ANALYSIS OF THE POLICY EFFECTIVENESS OF CORN TO RICE IN NORTHEAST CHINA

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ABSTRACT

The income gap brought about by the cultivation of corn and rice has been widening, driving a structural adjustment in Northeast China from growing corn to growing rice. This paper uses household survey data from 2016 to 2018 and a Difference-in-Differences (DID) model to assess the impact of this structural adjustment on farmers' agricultural income. The research results have identified three key findings. Farmers participating in the rice-growing transformation project have seen a significant increase in their income, and the productivity of their land has also improved. However, population factors can limit these benefits. For every year older a farmer is, their agricultural income decreases by 0.4%. This is because rice cultivation requires a relatively high labor intensity. Male-headed households earn 16.5% more than female-headed households. Most farmers in Northeast China earn money through agriculture, and their income is still easily affected by fluctuations in market prices. Based on these findings, this article believes that the government can continue to maintain the policy of price support and provide more technical services to help those elderly and weak labor force farmers.

Keywords: Corn-to-rice conversion; Difference-in-differences (DID); Farmer income; Structural adjustment; Northeast China.

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INTRODUCTION

For a country with strong agricultural strength, ensuring food security and a stable supply of agricultural products has always been a crucial foundation. Currently, in China, the supply and demand of grain and key agricultural products can basically maintain a balance. Over the past nine consecutive years, the national grain output has exceeded 0.65 trillion kilograms, and the average grain consumption per person is 493 kilograms. This is much higher than the internationally recognized 400-kilogram food security line. However, as the economy gradually develops and people's living standards improve, the demand for grains and basic agricultural products may increase in the future (Fukase and Martin, 2020). As a result, the changes between supply and demand may become increasingly tense, and stabilizing grain production becomes particularly urgent. Under such circumstances, rice (*Oryza sativa* L.) and corn (*Zea mays* L.), as the main staple crops we eat, it has played a very crucial role in safeguarding national food security(Mohidem *et al.*, 2022).

To protect the actual interests of farmers and ensure the stability of the country's grain supply, the Chinese government has long implemented the "minimum purchase price policy". The specific mechanism of this policy is as follows: When the price of grain in the market is lower than the set minimum price, the government will intervene and purchase the grain at the protected price. Conversely, if the market price is relatively high, farmers can directly sell the grain to the market (Qian *et al*., 2020). Although this policy successfully stabilized grain prices and increased farmers' income (Attanasio *et al*., 2013), it also brought about some market distortion problems. The artificially high prices set by the government led us to hoard too much grain. As a result, grain prices were disconnected from actual market demand, which hindered the development of the grain processing industry (Johnson and Kurosaki, 2024; Wang and Si, 2021). Some scholars believe that although the basic framework for protecting farmers should remain unchanged, the specific price levels need to be reasonably adjusted so that policies can once again play the role of a "safety net" rather than becoming the main force driving the market (Liu *et al*., 2020). In response to these market changes, China initiated major policy reforms in 2016, with the government lowering the minimum purchase prices for certain crops. For instance, the price of wheat is even lower than the production cost (Zhu *et al*., 2019). However, because rice holds a crucial strategic significance for national food security, here. To make up for the possible income loss of farmers, major grain-producing

provinces such as Heilongjiang, Jilin and Liaoning have introduced rice subsidy policies since 2018. These measures aim to transition from price support to a producer subsidy mechanism, ensuring that farmers can earn money while keeping prices in line with market trends.

The corn sector, which is the focus of this article, has also carried out parallel reforms. Relevant departments have introduced subsidy policies for corn and soybean producers, using these subsidies to replace the previous storage system, aiming to reduce the production costs of downstream processing enterprises and livestock enterprises (Li, 2017; Lu and Chen, 2021). However, at the beginning of the reform, it exerted downward pressure on corn prices. This situation has reduced the income of farmers from growing corn (Pu and Zheng, 2020; Zheng *et al*., 2022). Since 2015, a significant structural shift has emerged in Northeast China, known as "corn to rice", as the policy has created a price gap - the price of corn has dropped, but the price of rice has remained relatively protected.

