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The impact of agricultural product branding on farmers' income inequality: evidence from China

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Introduction: Income inequality is related to farmers' welfare, access and satisfaction. Addressing income inequality among farmers is particularly urgent as it is growing. So, as an important symbol of the development of the agricultural industry, what is the impact of agricultural product branding on farmers' income inequality?

Methods: To answer this question, this paper uses panel data from 1986 counties in China from 2000 to 2021 and employs the Recentered Influence Function (RIF) method to explore the impact of agricultural product branding (APB) on farmers' income inequality and its mechanism of action.

Results and discussion: The results of the study show that while the APB boosted farmers' incomes by an average of 1.6%, they exacerbated farmers' income inequality by an average of 0.4% (using the Gini coefficient as an example). Mechanistic analysis shows that the APB exacerbates farmers' income inequality by widening the gap between counties in terms of the level of adoption of agricultural technology and agricultural labor productivity. Heterogeneity analysis reveals that, compared to non-agricultural provinces, the APB in agricultural provinces reduces interregional farmers' income inequality. Furthermore, the APB in the grain category mitigates this inequality, whereas the APB in the cash crop and aquatic product categories exacerbates it. The APB in the livestock category, however, has no significant effect on interregional farmers' income inequality. Considering these findings, the government should regularly assess the impact of agricultural branding policies on income inequality among farmers and adjust policies in a timely manner to ensure their effectiveness and fairness.

KEYWORDS

agricultural product branding, income inequality, county agriculture, agricultural sustainability, China

1 Introduction

After three decades of trade and financial globalization, global inequality remains starkly visible.[1] As the world's largest developing country, China has completed the historic task of lifting people out of poverty on schedule, lifting 770 million rural poor out of poverty and contributing more than 70% to global poverty reduction in its glorious journey of more than

1 https://wid.world/news-article/world-inequality-report-2022/

40 years of the Reform and Opening up. At the same time, the problem of income inequality among farmers in China has increased significantly (Wang et al., 2014). According to data from the National Bureau of Statistics of China, the Gini coefficient of China's residents' income has remained above 0.46 from 2010 to 2022, much higher than the international warning line of 0.4; The ratio of the *per capita* disposable income of China's rural residents in the high-income group (the top 20%) to the low-income group (the bottom 20%) has increased from 7.4 to 9.5 times during the period from 2013 to 2023.[2] This suggests that there is significant income differentiation between rural areas in China, and that the income gap is clearly widening.

Regional Public Brands of Agricultural Products (RPBAP) refer to brands owned by relevant organizations and jointly used by multiple agricultural production and management entities within a defined production area that features specific natural ecological environments, history, and humanistic factors.[3] The brand name consists of "origin name + product name," and the origin is at the county or prefecture level. With the development in recent years, RPBAP is gradually becoming an important strategy to promote farmers' income, promote high-quality agricultural development and enhance the international competitiveness of agriculture (Wang et al., 2022; Tang H. et al., 2024). By the end of 2021, China's provincial agricultural and rural departments had focused on cultivating about 3,000 regional public brands, 5,100 corporate brands and 6,500 product brands.[4] In terms of brand benefits, the output of RPBAP in China's agricultural brand catalog has increased by nearly 55% between 2012 and 2022, sales have increased by nearly 80%, and local farmers have been driven to increase their incomes by 65%. However, while driving the development of rural industries and promoting the growth of farmers' incomes, the development of RPBAP is also accompanied by the risk of exacerbating income inequality.

The specific analyses are as follows: First, by the end of 2021, Shandong Province had 250 RPBAP. While Tianjin, the city with the least number of them, has only 8. The degree of development of RPBAP varies among provinces and cities, which may lead to significant differences in the effect of farmers' income growth in each region. Secondly, brand building relies on superior local natural conditions. China is a vast country with obvious differences in natural resource endowments between regions (Liu et al., 2016), which may lead to differences in the effectiveness of RPBAP in promoting farmers' income growth in different regions. Finally, different types of agricultural products have their own characteristics. Seeds for grain crops are readily available, easy to save and suitable for large-scale cultivation, while livestock and aquaculture produce are riskier (Qie et al., 2023). So, under the current constraints of frequent occurrence of extreme weather and insufficient endogenous driving force in rural areas, can the agricultural product branding (APB) curb the inequality of farmers' income? What is the specific mechanism of action? Answering this question is of great practical significance for promoting the modernization of China's agriculture and rural areas and the sustainable development of agriculture.

The issues discussed in this paper relate to two types of literature. The first type of literature is on the impact of APB on farmers' incomes, which can be categorized into positive and negative aspects. In terms of positive impacts, several studies have pointed out that branding of agricultural products clearly contributes to raising farmers' incomes (Li C. et al., 2024; Wang et al., 2024; Yin et al., 2024). As an excellent institutional design, APB can not only promote the flow of commercial and industrial capital to the countryside (Qie et al., 2023), but also effectively convey market information on agricultural products, incentivize farmers to engage in green production behaviors, and enhance the quality and safety of agricultural products (Li D. et al., 2024; Zhang S. et al., 2024). This increases the bargaining power of farmers, and the value added to their products, thereby contributing to local agricultural growth and farmers' income growth (Ohe and Kurihara, 2013; Yin et al., 2024). However, in terms of negative impacts, studies have shown that the APB has made a limited contribution to the growth of local farmers' incomes (Minten et al., 2013), and a negative spatial spillover effect on farmers' incomes in neighboring regions (Dong et al., 2021). Consumers will evaluate a brand's self-regulatory messages positively only if they have favorable attitudes toward that brand (Park and Unnava, 2024).

