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# Effects of Land and Labor Costs Growth on Agricultural Product Prices and Farmers' Income

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**Abstract:** Widespread attention has been paid to the continuous rounds of rising agricultural product prices in China since 2003. During this period, rising prices were affected by input costs and international market prices; therefore, the degree of benefits obtained by farmers from the rise in agricultural product prices has been questioned. However, limited studies have examined the effect and relationship between rising agricultural product prices and farmers' income. The purpose of the study was to provide empirical evidence on how the rise in agricultural product prices affects farmers' income and to understand the role of land and labor costs in this context using provincial data from 2003 to 2020. The findings reveal that there is a threshold effect on the impact of the rise in agricultural product prices on farmers' income. A moderate rise in agricultural product prices can increase farmers' income, but excessive price increases have an insignificant effect. The causes behind the price rise significantly influence farmers' income. An increase attributed to higher land and labor costs can improve farmers' income, whereas a rise driven by international market prices or the cost of agricultural production inputs is unlikely to benefit farmers.

**Keywords:** agricultural product prices; farmers' income; land cost; labor cost

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## 1. Introduction

Agricultural product prices, which are a crucial aspect of the Chinese national economy and the livelihood of a large proportion of the population, are an important policymaking consideration for the government to understand and guide agricultural economic development and formulate relevant macroeconomic policies. The government exercised control over agricultural product prices for a long period following the founding of the People's Republic of China, and early price fluctuations of agricultural products were more government-oriented. After the reform and opening-up, price control of agricultural products was gradually loosened as China transitioned from a planned economy to a market economy, and the influence of market supply and demand factors in price fluctuations gradually became prominent, particularly with the promotion of market-oriented price reform in 1992 [1]. After the millennium, a trend in agricultural product prices rising rapidly emerged beginning in 2003, accompanied by China's new round cycle of economic upturn. The producer price index for agricultural products reached nearly 120% in 2007 and 2008 after the price fell in a short time, and market disruptions caused by a rapid rise in agricultural product prices also occurred in 2010 and 2011. The agricultural product prices started to fall after 2011 at a low level across the country and even underwent negative growth in 2017 and 2018. However, the price of agricultural products rose rapidly in 2019, which is attributable to the African swine fever and the COVID-19 pandemic, and the producer price index for agricultural products reached 115% in 2020. Agricultural product price fluctuation remained steady until 2021 (Figure 1).

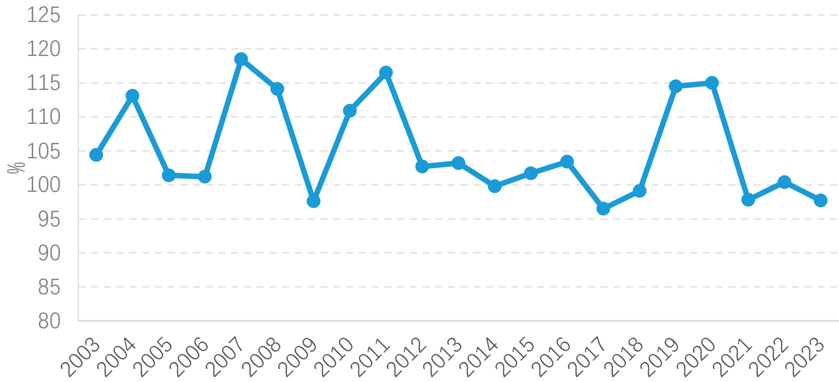


**Figure 1.** Changes in the producer price index for agricultural products (2003–2023). Data source: China Statistical Yearbook.

