-0.150**	-0.153**	-0.154**
		(-6.18)	(-6.25)	(-2.27)	(-2.32)	(-2.33)
finance			1.467**	1.033**	1.105**	1.121**
			(2.41)	(2.27)	(2.45)	(2.46)
dpi				0.288***	0.298***	0.297***
				(14.60)	(13.92)	(13.58)
scale					-0.0358	-0.0342
					(-1.24)	(-1.14)
fertilizer						0.0280
						(0.22)
_cons	0.654***	0.693***	0.594***	0.0979	0.113*	0.0992
	(11.35)	(12.38)	(8.32)	(1.47)	(1.71)	(1.09)
sigma_u	0.117***	0.116***	0.125***	0.105***	0.0975***	0.0968***
	(6.48)	(6.58)	(6.53)	(6.87)	(6.28)	(6.15)
sigma_e	0.155***	0.145***	0.142***	0.108***	0.108***	0.108***
	(23.19)	(23.20)	(23.11)	(23.18)	(22.99)	(22.93)
N	300	300	300	300	300	300
Waldchi2	27.29***	67.94***	74.15**	340.00***	344.05***	344.01***
Pro>chi2	0.000	0.000	0.000	0.000	0.000	0.000
LR	77.26***	82.76***	91.39***	125.51***	91.15***	85.35***

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4.2. Mechanism test

The results of the mediating role played by the intensity of mechanical inputs are shown in Table 3.

Table 3 shows that there is a significant effect of explanatory variables on machinery input intensity. The ratio of agricultural loan balance has a significant positive effect on machinery input intensity, and the increase of the ratio of agricultural loan balance strengthens the machinery input intensity in each province.

Agricultural machinery inputs can not only improve the efficiency of agricultural production but also increase carbon and pollution emissions, with an overall negative effect. The increase in the level of agricultural mechanisation significantly and negatively affects the agro-ecological efficiency in all regions [6]. The results show that the ratio of agricultural loan balance can reduce the agroecological efficiency of each province by increasing the intensity of mechanical inputs. It is consistent with hypothesis H2.

Table 3: Mechanism test

	mechanical
loanrate	0.0400**
	(2.02)
disaster	-0.00877
	(-1.47)
finance	-0.0896*
	(-1.90)
dpi	0.00375*
	(1.78)
scale	-0.00579*
	(-1.73)
fertilizer	0.121***
	(6.39)
_cons	0.0271**
	(2.11)
sigma_u	0.0384***
	(7.51)
sigma_e	0.00953***
	(23.17)
N	300
Waldchi2(6)	78.24***
Pro>chi2	0.000
LR	624.09***

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4.3. Robustness analysis

Table 4: Lagged effect

	(8)	(9)	(10)	(11)
	efficiency	efficiency	efficiency	efficiency
one period behind	-0.524***			
	(-2.81)			
two period behind		-0.488**		
		(-2.26)		
three period behind			-0.397*	
			(-1.72)	
four period behind				-0.363
				(-1.31)
disaster	-0.138*	-0.0836	-0.0824	-0.0209
	(-1.89)	(-1.01)	(-0.95)	(-0.23)
finance	1.502***	1.851***	1.939***	2.228***
	(2.83)	(3.16)	(3.09)	(3.52)
dpi	0.316***	0.371***	0.408***	0.491***
	(12.83)	(13.38)	(12.38)	(12.84)
scale	-0.0337	-0.0701**	-0.0844**	-0.107**
	(-1.01)	(-1.96)	(-2.15)	(-2.43)
fertilizer	-0.0194	-0.106	-0.151	-0.328
	(-0.13)	(-0.63)	(-0.78)	(-1.31)
_cons	0.0707	0.0195	-0.0344	-0.107
	(0.69)	(0.17)	(-0.25)	(-0.62)
sigma_u	0.106***	0.115***	0.128***	0.163***
	(5.90)	(5.59)	(5.46)	(5.20)
sigma_e	0.110***	0.108***	0.109***	0.0994***
	(21.43)	(19.75)	(18.04)	(15.88)
N	270	240	210	180
Waldchi2(6)	274.74***	243.21***	199.03***	200.21***
Pro>chi2	0.000	0.000	0.000	0.000
LR	79.03***	73.96***	69.16***	78.54***

The robustness test section was chosen to explore the lagged effects as well as the replacement of the explanatory variables.