The second strand of literature focuses on farmer income inequality. Existing studies have analyzed this issue in depth from several perspectives, including social capital (Liu et al., 2019), land reforms (Kimhi, 2023), digital economy (Wei et al., 2024), agricultural subsidies (Tang C. S. et al., 2024; Sha et al., 2024). However, relatively little has been said about the impact of APB on farmers' income inequality. In addition, there is some literature that explores the relationship between the APB and income inequality. The APB can reduce the economic growth gap in counties, which in turn helps to reduce the income gap of the entire population (Qie et al., 2023). The APB can form a stronger competitive advantage in foreign trade and promote the level of agricultural exports, thus narrowing the income gap between urban and rural areas (Zhang et al., 2023).

Overall, the existing literature on the impact of APB on farmers' incomes has not yet reached a consistent conclusion. At the same time, there have been many studies on income inequality, but there is a lack of systematic theoretical analysis and empirical evidence on how the APB affects farmers' income inequality and their mechanism of action. In addition, the use of county-level data allows, on the one hand, to maintain the same administrative unit as the origin of the RPBAP, ensuring the accurate identification of the net effect of APB on the inequality of local farmers' incomes. On the other hand, it can also increase many samples to guarantee the robustness and feasibility of the results. Therefore, this paper utilizes Chinese county data from 2000 to 2021 and applies the RIF regression function to deeply explore the impact of APB on farmers' income inequality and its mechanism of action.

Compared with existing studies, the marginal contribution of this paper is mainly reflected in the following three aspects: First, based on the theory of technology diffusion, this paper constructs a systematic theoretical framework to analyze the impact of APB on farmers' incomes and income inequality and its mechanism of action. Second, from the perspective of inter-regional farmers' income inequality, this paper empirically analyzes the impact of APB on farmers' income inequality and its mechanism of action by using macroeconomic data of 1986 counties in China from 2000 to 2021, and by applying the RIF regression model. Finally, considering that the development and construction of RPBAP are extremely dependent on natural conditions

2 https://data.stats.gov.cn/easyquery.htm?cn=C01&zb=A0A01&sj=2023

3 https://www.gov.cn/zhengce/zhengceku/202305/co

4 https://mp.pdnews.cn/Pc/ArtInfoApi/article?id=30527068

and their own characteristics, this paper analyzes the heterogeneous impacts of APB on the inequality of farmers' incomes in terms of the natural resource endowment of each province and the types of APB in each province. This analysis helps to understand more deeply how the APB affects farmers' income growth and provides more detailed reference for the government to implement precise policies.

2 Theoretical analysis and characteristic facts

2.1 Theoretical analysis and research hypotheses

2.1.1 The impact of APB on farmers' income inequality

Brand premium theory suggests that brands can establish unique perceptions and values in the minds of consumers and shape consumer expectations of quality, trust and satisfaction with the product (Fatma and Khan, 2024). Agricultural products have multiple attributes such as experience goods and trust goods, and consumers are unable to have complete information about the products during the purchasing process, thus showing the information asymmetry between buyers and sellers in the agricultural products market (Winfree and McCluskey, 2005). Regional public brands can effectively convey market information about agricultural products (Zhang S. et al., 2024) and stimulate farmers' green production behavior, thus improving the quality of agricultural products (Zou et al., 2015). Consumers are willing to pay an additional value premium for high quality products (Odoom et al., 2024), which directly contributes to the income of farmers in the county (Zhang and Juan, 2014). In addition, RPBAP has government-certified brand logos, which enable consumers to easily distinguish them from ordinary agricultural products (Zhang et al., 2019). Consumers have higher recognition and stronger willingness to pay for agricultural products that are government certified and traceable (Bai et al., 2013). However, there are significant differences between different regions of China in terms of natural resource endowment and level of economic development. This leads to heterogeneity in the way local farmers operate RPBAP, with significant differences in their income growth and sources of income. Specific analyses are presented below:

On the one hand, APB rely on the advantages of specific geographic environments to produce and sell distinctive agricultural products through the cooperation of the government, enterprises and farmers, utilizing unique natural resources as well as planting, breeding, cultivation and processing technologies (Lin and Wang, 2023). Such unique agro-ecological and geographical conditions, representative varieties and regional cultural traditions give RPBAP a differentiated competitive advantage (Josling, 2006). Usually, well-known RPBAP are concentrated in regions with more developed economies and superior natural resource conditions (Qie et al., 2023). As a result, local farmers are more likely to receive a premium from brands. In areas with poorer natural resources, where the quality of products is relatively low (Xu et al., 2024), it is difficult for farmers to obtain the same brand premium effect, further exacerbating income disparities.

On the other hand, the development level of rural areas in China's counties lags, with a lack of industrial dynamics, a single structure, and a low level of economic development (Zhao, 2019). The establishment and promotion of RPBAP requires the investment of a large amount of resources such as capital, technology and market channels (Zhang S. et al., 2024), a process that cannot be separated from governmental support (Pasquinelli, 2014; Liu, 2017). However, compared to economically developed regions, governments in economically backward regions often find it difficult to bear the high costs of brand building and maintenance, and the lack of corresponding policy subsidies makes it difficult for enterprises in these regions to obtain the same market recognition and prices as those in developed regions. Based on this, this paper proposes Hypothesis 1.