From an economic perspective, this paper finds that agricultural support policies will actually influence farmers' production decisions through the transmission mechanism of "policy support - income expectations - output growth". Existing related studies have pointed out that the planting conversion from "corn to rice" can effectively promote the increase of grain output and also help farmers increase their income. It has played a very crucial role in ensuring food security (Pan *et al*., 2019; Wang *et al*., 2023). However, most of the current research on this topic either only focuses on the technical aspects or makes some qualitative descriptions. Few studies use strict quantitative methods to separately identify the net effects of these overlapping policies, which limits our accurate judgment on whether the policies are effective or not.

To figure out exactly what this gap is all about, this paper investigates the impact of the "corn-to-rice" structural adjustment on the effective supply of grain in Northeast China. We use the field research data collected from 2016 to 2018 and also select the differential model to see how this policy affects grain production. The contributions of this paper are in two aspects: First, in addition to text analysis, a quantitative assessment of the net effect of policies was also conducted. Second, when using the DID model, the impact during the same period and the differences before conversion were taken into account, which can effectively alleviate endogenous problems. These research results can provide a scientific basis for improving future agricultural support policies and increasing the output of key agricultural commodities.

MATERIALS AND METHODS

Model Specification: To quantify the net impact of the "corn to ric" policy on farmers' income, this paper adopts a differentially in-differences model. Farmers who have participated in the "corn to Rice" project since 2017 are classified as the treatment group, while those who have not participated in the project are regarded as the control group. The DID method can take into account the time-invariant individual characteristics and common time trends affecting both groups (Ruan *et al*., 2020). Effectively isolate the impact of the policy. This article uses this method to isolate the net policy effect of the "Corn to Rice" initiative. The policy effect and time effect are obtained by comparing the experimental group before and after the policy, while the time effect is measured from the control group over the same period. Subtracting the time effect from the experimental group difference yields the net policy effect. The DID estimation equation used in this study is as follows:

$$Y_{it} = \beta_0 + \beta_1 Treated_i + \beta_2 Post_t + \beta_3 (Treated_i \times Post_t) + \beta_4 X_{it} + \varepsilon_{it} \quad (1)$$

Where Y_{it} represents the outcome variable, specifically the income derived from land cultivation for farmer *i* in year *t*. The variable $Treated_i$ is a dummy variable that equals 1 if the farmer belongs to the experimental group (participated in the "corn-to-rice" project) and 0 otherwise, capturing the time-invariant differences between the groups. $Post_t$ is a time dummy variable that equals 1 for the post-implementation period (2017 and beyond) and 0 for the pre-implementation period, accounting for temporal factors affecting all farmers. The interaction term $Treated_i \times Post_t$ is the key regressor, and its coefficient β_3 identifies the net policy effect of the project on farmers' income. Finally, X_{it} denotes a vector of control variables—including age, gender, education, household labor force, and other socioeconomic factors—while ε_{it} represents the random error term.

Variable Selection: The definitions and descriptive statistics of the variables used in the model are presented in Table 1. The dependent variable is the actual income derived from planting. Key control variables include household demographics, economic status, and market prices for rice and corn.

Table 1 Variable interpretation and assignment.

Variable Name	Variable Code	Variable Assignment
Income from land cultivation	Benefit	Actual planting income (RMB)
Treatment group	Treated	1 if the farmer is in the experimental group; 0 otherwise
Post-policy period	Post	1 for years 2017 and beyond; 0 for years prior to 2017
Age	Age	Actual age of the respondent (years)
Education level	Education	1 = Elementary school or below; 2 = Junior high; 3 = High school; 4 = College or above
Gender	Gender	1 = Male; 0 = Female
Family farming workforce	Agrnum	Number of family members actually engaged in agriculture
Share of farming income	Agriprop	1 = 100%; 2 = 80%–99%; 3 = 50%–80%; 4 = 30%–50%; 5 = Below 30%
Household consumption (log)	Lnconsume	Natural logarithm of annual household consumption
Price of rice	Ricepr	Actual selling price of rice (RMB/kg)
Price of corn	Cornpr	Actual selling price of corn (RMB/kg)
Land area (log)	Lnarea	Natural logarithm of actual arable land area
Irrigation facilities	Dryirr	1 if irrigation facilities are available near dry land; 0 otherwise

Data Collection: Data for this study were obtained from a household survey conducted by the research group on "Corn-to-Rice Mechanism and Agricultural Policy Innovation in Northeast China."To make the survey samples more representative, this paper adopted the method of stratified random sampling for sample selection. The survey scope was selected from four cities in Northeast China, namely Harbin and Shuangyaoshan in Heilongjiang Province, and Shenyang and Dianlin in Liaoning Province. During the selection, two counties were randomly picked from each city first, and then 2 to 3 villages were selected from each county. After arriving at each village, 10 to 15 households will be randomly surveyed based on the size of the village.