Agricultural products' price fluctuation causes a series of chain reactions that can change farmers' welfare. There is a classic phenomenon named "cheap grain harms peasants". It means that when agricultural product prices fall, the decrease in prices will exceed the increase in agricultural product demand in terms of the small price elasticity of demand for agricultural products. So, it will reduce farmers' income. Lots of studies confirm this viewpoint. Existing studies have primarily focused on the impact of rising food prices on farmers' poverty status. Theoretically, the rise in food prices can improve farmers' income when farmers produce grain [2]; however, from the perspective of consumption welfare, rising food prices increase consumers' food expenditure, which decreases farmers' consumption welfare [3,4]. Most studies have found that increasing food prices intensify rural poverty because poor farmers are predominantly net food consumers [5–7]. Wright [8] and Brobakk [9] noted that primary agricultural products like grain are more sensitive to the short-term impact on distribution that occurs under the influence of agricultural products' financialization, and the rise in agricultural product prices is not necessarily transferred to farmers' production welfare, even aggravating poverty for some farmers [10,11]. The report of the 20th National Congress of the Communist Party of China (CPC) stated that "Chinese modernization is the modernization of common prosperity for all" and "the most challenging and arduous tasks we face in building a modern socialist China in all respects remain in our rural areas." Although rural residents' income has improved much in recent years, the considerable income disparity between urban and rural areas and farmers' relatively low income has become a primary obstacle to China's attainment of common prosperity for all. Previous research has examined various impact factors on farmers' income, such as digital economy development [12], land transfer [13], and financial development [14]. However, existing studies have not reached a consensus concerning how agricultural products' price fluctuation impacts farmers' income. One perspective is that the rising price of agricultural products cannot cause farmers' income to increase markedly due to its weak correlation [15,16] and can even decrease farmers' income and aggravate vicious competition between farmers due to frequent price fluctuation [17]. Another perspective is that the rise in agricultural products' price positively impacts farmers' income [18], but this impact is limited [19–22] due to a rise in the price of the means of agricultural production and the impact of input cost and international market price, among other external factors.

In the global context, agricultural product prices are influenced by a myriad of factors, including policy changes and geopolitical conflicts. For instance, the European Union's Common Agricultural Policy (CAP) has significantly shaped agricultural markets within its region. The CAP, with its various interventions and support mechanisms, has been a subject of interest for scholars examining price fluctuations and their impact on farmers' income. Studies such as those by Swinnen [23] and the International Monetary Fund [24] have highlighted how policy reforms within the CAP have led to adjustments in agricultural product prices, affecting not only European farmers but also global implications. More recently, the agricultural sector has been deeply impacted by geopolitical events. A poignant example is the war in Ukraine, a significant exporter of wheat and other grains. Since the onset of the conflict in early 2022, there has been a marked increase in global wheat prices due to supply disruptions and export limitations imposed by the warring parties. Research by the International Food Policy Research Institute indicates that such geopolitical shocks can lead to food price spikes with severe consequences for food security, particularly in import-dependent countries [25].

Agricultural product price volatility plays a significant role in farmers' income and the overall economic equilibrium. Therefore, it is crucial to clarify the relationship between agricultural products' price fluctuation and farmers' income in the new period. However, the data used in previous studies do not cover the current circumstances, and the conclusions may not apply to the present. The previous conclusions may no longer provide effective academic references, particularly in the context of China's current concentrated effort to promote common prosperity. In addition, most of the previous research has been limited to empirically examining the impact of agricultural product prices on farmers' income and has not explored the specific impact of agricultural products' price fluctuation driven by different causes on farmers' income in depth. In the past 20 years, the proportion of land expenses in agricultural production cost has increased significantly, becoming a new trend in agricultural production and management. The land cost for China's three staple crops rose by 262% from 2001 to 2020, increasing from 12% to 21% of the total production cost [26]. Meanwhile, the agricultural labor market underwent profound changes, with agricultural labor prices rising from CNY 12 per day to CNY 122 per day from 1998 to 2021, representing a 10-fold increase [27]. Land and labor costs have become significant driving forces of the rise in agricultural product prices, which may lead to changes in the impact of increasing agricultural product prices on farmers' income. Using provincial panel data from 2003 to 2020, this study further explored the heterogeneous impact of the rise in agricultural product prices driven by land and labor costs on farmers' income. The outline of the rest of the paper is as follows: Section 2 presents typical facts about changes in agricultural product prices and farmers' income. Section 3 constructs a theoretical model of how agricultural product prices affect farmers' income. In Section 4, empirical design, results and analysis are provided. Finally, we end the paper with conclusions and policy recommendations.

## 2. Typical Facts About Changes in Agricultural Product Prices and Farmers' Income

Profound changes have occurred in China's agriculture and rural areas since 2003 as a result of the reform and opening-up, and the driving forces of agricultural product price fluctuation considerably differ from those of the past. Meanwhile, farmers' income structure has changed as economic development entered a new stage.