> Hypothesis 1: The APB can help increase overall farmers' incomes but can exacerbate interregional inequalities in farmers' incomes.

2.1.2 The mechanism of APB on farmers' income inequality

The theory of technology diffusion suggests that technology diffusion is a process that passes between members of a society through a few channels at a specified time and that there are differences in the adoption of new technologies by different social groups (Rogers, 1964). To maintain brand image and ensure product quality, RPBAP who have been granted the right to use the brand to follow relevant production norms and codes of practice (Qian et al., 2024b). These quality standards help to promote vertical cooperation and knowledge sharing among enterprises in the supply chain and promote quality upgrading of the entire agricultural industry chain through technological spillover effects (Deselnicu et al., 2013).

On the one hand, the APB can promote agricultural production operators to increase investment in R&D of agricultural products, promote the progress of agricultural technology, and increase the total factor productivity of agriculture (Hummels and Klenow, 2005). However, there are significant differences in the process of technology diffusion among different farmers, especially those who are remote and unorganized, and who have difficulty in directly interfacing with modern agricultural technologies due to weaker knowledge of agricultural technologies (Yao et al., 2021).

On the other hand, the APB helps to integrate scattered farmers and enterprises under the leadership of leading enterprises, rapidly enhance regional competitive advantages, optimize the allocation efficiency and quality of agricultural production factors, and then promote industrial agglomeration and industrial integration within the region (Wilkinson et al., 2017). Such agglomeration and integration can promote the development of agricultural production and operation to scale, further promote technological progress and diffusion, and increase agricultural labor productivity (Wang et al., 2024). In counties where RPBAP has been established, farmers are usually able to obtain more advanced agricultural technology and market information support, thus increasing agricultural labor productivity (Qian et al., 2024a). In contrast, farmers in counties without established brands lack the same level of support, leading to a gradual widening of the productivity gap. Based on this, this paper proposes Hypothesis 2.

> Hypothesis 2: The APB exacerbates farmers' income inequality by expanding the agricultural technology adoption level, agricultural labor productivity among farmers.

2.2 Characteristic facts

This paper synthesizes and analyzes a dataset of *per capita* disposable income of farmers in 1986 counties in China from 2000 to 2021, and statistically describes the distribution of kernel densities of *per capita* disposable income of farmers in counties that have and do not have RPBAP in relation to the overall counties in the country. As Figure 1 illustrates, the income distribution of counties with constructed RPBAP tends to the right side of the national counties, whereas counties without brands tend to the left side, a trend that reveals a significant income gap between the two. On this basis, this paper will further explore the relationship between APB and farmers' income inequality in these two types of counties, as well as the deep-rooted causes of income inequality. The subsequent empirical analysis will be devoted to elucidating this association and attempting to answer how regional branding works on farmers' income disparity and the economic mechanisms behind it.

3 Materials and methods

3.1 Data

The data on national RPBAP used in this study come from the official website of the Ministry of Agriculture and Rural Development of the People's Republic of China.[5] Data on national-level poor counties are from the Government of the People's Republic of China website.[6] The data on the comprehensive demonstration policy of e-commerce into rural areas (CDERA) policy from 2014 to 2021 used in this paper are from the list of demonstration counties published on the website of the Ministry of Commerce of the People's Republic of China.[7] Social and economic data at the county level are obtained from the China County Statistical Yearbook, the China Rural Statistical Yearbook, and statistical yearbooks and bulletins of individual provinces, cities and counties. Together, they construct an unbalanced panel dataset covering 1986 county-level administrative units under 29 provinces, autonomous regions and municipalities in China over the period 2000–2021. Due to the lack of county-level disposable income data for rural residents in Shanghai, Tibet, and Hong Kong, Macao and Taiwan in the relevant years. Therefore, these regions are not included in the sample of this study. Table 1 demonstrates the definitions of the main variables and the results of the relevant descriptive statistics. Considering the inconsistency of inflation in different provinces and to eliminate the influence of price factors, this paper takes 2000 as the base period to adjust all variables measured in monetary terms according to the CPI of the province where they are located to obtain the real value level. In addition, to deal with the impact of outliers and extreme values in the sample on the estimation results, this paper winsorizes all continuous variables by 1%.

3.2 Model specification

This paper uses the Recentered Influence Function (RIF) proposed by Firpo et al. (2018) to analyze the impact of APB on farmers' income inequality in the county. Further, this paper provides insights into the various sources of variation in farmers' income inequality through the RIF decomposition method. Compared with ordinary least squares regression, RIF regression can effectively overcome the problem of endogeneity bias generated by omitted variables and obtain more robust estimation results. The defined expression of RIF regression is:

$$RIF\left\{y;v\left(F_Y\right)\right\}=v\left(F_Y\right)+IF\left(y;v\left(F_Y\right)\right) \tag{1}$$

where the statistic $v\left(F_y\right)$ represents a series of key indicators, including the level of farmers' incomes in the county (conditional mean) and the degree of inequality in farmers' incomes (interquartile range, Gini coefficient, variance and other statistical indicators). $IF\left(y;v\left(F_Y\right)\right)$ can measure the effect of a small change in observation y on $v\left(F_y\right)$. Thus, the RIF reflects the relative contribution of F_y to $v\left(F_y\right)$, given the original distributions F_y and $v\left(F_y\right)$.