We first conducted a pilot survey in Jilin City to make the questionnaire more complete before the large-scale investigation began. The data collected during the pilot stage were eventually removed from the formal dataset. At the beginning, we collected a total of 693 questionnaires. Later, when doing data cleaning, we removed those involving land exchange and those with informal labor force situations. All incomplete samples with missing parts in cost or revenue data were deleted. A total of 54 samples were removed. Only 639 households remained as valid samples in the end, and the time range of these samples was from 2016 to 2018.

Sample characteristics: To clarify the specific structure of the dataset we used; this article first analyzed the basic characteristics of all respondents. These data are all placed in Table 2. We divided the collected samples into three different groups based on income levels, namely the low-income group, the middle-income group, and the high-income group. By conducting descriptive analysis, this article finds that there is a positive correlation between the participation in the "Corn to Rice" project and people's income levels. Specifically, looking at the data from the high-income group, 61.03% of the people participated in this project. However, in the middle and low-income group, the number of participants was much lower, only around 35%. From this data comparison, it can be seen that this project may be helpful for everyone's income growth. Why is that? Perhaps it is because compared with corn, the yield of rice is more stable and the price of rice is much higher than that of corn. The combination of these two reasons may increase the income of the people involved in the project.

Regarding the issue of labor force immigration, we found that 65.26% of high-income farmers have never had the experience of immigration work before. This data indicates that because the per capita cultivated land in Northeast China is relatively large, full-time agriculture in the local area may be more profitable than going out to do immigration work. Furthermore, government technical training appears effective: 53.99% of high-income farmers received training, compared to only 38.97% in the low-income group.

Table 2. Basic characteristics of the respondents

The income level of farmers	Whether to participate in the corn to rice project		Whether to work outside the home		Receive training or not	
	No	Yes	No	Yes	No	Yes
Low-income	139	74	131	82	130	83

Middle-income	138	75	110	103	124	89
High-income	83	130	139	74	98	115

Summary Statistics and Multicollinearity Test: The descriptive statistics for the main variables are summarized in Table 3. To ensure the robustness of the regression analysis, a multicollinearity test was conducted. The correlation matrix indicates that correlation coefficients between variables are generally below 0.3. Furthermore, the Variance Inflation Factors (VIF) for all variables are concentrated between 1 and 2, well below the threshold of 10. This confirms that multicollinearity is not a concern in this study.

Table 3 Basic information of the main variables of the model

Variable	Obs	Mean	Std. Dev.	Min	Max
Lnbenefit	639	6.85	0.42	5.42	7.71
Age	639	49.27	10.54	23	74
Education	639	1.88	0.73	1	4
Gender	639	0.92	0.28	0	1
Agrnum	639	1.95	0.71	1	4
Agriprop	639	2.01	1.15	1	5
Lnconsume	639	10.48	0.66	8.52	11.58
Ricepr	639	1.37	0.09	0.9	1.66
Cornpr	639	0.66	0.11	0.33	1
Lnarea	639	4.29	1.24	0.88	7.39
Dryirr	639	0.31	0.46	0	1

RESULTS

Main Effects of the "Corn-to-Rice" Policy on Income: Table 4 presents the stepwise regression results of the DID model. The consistency of the coefficients between Model 1 and Model 4 indicates that our estimation is very robust. The coefficient of the core interaction term, that is, the one after processing ×, is the main focus of this paper. In all model Settings, this coefficient has always been positive at the 1% level and is statistically significant. In the fully set Model 4, the coefficient is 0.670. This means that, under the condition that all other factors remain unchanged, the structural adjustment of "switching from corn to rice" can increase farmers' agricultural income. This positive result indicates that the net policy effect is beneficial: Compared with farmers who have never grown corn, those who switch from growing corn to growing rice can earn a considerable income premium. This empirical finding aligns with a view that rice cultivation in Northeast China, supported by government prices and subsidies, has higher profitability and more stable yields than corn, while corn is more susceptible to price fluctuations and climate risks.