### *2.1. Fluctuations in Agricultural Product Prices*

In the early years of reform and opening-up, China exerted control over the pricing system, especially agricultural product prices, and rises in the agricultural product prices were largely a result of the government's intervention [28]. However, a market-oriented pricing system was gradually established with successive lifting of price control in China, and the market mechanism played a more decisive role in price changes, which was applied to agricultural product prices [1]. China continuously adjusted the price control policy for agricultural product prices to support the reform of the pricing mechanism for agricultural products and to maintain the stability of farmers' income from grain growing [29]. The Chinese government explored policies that contribute to the interests of farmers, maintain agricultural product price stability, and promote the shift to a market-oriented pricing mechanism, implementing a series of policies covering price floors, temporary purchase and storage, target prices for agricultural products, direct subsidies, and market-oriented acquisition [30]. For example, China cut the price floor on rice across the board for the first time in 2017 and cut the price floor on rice and wheat in 2018 to alleviate the market distortions caused by the government's direct price intervention. The price floor on wheat was cut once more by 3 cents per half a kilogram in 2019 and was not raised until recently.

In terms of subsidy policies, pricing is market-based, with separate subsidies that are gradually shifting from indirect to direct subsidies, the price being left to the market to decide, and subsidies being separately determined by the government. Concerning market-oriented acquisition, multiple market entities related to the deep processing of corn, soybeans, and rice trade and reserves are encouraged and supported to participate in the acquisition, fully leveraging the market's decisive role in pricing and improving the pricing mechanism for agricultural products.

In this context, China's agricultural product prices have experienced several rounds of pronounced fluctuations since 2003, with considerable changes in market supply and demand. The rise in labor wages has been notable in those fluctuations, which has triggered a debate on whether China has now reached the Lewis turning point [31]. Mao and Liu [32] found that wages for household and hired labor in the grain production process have risen significantly, suggesting that the influence of rising wages in China's increasing agricultural product prices cannot be ignored. Figure 2 shows the growth rate of labor cost for grain production in China from 2003 to 2020. Labor costs also increased markedly from 2007 to 2008 and from 2010 to 2012, when agricultural product prices rose rapidly, reflecting an obvious increase in agricultural production labor cost that parallels the increasing price of agricultural products. In addition, the agricultural land cost in early China was not high, including a special phenomenon of zero rent [33,34]; however, land costs steadily increased since 2003, rising by about 20% in 2007 and 2008, as shown in Figure 2. Previous research has revealed that the growth rate of land cost has exceeded that of labor cost, becoming a significant driver of the rising total cost of agricultural production [35,36].

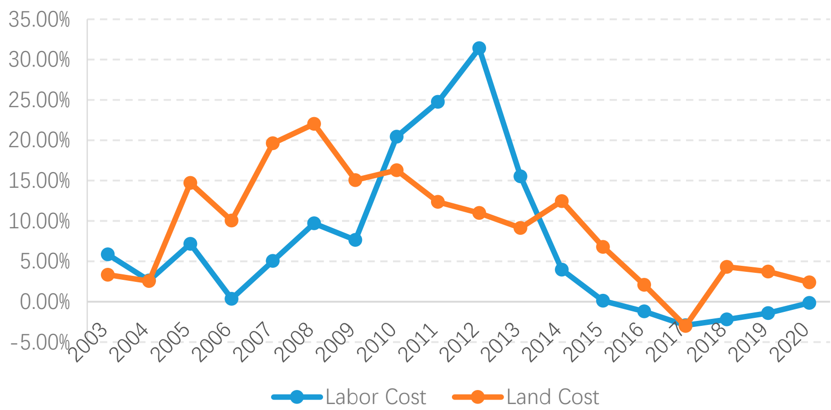


**Figure 2.** Changes in labor and land cost (2003–2023). Data source: China Statistical Yearbook, Forward Database.

Figure 3 presents the trajectory of producer prices for agricultural products and the price of the means of agricultural production from 2003 to 2020. The trajectories of the two are largely consistent, revealing a significant increase in the price of the means of agricultural production as the producer price for agricultural products rises. This is evident in the increase in the price of agricultural machinery, as well as the increase in the price of all feeds. For example, during the two rises in agricultural product prices in 2007–2008 and 2010–2012, the average price of mixed feeds rose to CNY 1.3 per half a kilogram in early 2008, representing a 41.3% increase from the beginning of 2007 and 62.5% from the beginning of 2006 [37], and feed price also increased by 8.3% in 2010 compared with 2009. This directly contributed to the increased price of the means of agricultural production. However, the increased price of the means of agricultural production primarily stems from rapid growth in demand. In particular, farmers are encouraged to plant agricultural products with the rise in agricultural product prices, which raises demand for the means of agricultural production, increasing its price [38,39]. The rise in the price of the means of agricultural production diminishes the effects of various preferential agricultural policies and affects farmers' actual interests.