In exploring the regression of APB affecting the overall farmers' income in the county, this paper uses the conditional means of the logarithm of the disposable income of rural residents in the county to measure the level of farmers' income. To accurately clarify the relationship between APB and farmers' income inequality, this paper quantifies farmers' income inequality by using different perspectives such as the interquartile range, Gini coefficient and variance of farmers' income level in the county. To test the robustness of the baseline regression results, the paper further conducts a series of robustness tests and uses the Interquartile ratio, Atkinson index and generalized entropy index to measure farmers' income inequality. Taking the Gini coefficient as an example, the formula is as follows:[8]

$$v^{gini}\left(F_Y\right)=1-\frac{2}{\mu}R\left(T\right) \tag{2}$$

Where $R\left(F_Y\right)=\int_0^1 GL_Y\left(p\right)dp, GL_Y\left(p\right)=\int_{-\infty}^{q\left(Y\left(p\right)\right)} ydF_Y\left(y\right).$

Therefore, to examine the relationship between APB and farmers' income inequality, this paper constructs the following model based on the RIF regression method:

$$RIF\left(\ln Rin_{it},v^{gini}\left(F_{\ln Rin_{it}}\right)\right)= \alpha_0+\alpha_1 CRPBAP_{it}+\alpha_2 X+\mu_i+\delta_t+\varepsilon_{it} \tag{3}$$

where subscripts i and t represent regions and years, respectively. $\ln Rin_{it}$ is an explanatory variable indicating the level of farmers' income in the county; $v^{gini}\left(F_{\ln Rin_{it}}\right)$ is the Gini coefficient defined by $\ln Rin_{it}$ on the distribution function F, and c is the RIF constructed based on the Gini coefficient, which is used to measure the degree of inequality in farmers' income. $RIF\left(\ln Rin_{it},v^{gini}\left(F_{\ln Rin_{it}}\right)\right)$ is the RIF constructed based on

5 http://aboc.agri.cn/#/areaBrandList

6 https://www.gov.cn/gzdt/2012-03/19/content_2094524.htm

7 https://www.mofcom.gov.cn/index.html

8 The formulae for the measurement of interquartile distance and variance can be found in the appendix of Rios-Avila (2020) and are not listed here.

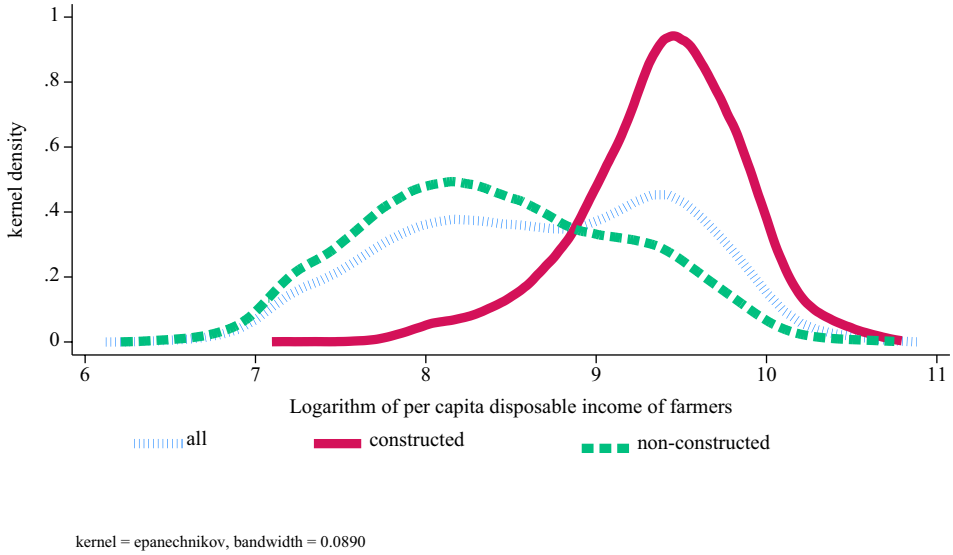

FIGURE 1
Logarithm of *per capita* disposable income of farmers in districts.

TABLE 1 Variable definitions and descriptive statistics.

Variables	Variable definition	Mean	Sd
Farmers' income level	Logarithm of *per capita* disposable income of farmers (yuan/capital)	8.432	0.691
CRPBAP	County build a RABAP county in that year = 1, otherwise = 0	0.272	0.445
Financial development level	Year-end loan balance of financial institutions/GDP	0.613	0.363
Regional industrial structure	Value added of the primary industry/GDP	0.232	0.131
Human capital level	Number of students in school/total county population	0.054	0.017
Social welfare level	Logarithm of number of beds in social welfare adoptive units (number)	6.296	1.434
Consumption level	Gross retail sales of consumer goods/GDP	0.318	0.123
Infrastructure level	Logarithm of the number of fixed telephone subscribers (number)	10.55	1.100
National-level poor counties	County is a National-level poor counties in that year = 1; otherwise = 0	0.104	0.306
CDERA	County is a CDERA in that year = 1; otherwise = 0	0.127	0.333

The variable CRPBAP denotes the construction of regional public brands for agricultural products; the variable CDERA denotes the comprehensive demonstration of e-commerce in rural areas policy.

the Gini coefficient to measure farmers' income inequality. The variable Construction of Regional Public Brands for Agricultural Products (CRPBAP) denotes the core explanatory variable, which takes the value of 1 in the year the county builds the RPBAP and in subsequent years, otherwise the variable takes the value of 0. X is the control variable. μ_i, δ_t and ε_{it} denote county fixed effects, time fixed effects, and error terms, respectively. The relationship between APB and farmers' income inequality is judged according to the significance level of α_1. If α_1 is significantly >0, it means that APB has widened farmers' income inequality; if α_1 is significantly <0, it means that the has narrowed farmers' income inequality.