Table 4 Regression results for the samples

Variables	model1	model2	model3	model4
Treated × post	0.714***	0.713***	0.658***	0.670***
	(22.69)	(22.71)	(25.48)	(25.54)
Treated	-0.093***	-0.082**	-0.027	-0.029
	(-2.76)	(-2.47)	(-0.96)	(-1.04)
Post	0.088***	0.089***	0.053***	0.049**
	(3.8)	(3.83)	(2.63)	(2.4)
Age		0	-0.003***	-0.004***
		(-0.00)	(-2.66)	(-3.15)
Education		0.024	0	0.004
		(1.34)	(-0.03)	(0.25)
Gender		0.125***	0.144***	0.165***
		(2.67)	(3.7)	(4.26)
Agrnum		0.017	0	0.006

		(0.93)	(0.02)	(0.42)
Agriprop		0.041***	0.019*	0.005
		(3.51)	(1.93)	(0.48)
Lnconsume		-0.065***	-0.042**	-0.024
		(-2.95)	(-2.27)	(-1.30)
Ricepr			0.550***	0.532***
			(6.04)	(5.82)
Cornpr			1.303***	1.232***
			(16.57)	(15.38)
Lnarea				-0.033***
				(-3.07)
Dryirr				0.01
				(0.54)
Constant	6.578***	6.977***	5.391***	5.436***
	(-264.18)	(-25.93)	(-20.18)	(-20.79)
Observations	639	639	639	636

*Note: T-statistics are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Model 1 includes basic DID variables; Model 2 adds household characteristics; Model 3 adds price variables; Model 4 adds land characteristics.*

Effects of Household and Market Characteristics: Apart from the impact brought by policies, the several control variables selected in this article also have a significant effect on income, which can help us clearly understand the specific small mechanisms of agricultural production in this region. Let's first look at the age factor in people's minds. The coefficient of age has always been negative, which is quite obvious. There is an inverse relationship between age and agricultural productivity. Although older farmers have a lot of traditional planting experience, but they may encounter physical limitations and also find it a bit difficult to adapt to the modern agricultural technologies required for growing rice. From the specific data, it can be seen that for every additional year a farmer gets, their agricultural income decreases by 0.4%. This clearly indicates the problems brought about by the aging of agricultural labor force. Looking at the gender factor, its impact is also prominent and positive. If the head of the household is male, the income will be approximately 16.5% higher than that of households with female heads. This difference may be related to the scale of grain cultivation in rural areas of Northeast China and the traditional division of labor. Because grain cultivation requires a lot of physical strength, men usually do the main farm work in the fields.

Market and resource factors have also played a crucial role. The prices of rice and corn are positively correlated with income, with specific coefficients of 0.532 and 1.232 respectively. The significant impact of income on corn prices actually reflects the historical reliance of this region on corn. However, later on, farmers began to shift to growing rice. Such structural changes enable them to take advantage of the higher and more stable price mechanism in the rice market, thus effectively coping with the pressure brought about by the decline in corn prices. In addition, the logarithm of the land area in Model 4 shows a negative coefficient, with the specific value being β= -0.033, and the p value is less than 0.01. This negative correlation may indicate that in the absence of sufficient mechanization, when farmers manage overly large plots of land, either the return on scale is not high or the efficiency is relatively low. This situation is often observed in the agricultural economy during the transitional period.

Robustness Checks: To ensure that the effect of causal inference is good enough, this paper has conducted two very strict robustness checks. The first point to be discussed is the possible endogeneity issue, which is a common situation in observational studies - those factors that have not been observed might simultaneously affect people's participation in policies and income situations. To verify this, this paper examines the independence between key explanatory variables and control variables, specifically by analyzing the interaction terms together with control variables that may have endogeneity. The analysis results show that there is no systematic connection between them, which supports a hypothesis: policy implementation can be regarded as an exogenous shock based on control measures, and the estimated income increase should be attributed to the policy itself rather than the impact of choice bias.