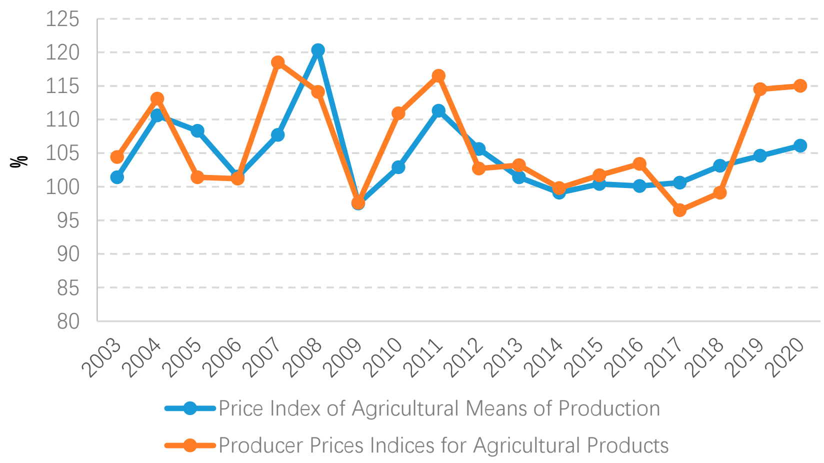


**Figure 3.** Changes in producer price indices for agricultural products and the price index of the means of agricultural production. Data source: China Statistical Yearbook.

In addition to labor cost, land cost, the price of means of agricultural production, and other domestic factors affecting agricultural product prices, changes in international agricultural product prices will also impact domestic agricultural product prices, particularly for China's enormous demand for soybeans, meat, and other agricultural imports. International agricultural product prices will have a direct impact on domestic agricultural product prices. Figure 4 demonstrates the relatively consistent trajectories of international food prices and domestic agricultural product prices. Significant increases in international food prices in 2007–2008, 2010–2011, and 2019–2020 coincide with periods of rapid increase in domestic agricultural product prices, suggesting that international food price has a significant impact on domestic agricultural product prices. It must be clarified that the impact of the international market on domestic agricultural product prices is not only reflected in imports but also realized through price transmission. As for the current global agricultural market, the United States (US) dollar is the main denominated currency for global commodities, and agricultural products are still priced and settled, referencing the US dollar. Some studies have demonstrated that China's agricultural product prices are sometimes detached or even inverted from international commodity prices [40], but theoretically, arbitrage will be triggered until the price difference is within a reasonable range if domestic and international prices differ widely. Therefore, a decline in international agricultural product prices will inevitably spill over to domestic agricultural product prices.

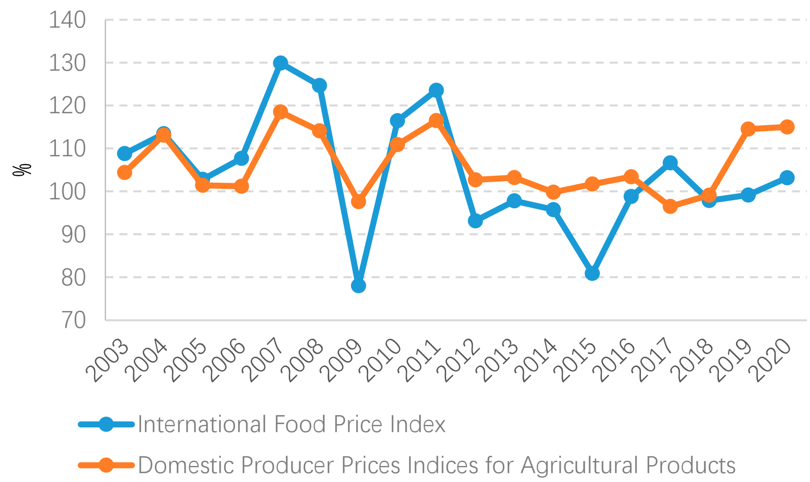


**Figure 4.** Changes in domestic producer price indices for agricultural products and the international food price index. Data source: China Statistical Yearbook, United Nations Food and Agriculture Organization.