3.3 Variables definition and descriptive statistics

3.3.1 Dependent variable

Farmers' income level. In this paper, we refer to the study of Chen et al. (2024) and use the logarithmic measure of disposable income of rural residents. To eliminate the influence of the price factor, this paper transforms the level of farmers' income according to the CPI of the province they belong to into comparable prices with 2000 as the base period. The dependent variable in this paper is the conditional mean and Gini coefficient of farmers' incomes in the county, based on the measured level of farmers' incomes, using Equation 1 and Equation 2, to explore the impact of APB on farmers' overall incomes and the inequality of incomes within farmers.

3.3.2 Explanatory variable

Construction of regional public brands for agricultural products. Referring to existing studies (Qian et al., 2024a; Zhang Z. et al., 2024), if a county has constructed an RPBAP, the variable takes the value of 1, otherwise it takes the value of 0. A total of 1,413 counties in the 2000–2021 sample selected for this paper have constructed RPBAP, including grain, cash crops, livestock products, and aquatic products.

3.3.3 Control variables

To avoid endogeneity problems due to omitted variables and to clarify the impact of APB on farmers' income inequality, this paper controls for all factors affecting APB and farmers' income inequality as much as possible. Referring to related studies (Qie et al., 2023; Chen et al., 2024; Hua et al., 2024; Zhang Z. et al., 2024; Zhang S. et al., 2024), the following control variables are selected in this paper: the financial development level, regional industrial structure, human capital level, consumption level, social welfare level, and infrastructure level. In addition, to exclude the impact of relevant policies implemented during the same period on farmers' incomes, the paper also controls for national-level poor counties and the Comprehensive Demonstration of E-commerce in Rural Areas policy.

4 Results

4.1 Benchmark regression

Column (1) of Table 2 shows the regression results of the conditional means of the impact of APB on farmers' income. The results show that the coefficient of variable CRPBAP is significantly positive at the 1% level, which indicates that the APB can contribute to the growth of farmers' income in the county. Columns (2–4) show the regression results of different interquartile range measures of farmers' income inequality, and the coefficients of variable CRPBAP are all significantly positive at the 1% level, suggesting that the APB has widened the income gap between high-income and low-income farmers, thus exacerbating the inequality of farmers' income. To measure the relationship between APB and farmers' income inequality from multiple perspectives, this paper continues to include the Gini coefficient and variance of the logarithm of farmers' income as explanatory variables. The results are shown in columns (5, 6), and the coefficient of CRPBAP is still significantly positive at the 1% level. This shows that the APB exacerbates the inequality of farmers' income.

In addition, the financial development level, regional industrial structure, consumption level, social welfare level, human capital level, infrastructure level, national-level poverty county, and CAERA are also important factors affecting farmers' income inequality. Among them, the financial development level, regional industrial structure, and consumption level significantly exacerbate the inequality of farmers' incomes. This is mainly due to the limited number of agricultural financial institutions in rural areas and the higher operating costs that the former must bear, which results in financial institutions being more inclined to serve middle- and

TABLE 2 Benchmark regression results of APB on farmers' income inequality.

	Interquartile range					
	Mean	90–10	80–20	75–25	Gini	Var
	(1)	(2)	(3)	(4)	(5)	(6)
CRPBAP	0.016***	0.055***	0.076***	0.082***	0.004***	0.036***
	(0.002)	(0.020)	(0.019)	(0.018)	(0.001)	(0.007)
Financial development level	−0.044***	0.308***	0.299***	0.253***	0.025***	0.218***
	(0.004)	(0.032)	(0.027)	(0.024)	(0.002)	(0.014)
Regional industrial structure	−0.222***	1.904***	1.688***	1.369***	0.094***	0.710***
	(0.018)	(0.148)	(0.120)	(0.107)	(0.007)	(0.061)
Consumption level	−0.167***	0.678***	0.186**	0.200***	0.036***	0.301***
	(0.011)	(0.101)	(0.084)	(0.076)	(0.004)	(0.037)
Social welfare level	0.008***	−0.079***	−0.065***	−0.051***	−0.003***	−0.024***
	(0.001)	(0.010)	(0.009)	(0.008)	(0.000)	(0.003)
Human capital level	0.838***	−10.040***	−5.405***	−2.978***	−0.462***	−4.119***
	(0.066)	(0.576)	(0.480)	(0.441)	(0.025)	(0.221)
Infrastructure level	0.013***	−0.069***	0.016	0.029**	−0.002**	−0.014**
	(0.002)	(0.016)	(0.014)	(0.013)	(0.001)	(0.006)
National-level poor counties	0.050***	−1.221***	−1.578***	−1.679***	−0.084***	−0.711***
	(0.003)	(0.023)	(0.021)	(0.021)	(0.001)	(0.009)
CDERA	0.055***	−1.101***	−0.959***	−0.779***	−0.055***	−0.458***
	(0.003)	(0.027)	(0.024)	(0.022)	(0.001)	(0.012)
Year fixed effects	Y	Y	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y	Y	Y
N	35,668	35,668	35,668	35,668	35,668	35,668
R^2	0.973	0.392	0.383	0.371	0.582	0.536

*, **, and *** indicate that the estimates are significant at the 10, 5, and 1% levels, respectively; robust standard errors are in parentheses; fixed effects include county and year fixed effects.