Next, we tested the sensitivity of the results to outliers. Since the income gap in rural areas is indeed significant, those extreme values might distort the regression results. We excluded the top 20% of households with the highest agricultural income and re-estimated this pattern. Judging from the results of this sub-sample analysis, Although the coefficient amplitude after processing × only slightly decreased, it still remained positive and statistically significant. This indicates that the income-increasing effect of the "Corn to Rice" project is not entirely driven by a few relatively affluent farmers, but rather by the broader benefits that more families participating in the project can enjoy.

DISCUSSION

The results of this study show that the initiative of "switching corn to rice" has significantly increased the agricultural income of farmers in Northeast China. We have observed in several different models that the coefficients of the post-treatment variables and time are strong and stable. The effect of increased income is not due to the selection of different models or control variables, but rather a consistent result brought about by this project itself. This discovery is in line with previous theories and actual evidence, indicating that farmers adjust their production structure based on the income from different crops and policy incentives (Abu Harb *et al.*, 2024; Severini *et al.*, 2021). With policy support, they switch from growing corn to growing rice, seemingly shifting both land and labor towards more profitable and stable crops.

A key reason for the observed income gains is the fundamental difference in production characteristics between corn and rice. In the past two decades, rice cultivation in Northeast China has maintained a relatively stable output due to the emergence of cold-resistant rice varieties and significant improvements in mechanization and irrigation techniques. Unlike rice, the corn yield in this region is more sensitive to climate change. When drought or early frost occurs, (Pang *et al*., 2025) Research articles on agricultural risks and farmers' seed selection mention that even if the expected income of the two crops is similar, farmers who do not want to take risks are more likely to switch to crops with more stable yields (Kumar *et al*., 2020). The empirical research results we conducted support the situation stated in this theory: farmers who grow rice have higher incomes because rice can be sold at better prices and the production process fluctuates less. Additionally, the positive coefficients of both rice and corn are quite strong, which also indicates that the income from growing these two crops in this region is particularly sensitive to price changes (Jouf and Lawson, 2022).

In addition to the influence of price and output on policy responses, this paper finds that the structural characteristics of agricultural production in Northeast China may explain the strong response of local farmers to policies. The main characteristics of this area are threefold. Firstly, the land resources are relatively abundant. Secondly, the level of agricultural mechanization is also relatively high. As a result, the restrictions on labor force are lower than those in other places. However, the agricultural production conditions in other regions of China are significantly different from those in Northeast China (Thi and Zhou, 2024). Because rice cultivation requires more labor input and relies more on irrigation facilities than corn cultivation, the shift to rice cultivation may bring more benefits to farmers who already have better land conditions or irrigation opportunities. This increases the possibility that this policy may magnify the existing differences in the production capacity of farmers' households. This issue can serve as a direction for future research. Explore by analyzing the differences among various farmers.

Population results have helped us understand the mechanism behind income changes. The negative coefficient of age indicates that after policies have an impact, older farmers will have less agricultural income. Although people usually think that more experience can make farms perform better, several studies have mentioned that if technology upgrades rapidly, new skills, new knowledge or higher adaptability are needed. Then the advantage of relying on experience will become smaller (Huang and Wang, 2024; Oli *et al*., 2025). Nowadays, mechanized equipment, digital farm tools and improved rice varieties are increasingly favored by younger and more adaptable farmers, as they are more willing to change their production methods. The negative correlation between age and income may reflect that the structure of production activities in our society is changing. In such changes, whether a person can succeed more often depends on whether he can use new technologies rather than relying solely on traditional experiences from the past.

Gender differences also play a crucial role in this. This study found that families with men as the head of the household have much higher incomes. This result is consistent with many previous studies on gender inequality in agricultural production (Ge *et al*., 2023; Midamba *et al*., 2025). For example, in Northeast China, male farmers often do more direct field management work. Things like working with machinery, buying production materials and selling agricultural products all have a significant impact on their income. Although female farmers are also crucial in the distribution of labor within the family, they often encounter certain restrictions when it comes to doing manual labor, obtaining machinery, managing farms and participating in training. Research findings indicate that even if major structural reforms such as the shift from corn to rice occur, the gender gap in agricultural productivity still exists. This also makes this article think that future policies might benefit from support for female farmers, such as providing inclusive training, gender-sensitive extension services, or supporting mechanization to alleviate their labor burden.