*2.2. Trajectory of Farmers' Income*

China's economic growth miracle has attracted worldwide attention over the past 40 years of reform and opening-up. However, deep-rooted socioeconomic challenges have gradually emerged with rapid economic development, particularly the widening gap between urban and rural areas in the distribution of welfare, which has attracted considerable attention. A series of policies have been introduced to increase farmers' income and narrow the income gap between urban and rural areas. The State Council suspended the agriculture specialty tax other than that of tobacco leaf and issued the Opinions on Several Policies to Promote Farmers to Increase Income since 2003. In particular, General Secretary Xi Jinping proposed the idea of "targeted poverty alleviation" in 2013. The rural revitalization strategy was proposed for the first time in the report of the 19th National Congress of the CPC in 2017, which focused on solving the imbalance in development between urban and rural areas, with the primary goals of increasing farmers' income, production, and opportunities to acquire income through multiple channels, narrowing the income gap between urban and rural areas, and achieving common prosperity. Farmers' income increased significantly as a result. Figure 5 depicts the level and growth of rural residents' income in China since 2003. Farmers' per capita income entered a period of rapid growth after 2003, with a growth rate of more than 8%, as shown in Figure 5. Based on the data published on the website of the National Bureau of Statistics of China, rural residents' per capita disposable income in 2020 exceeded CNY 17,000, which was about eight times as much as that in 2003. This demonstrates that farmers' income also presents a trend of continuous improvement as China's economic development enters a new phase.

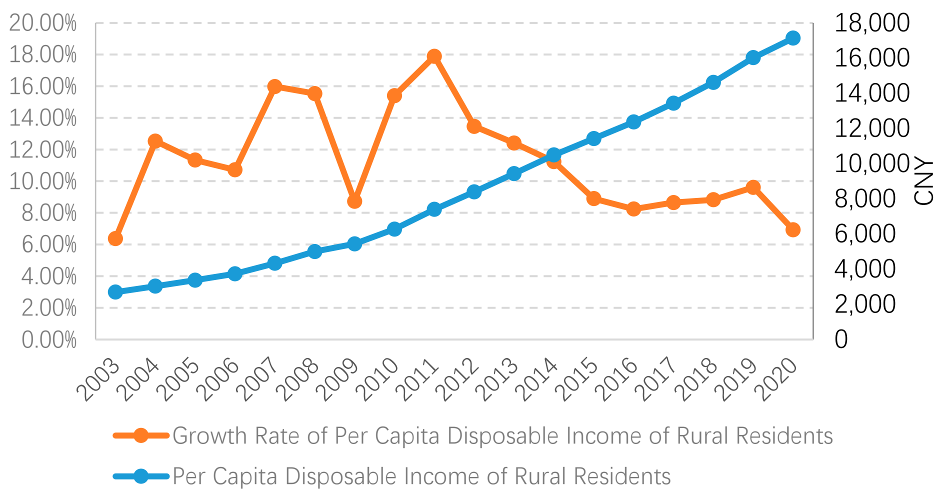


**Figure 5.** Rural residents' per capita disposable income and its growth rate. Data source: China Statistical Yearbook.

Moreover, in terms of income composition, rural residents have basically overcome previous over-reliance on agricultural business or business income, exhibiting a pattern of synergistic increase in income through multiple channels, including household business, salary, property, and transfer income. Table 1 presents the specific data and proportion of business, salary, property, and transfer income in the structure of farmers' income from 2003 to 2020. As shown in Table 1, business income was still the main component of farmers' income in 2004, accounting for 60%, but it has been declining since then, plummeting significantly to 35% by 2020. Correspondingly, salary income has increased dramatically. Rural residents' per capita salary income was only CNY 905 in 2003 but reached CNY 6974 in 2020, indicating a rise from 34% to 41% as the main part of farmers' income. Rural residents' transfer income has also grown, accounting for 21% of the total from less than 5%. In addition, the proportion of rural residents' property income has remained relatively stable, at around 2%.