high-income groups, while barriers to accessing financial services tend to be higher for vulnerable groups (Lian et al., 2023), thus widening the gap in farmers' incomes. As consumption levels rise, consumer preferences are skewed toward higher-quality agricultural products (Fatma and Khan, 2024). This has resulted in greater benefits for farmers who are able to provide high-quality agricultural products, while smallholder farmers competing in traditional low-end markets may be at risk of being priced out, resulting in a further decline in incomes. When the share of value added of the primary industry increases, it often means that agriculture or the exploitation of natural resources occupies a larger share of the economy. This leads to a greater concentration of resources and profits in the hands of large agribusinesses or a few farmers who own the resources, while small farmers have limited access to returns due to a lack of capital and technical support (He et al., 2024), thus exacerbating farmers' income inequality. The social welfare level, human capital level, infrastructure level, national-level poverty county, and CAERA significantly suppress farmers' income inequality. Therefore, the government should provide more services and support to poor farmers through social welfare policies and strengthen the infrastructure level, which can help to reduce the income gap. At the same time, the human capital level of farmers should be improved, and their skills and knowledge should be upgraded through education and training, which will help to increase productivity and income levels.

4.2 Robustness check

To further verify the accuracy of the benchmark regression results, this paper conducts a series of robustness tests. This paper focuses on the relationship between APB and farmers' income inequality. Therefore, the robustness test part is also dominated by farmers' income inequality. In addition, due to space constraints, the subsequent studies mainly use the Gini coefficient of income as the explanatory variable. The reason for this is that the Gini coefficient, which is a widely used measure of group income inequality (Chen et al., 1982), is more sensitive to changes in middle-income groups.

4.2.1 Replacement of dependent variables

In addition to the Gini coefficient, the interquartile ratio, the Atkinson Index, and the Generalized Entropy Index are also relative indicators commonly used to measure income inequality (Wang and Gao, 2018). Therefore, we take the above three metrics as explanatory variables to test the robustness of the benchmark regression results. The results in columns (1–3) of Table 3 show that the coefficients of APB are significantly positive at the 1% level regardless of the measure used. This suggests that the APB exacerbates the inequality of farmers' incomes, and the basic conclusion of the paper remains unchanged.

4.2.2 Replacement of explanatory variables

Since more than one RPBAP exists in some counties, we regress the sample data on the level of RPBAP development as measured by the number of RPBAP constructed. The results obtained are shown in column (4) of Table 3, where the coefficients of the core explanatory variables are significantly positive at the 1% level and the basic conclusions of the paper remain unchanged.

4.2.3 Sample processing

First, the sample interval is shortened. China completely canceled the agricultural tax in 2006; to avoid the impact of the cancelation of agricultural tax on the inequality of farmers' income, this paper retains the data after 2006 and re-runs the regression. Second, the sample is re-adjusted. Considering Beijing, Tianjin and Chongqing as municipalities directly under the central government, they have both the attributes of provincial-level administrative units and the functions of municipal-level administrative units, which gives them a unique status and governance system. The districts and counties under these municipalities differ significantly from other conventional county-level administrative regions in terms of their governance structures and functions, which may have an impact on the robustness of the regression analyses. For this reason, this paper chooses to exclude the data from Beijing, Tianjin and Chongqing and re-regress the remaining data in the regression analysis. The regression results are displayed in columns (5, 6) of Table 3, and the coefficients of APB are significantly positive at the 1% level regardless of how the samples are treated. The basic conclusion of the paper remains unchanged.

TABLE 3 Results of robustness test of APB on farmers' income inequality.

	Interquartile ratio	Atkinson	Entropy	Gini		
	(1)	(2)	(3)	(4)	(5)	(6)
CRPBAP	0.025**	0.001***	0.001***		0.002*	0.004***
	(0.011)	(0.000)	(0.000)		(0.001)	(0.001)
RPBAP development level				0.002***		
				(0.000)		
Control variables	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y	Y	Y
N	35,668	35,668	35,668	35,668	27,365	34,847
R^2	0.460	0.522	0.487	0.498	0.525	0.498

*, **, and *** indicate that the estimates are significant at the 10, 5, and 1% levels, respectively; robust standard errors are in parentheses; fixed effects include county and year fixed effects; control variables are consistent with the baseline regression.

4.3 Mechanism analysis

The theoretical analysis in the previous section shows that the APB exacerbates farmers' income inequality by widening the gap between counties in terms of the level of agricultural technology adoption and agricultural labor productivity. To test these two mechanisms, this paper draws on the study of Chen et al. (2020) and mainly explores the impact of explanatory variables on mechanism variables. The specific analyses are as follows.

Drawing on the study of Xu (2023), this paper uses the total power of agricultural machinery and the number of employees in agriculture, forestry, livestock and fisheries to measure the level of agricultural technology adoption; at the same time, it uses the value-added of the primary industry and the number of employees in agriculture, forestry, livestock and fisheries to measure the productivity of agricultural labor. The results in columns (1, 2) of Table 4 show that the APB promotes the level of agricultural technology adoption in counties but exacerbates the gap in the level of agricultural technology adoption among counties. The results in columns (3, 4) show that the APB promotes agricultural labor productivity but exacerbates the gap in agricultural labor productivity between counties.

TABLE 4 Results of mechanism test of APB on farmers' income inequality.