Unlike population factors, variables such as education, the scale of household labor, and household consumption, after we controlled for crop selection and prices, did not have a very significant impact on agricultural income. This result is similar to the previous research results conducted in highly mechanized agricultural areas, where technological scale, land endowment, and market conditions were the main factors determining income. This reduces the marginal contribution of basic demographic factors to income (Kusz *et al*., 2022). For instance, some research has pointed out that in some areas, the impact of education on income is often more crucial than that of crop production in mechanized grain-growing regions. (Wang *et al*., 2024). Additionally, the number of agricultural laborers may have little

influence in these production systems because more mechanical work is relied on rather than manual labor. The limited impact of these factors can also indicate crop selection and market incentives. It is quite crucial for the demographic characteristics of a family. In this way, in an environment of large-scale grain cultivation, it can promote the formation of income outcomes.

One rather unexpected finding is that when all the variables that need to be controlled are taken into account, the coefficient of land area turns out to be negative. Although large farms generally earn more money, previous studies have suggested that the relationship between farm size and production capacity may not be linear, and sometimes it may even be reversed. This does not match the costs of labor management, machinery, and land scale. Or the land is too scattered. All these situations are related (Omotilewa *et al*., 2021). In our current study, families with larger land areas may grow more types of crops and use more diverse farming methods. Or due to poor land quality or scattered plots, the cost of opening up each additional plot of land is higher. Although the value of this coefficient does not change much, from this trend, The structural characteristics of the land itself may slightly increase the income, and this point is worth our further study.

These survey results can help us conduct a more comprehensive discussion on the changes in agricultural structure and policy-driven crop replacement in emerging economies. The evidence provided in this article supports a view: Price incentives and risk stability are the key driving forces for farmers to select seeds (Hao *et al*., 2025). Combined with ensuring the minimum purchase price, improved rice varieties and targeted policy support, the "corn to Rice" project has indeed changed farmers' economic calculation methods and accelerated the adjustment of land to rice cultivation. This is in line with China's general direction of optimizing the grain structure, enhancing food security and stabilizing rural income. However, the success of this project is highly dependent on price differences, indicating that its long-term sustainability may be affected by market fluctuations or changes in national purchase policies. Just as past experience has shown, if the price of rice is lower than that of corn, Farmers may return to their previous planting habits when irrigation costs rise or environmental pressure increases.

The results of this research have also drawn people's attention to emerging environmental issues. Although our analysis did not directly look into this, it is well known that growing rice requires more water than growing corn. This may put pressure on the underground water resources in areas with insufficient irrigation facilities. Previous studies have warned of this Expanding rice cultivation poses risks such as reduced groundwater, salinized soil, and fertilizer runoff (Garbanzo *et al*., 2024; Su *et al*., 2026). As the plan to switch from corn to rice grows larger and larger, how to enhance the environmental sustainability of rice production has become a crucial topic in future research. Integrating hydrological, ecological and economic modeling can enable us to have a clearer understanding of the various trade-offs related to crop transition policies.

Overall, the results of our survey this time can bring some useful ideas to policy design. To maintain the benefits of this plan, policymakers can consider doing a few things. For instance, improving the infrastructure for irrigation, providing more people with opportunities for technical training - older farmers and female farmers, and paying more attention to changes in market prices can ensure that those who grow rice can earn enough money. In addition, if some policies that encourage water-saving rice technology, digital agriculture and mechanical transplantation can be introduced, production efficiency can be enhanced, and the pressure on the environment can also be reduced. Another crucial point is that when we collect data in the future, we should extend the time span and expand the geographical scope. Only in this way can we properly assess the long-term results of these policies. See if their positive effects can be sustained all the time or if they manifest differently in various places.

Conclusion: This study confirms that the "corn-to-rice" program in Northeast China has significantly increased farmers' income by taking advantage of stable yields and price support. However, due to the large amount of labor required for rice cultivation, the income of elderly farmers and female-headed households is relatively lower, and welfare is restricted by population factors. Additionally, agricultural income is still very sensitive to market prices. From these research results, it can be seen that the government can further expand the scope of support, not only providing financial subsidies, but also adding technical training and mechanized services. These measures can help those groups with less favorable conditions solve the problem of insufficient labor force. It is also crucial to always maintain a price safety net, which can reduce the risks brought by the market. It can also ensure that economic growth does not affect long-term ecological sustainability.

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