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Firstly, the lagged effect is considered by lagging the core explanatory variable, agricultural loan balance ratio. The regression results are shown in Table 4.

As can be seen from the table 4, there is a significant effect of the explanatory variables on agroecological efficiency. The results indicate that the ratio of agricultural loan balances has a dampening effect on agro-ecological efficiency and that this dampening effect has a time-three period persistence effect.

To further test the robustness of the results, agroecological efficiency with variable returns to scale is used as a new explanatory variable. The results in Table 5 show that this variable passes the 1% significance level test and has a negative impact on agroecological efficiency, indicating that the results have a certain degree of robustness.

Table 5: Robustness analysis

	Eff-vrs	efficiency
loanrate	-1.144***	-0.449***
	(-6.03)	(-2.84)
disaster	-0.161**	-0.154**
	(-2.53)	(-2.33)
finance	0.970**	1.121**
	(1.97)	(2.46)
dpi	0.307***	0.297***
	(13.90)	(13.58)
scale	0.0197	-0.0342
	(0.57)	(-1.14)
fertilizer	-0.321**	0.0280
	(-1.97)	(0.22)
_cons	0.461***	0.0992
	(4.27)	(1.09)
sigma_u	0.102***	0.0968***
	(22.94)	(6.15)
sigma_e	-1.144***	0.108***
	(-6.03)	(22.93)
N	300	300
Waldchi2(6)	466.72***	344.01***
Pro>chi2	0.000	0.000
LR	204.36***	85.35***

5. Conclusion and Implications

5.1. Research conclusions

This paper selects data related to agriculture and agricultural credit in 30 provinces from 2010 to 2019, chooses the super-efficient SBM model to measure the value of agricultural eco-efficiency in each province, and uses the random-effects panel Tobit model to explore the impact of agricultural credit on agricultural eco-efficiency, and the conclusions are as follows: firstly, the regional differences in agricultural eco-efficiency are obvious, and the regions with higher agricultural eco-efficiency are concentrated in the eastern coast as well as in the First, there are obvious regional differences in

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agricultural eco-efficiency, with areas of higher agricultural eco-efficiency concentrated in the eastern coast and some areas in the central and western regions with higher levels of agricultural green development. Northeast and central and western regions have lower agroecological efficiency values due to excessive input factor redundancy. Second, agricultural credit has a dampening effect on agroecological efficiency. When the ratio of the balance of agriculture-related loans increases, the internal structure of loans varies greatly, and funds flow to agriculture, forestry, fishery and animal husbandry loans, resulting in input factor redundancy, and the negative externality is much larger than the positive externality brought by agricultural science and technology loans. Third, the mediating effect shows that the ratio of agricultural loan balance can reduce agroecological efficiency by increasing the intensity of machinery input. There is a negative externality effect of agricultural machinery input intensity, and farmers tend to use credit funds to buy more agricultural machinery in pursuit of greater agricultural output, resulting in redundancy of non-desired outputs and lower agroecological efficiency.

5.2. Policy Recommendations

First, government departments should promote the coordinated regional development of green agriculture. China's agro-ecological efficiency regional differences are obvious, the lower regions of the financial institutions to subsidise, to encourage credit funds into the green credit in. Coordinate agricultural credit guidance with green industrial policies and fiscal policies of various sectors; innovate green financial credit products and application scope.

Second, adjust the internal credit structure of agriculture. The theory of agricultural transformation and development proposes that agricultural credit, as an important part of rural finance, provides capital for agriculture-related science and technology enterprises to research and develop green-related technologies and equipment through the input of credit funds, and ultimately realises agricultural transformation and green development. According to the externalities agricultural science and technology loans can bring positive externalities. Emphasis on agricultural science and technology loans, increase the proportion of loans, enhance the efficiency of agroecology.

Third, differentiated interest rates are applied to credit supply, and reasonable interest rates are set for agricultural means of production manufacturing loans, due to the existence of an impact path on the ratio of agriculture-related loan balances. Increase interest rates to inhibit the intensity of mechanical inputs and enhance agro-ecological efficiency. Apply preferential interest rates to agricultural technology loans to reduce the burden on enterprises.

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