	Agricultural technology adoption level		Agricultural labor productivity	
	Mean	Gini	Mean	Gini
	(1)	(2)	(3)	(4)
CRPBAP	0.259***	0.022*	0.519***	0.170***
	(0.095)	(0.013)	(0.863)	(0.029)
Control variables	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y
N	23,061	23,061	23,162	23,162
R^2	0.856	0.828	0.738	0.676

*, **, and *** indicate that the estimates are significant at the 10, 5, and 1% levels, respectively; robust standard errors are in parentheses; fixed effects include county and year fixed effects; control variables are consistent with the baseline regression.

4.4 Heterogeneity analysis

4.4.1 Heterogeneity of regional agricultural resource

China is a vast country with significant differences in natural resource endowments, agricultural infrastructure and technology levels in different regions, and these differences may lead to differences in the impact of APB on farmers' income inequality. Therefore, this paper introduces an interaction term between the agricultural province (AP) and variable CRPBAP based on Equation 3. The value of the variable takes the value of 1 if the proportion of value added of primary industry in GDP of each province is higher than the median, and 0 otherwise.

The results in column (1) of Table 5 show that the coefficient of CRPBAP is significantly positive at the 1% level, the coefficient of the interaction term is significantly negative at the 1% level, and the value of the coefficient of the interaction term is greater than the value of the coefficient of CRPBAP. This suggests that the APB in agricultural provinces helps to curb farmers' income inequality compared to non-agricultural provinces.

4.4.2 Heterogeneity of RPBAP species

Since RPBAP can be broadly classified into four categories: grain, cash crops, livestock products, and aquatic products, each of which has different growing environments and product characteristics, its effect on increasing the income of farmers in different income groups may be different. Therefore, with reference to Li C. et al. (2024), we divide RPBAP into the four categories mentioned above, and tests whether there is a significant difference in the impact of each category of APB on the inequality of farmers' incomes, respectively, and the results are shown in columns (2–5) of Table 5. The coefficient of APB in the grain category is significantly negative at 1% level, the coefficient of APB in the cash crops and aquaculture categories is significantly positive at 1% level and the coefficient of APB in the livestock category is not significant. This shows that APB in the grain category suppresses farmers' income inequality, APB in the cash crop and aquaculture categories exacerbates farmers' income inequality, and APB in the livestock category does not have a significant effect on farmers' income inequality.

TABLE 5 Results of heterogeneity analysis of APB on farmers' income inequality.

	Gini				
	(1)	(2)	(3)	(4)	(5)
CRPBAP	0.014***				
	(0.001)				
AP×CRPBAP	−0.021***				
	(0.001)				
Grain		−0.019***			
		(0.002)			
Cash crop			0.004***		
			(0.001)		
Livestock				0.001	
				(0.001)	
Aquatic					0.044***
					(0.002)
Control variables	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y	Y
N	35,668	35,668	35,668	35,668	35,668
R^2	0.596	0.584	0.582	0.582	0.589

*, **, and *** indicate that the estimates are significant at the 10, 5, and 1% levels, respectively; robust standard errors are in parentheses; fixed effects include county and year fixed effects; control variables are consistent with the baseline regression.

5 Discussion

5.1 New findings in comparison with previous studies

The APB is an important factor in promoting the development of the agricultural economy, an important means of helping the rural population to escape from poverty, and an important guarantee for the revitalization of the countryside. The results of this paper show that the APB significantly improves the level of farmers' income, which is consistent with the findings of related studies (Ma and Qiao, 2024; Li C. et al., 2024; Yin et al., 2024; Qie et al., 2024b). This indicates that the APB can realize the growth of farmers' income by improving the level of agricultural technology and agricultural labor productivity (Qian et al., 2024a; Li C. et al., 2024), enhancing the quality of agricultural products and brand premium. However, the results also revealed some inconsistencies.

First, Huang et al. (2023) argue that focusing on the value distribution chain and improving the distribution method when the APB can help to reduce the rural income gap. However, based on the findings of this paper, the APB has exacerbated income inequality among farmers. This situation may be caused by two main aspects.

On the one hand, there are significant differences in the resource endowments of China's regions, leading to uneven levels of development of RPBAP (Xu et al., 2024), and thus varying degrees of impact on farmers' incomes for different brands (Li G. et al., 2024). Agricultural provinces have a more favorable natural ecological environment, and agricultural products produced in such places are of high yield and quality (Liu, 2024), which make them more competitive in the market and enable them to obtain better prices in the market, thus contributing more to the increase in the sales income of farmers. In addition, the richer the regional and industrial resources, the more willing the government will be to adopt proactive development policies, provide better technical and personnel maintenance, and develop a more comprehensive system of standardization, quality and safety regulation, and after-sales service (Xu et al., 2024). On the contrary, in non-agricultural provinces, where agricultural products are produced on a smaller scale and have a limited market share, the APB may not be effective in improving the competitiveness and price of the products.

On the other hand, due to the differences in the types of agricultural products, the impact of APB on farmers' income shows obvious heterogeneity (Li C. et al., 2024). First, demand for food is stable, prices are less volatile and less risky than for other agricultural products (Qie et al., 2023), and the advantages of branding can increase market recognition and price premiums for grain and enhance the market bargaining power of small-scale farmers. Second, compared to grain crops, prices of cash crops are usually more affected by international markets, seasonal demand and changes in consumer preferences (Ma et al., 2022), and are more volatile. Small-scale farmers often have insufficient capital to undertake large-scale storage, transportation or processing to cope with the risks associated with price volatility. Again, fresh aquatics are more perishable than processed products, resulting in a short distribution radius and high transportation costs (Yang et al., 2016). Farmers who lack the relevant conservation techniques or management skills may not be able to take full advantage of the market opportunities offered by the brand, while those with stronger technical skills will be able to reap more benefits. Finally, prices of livestock agricultural products are susceptible to a variety of factors such as market supply and demand, disease, and climate (Hua et al., 2024), which can lead to instability in farmers' incomes even with a brand name.

Second, Ding et al. (2011) argue that since the adoption of new technologies by low-income farmers is roughly comparable to that of high-income farmers, the adoption of new technologies has a relatively small impact on farmers' income inequality. Otitoju et al. (2023) argue that technological advances in agriculture can improve productivity and efficiency and significantly reduce labor requirements, thereby reducing income disparities within the agricultural sector. In addition, the findings of Ma and Kong (2019) show that agricultural technological progress widens inter-regional farmers' income inequality. This is consistent with the findings of this paper. The main reasons are as follows:

On the one hand, as a quasi-public good, a RPBAP determines that the realization of its long-term stable income requires the common maintenance of the production main body (Qian et al., 2024a). To ensure the production of green agricultural products, local administrators need to train business owners in agricultural production techniques and codes of conduct (Li and Pan, 2024). Without government support, it is difficult to realize the effective development of RPBAP (Geng et al., 2023). However, administrative support is often difficult to implement due to the lack of financial support from local governments, especially in less economically developed regions. This has significantly weakened the technological capacity of farmers in these areas and slowed down their mastery and application of new production technologies.

On the other hand, in the process of promoting the branding of agricultural products, the resource endowments driving the development of regional brands are mainly divided into three categories: brand reputation, financial support and technical factors (Xiong and Xing, 2017). China's county rural areas are lagging in their level of development, with a lack of industrial dynamics, a single structure, and backward infrastructure (Zhao, 2019). The distribution of these resource endowments among regions is extremely uneven, and economically developed regions usually have access to more financial and technical support, which gives them an advantage in brand building (Xu et al., 2024). On the contrary, the relative economic backwardness of the region, due to the shortage of resources, makes it difficult to form an effective brand, leading to slow technological progress and further increasing the inter-regional gap.

5.2 Policy implications

Based on the above findings, we draw the following policy implications: First, strengthen training in agricultural technology. In view of the large differences in the level of agricultural technology adoption, the government should increase technical training and education for farmers, especially in poor areas, to help them improve agricultural production technology, to improve the overall agricultural

labor productivity. Develop diversified brand participation channels so that more farmers can participate in and profit from branding. Increase the capacity and confidence of farmers to participate in branding through education and training. Second, promote coordinated regional development. In the APB, the exchange of experience and cooperation between agricultural and non-agricultural provinces is encouraged to promote coordinated inter-regional development, especially in the upgrading of infrastructure and public services, to enhance the overall rural economy. At the same time, cooperative programs should be established between less developed regions to share successful experiences and resources and to balance the pace of agricultural development between regions. Third, differentiated policy support. Differentiated policy measures should be developed for different types of agricultural production, such as grain, cash crops and aquaculture products. For example, more support and subsidies should be given in grain production, while in cash crops and aquaculture products, support for small farmers needs to be strengthened to prevent the increase in income inequality due to market price fluctuations. Finally, data and monitoring systems should be strengthened to continuously track the income distribution effects of the construction of an income tax sharing system for urban and rural residents, and strategies should be adjusted accordingly to ensure that the benefits of the RPBAP are equitably distributed to all participants, especially disadvantaged groups. For farmers involved in branded agriculture, a benefit-sharing mechanism should be established to ensure that farmers share in the economic benefits of brand premiums.

5.3 Limitations

The limitations of the research in this paper are that the data used are macro data at the county level. On the one hand, this can only explore the impact of APB on farmers' income inequality between regions, and there is no way to know about the income inequality between farmers. On the other hand, there is a lack of data indicators at the county level on inputs, technology adoption and revenue from direct products of regional public brands, making it difficult to analyze in detail the development and construction of RPBAP. To address this limitation, in future research, data will be collected by means of field research and other means to explore the impact of APB on income inequality among farmers.

6 Conclusion

In the current context of frequent occurrence of extreme weather and deteriorating ecological environment, the problem of farmers' income inequality is becoming more and more serious, and it is particularly important to explore effective paths to curb farmers' income inequality. This paper examines the impact of APB on farmers' income inequality and its mechanism of action using RIF regression based on data from 1986 counties in China from 2000 to 2021. The conclusions of the study are as follows: first, the results of the study show that while APB boosted farmers' incomes by an average of 1.6%, they exacerbated farmers' income inequality by an average of 0.4% (using the Gini coefficient as an example). Second, mechanistic analysis shows that the APB exacerbates farmers' income inequality by widening interregional disparities in the level of agricultural technology adoption and agricultural labor productivity. Third, heterogeneity analysis shows that the APB in large agricultural provinces helps to curb farmers' income inequality compared to non-agricultural provinces; APB in the grain category suppresses farmers' income inequality, APB in the cash crop and aquatic product categories exacerbates farmers' income inequality, while APB in the livestock category does not have a significant effect on farmers' income inequality.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://www.stats.gov.cn/. Further details of the data that support the findings of this study are available from the corresponding author upon reasonable request.

Author contributions

JZ: Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. GL: Writing – review & editing, Visualization, Funding acquisition.

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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.

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