**Table 1.** Rural residents' per capita disposable income composition.

| | Salary Income | | Business Income | | Property Income | | Transfer Income | |
|---|---|---|---|---|---|---|---|---|
| | Value (CNY) | Percentage | Value (CNY) | Percentage | Value (CNY) | Percentage | Value (CNY) | Percentage |
| 2003 | 905 | 34% | 1599 | 59% | 57 | 2% | 129 | 5% |
| 2004 | 980 | 32% | 1820 | 60% | 65 | 2% | 163 | 5% |
| 2005 | 1147 | 34% | 1931 | 57% | 73 | 2% | 219 | 6% |
| 2006 | 1336 | 36% | 2030 | 54% | 81 | 2% | 284 | 8% |
| 2007 | 1543 | 36% | 2315 | 54% | 100 | 2% | 368 | 9% |
| 2008 | 1766 | 35% | 2556 | 51% | 112 | 2% | 565 | 11% |
| 2009 | 1940 | 36% | 2643 | 49% | 122 | 2% | 729 | 13% |
| 2010 | 2278 | 36% | 2978 | 47% | 144 | 2% | 873 | 14% |
| 2011 | 2734 | 37% | 3367 | 46% | 157 | 2% | 1136 | 15% |
| 2012 | 3123 | 37% | 3660 | 44% | 165 | 2% | 1441 | 17% |
| 2013 | 3653 | 39% | 3935 | 42% | 195 | 2% | 1648 | 17% |
| 2014 | 4152 | 40% | 4237 | 40% | 222 | 2% | 1877 | 18% |
| 2015 | 4600 | 40% | 4504 | 39% | 252 | 2% | 2066 | 18% |
| 2016 | 5022 | 41% | 4741 | 38% | 272 | 2% | 2328 | 19% |
| 2017 | 5498 | 41% | 5028 | 37% | 303 | 2% | 2603 | 19% |
| 2018 | 5996 | 41% | 5358 | 37% | 342 | 2% | 2920 | 20% |
| 2019 | 6583 | 41% | 5762 | 36% | 377 | 2% | 3298 | 21% |
| 2020 | 6974 | 41% | 6077 | 35% | 419 | 2% | 3661 | 21% |

### *2.3. The Trajectory of Farmers' Income with Fluctuating Agricultural Product Prices*

The strategy of prioritizing heavy industry development was established after the founding of the People's Republic of China. However, heavy industry is capital-intensive and characterized by a long construction period, slow profitability, and low labor force absorption [25]. Therefore, it was necessary to subsidize heavy industry development by lowering the price of products from light industry and agriculture by implementing price controls. These controls have decreased agricultural product prices and raised industrial product prices, which had an inevitable impact on farmers' income and income distribution between urban and rural areas [1]. This impact manifests direct and indirect effects. For the direct impact, agricultural product producers are predominantly rural residents, while most of the beneficiaries of industrial product production are urban residents. Therefore, lowering agricultural product prices and supporting rising industrial product prices will directly reduce rural residents' welfare and increase urban residents' welfare, exacerbating urban–rural income distribution. In terms of indirect impact, decreased agricultural product prices, coupled with the inherent weakness of agriculture, squeeze profit margins in agricultural production and lack effective incentives to absorb agricultural capital. In contrast to agricultural products, increased industrial product prices have attracted an enormous inflow of capital into industrial production, which has triggered disparity in industrial and agricultural investment. Moreover, unbalanced growth of investment in agriculture and industry can also lead to significant differences in productivity between the two sectors [32]. The rationale for this is that technological progress often requires large capital investments for developing countries [41], and differences in agricultural and industrial investment endogenize the productivity disparity between the two sectors. As a result, decreasing the agricultural product prices further worsens the rural–urban income distribution through this indirect mechanism.

The industrial and agricultural pricing system began to change gradually after the reform and opening-up, particularly with the implementation of the market-oriented reform established in China in the 1990s. The government's approach to controlling agricultural product prices also changed from direct administrative intervention to indirect control. In this context, China's agricultural product prices fluctuated many times due to changes in market supply and demand. The agricultural product prices have increased in most years since 2003, except in the middle and late 1990s when the price of agricultural products, including grain, declined due to a large increase in grain production that led to supply exceeding demand [29]. To clearly reflect the impact of agricultural product price fluctuation on the farmers' income, we examined this dynamic relationship below. Figure 6 uses quarterly data to illustrate the trends in rural residents' income and producer prices for agricultural products from 2003 to 2012, a period of frequent fluctuations in agricultural product prices in China. The trends of farmers' per capita business and disposable income and producer price for agricultural products closely mirror one another for most of the time. In other words, farmers' income generally exhibits a similar trajectory in years when producer prices for agricultural products rose or fell. However, Figure 6 shows that the growth rate of farmers' business and per capita disposable income in some years declined when producer prices for agricultural products rose sharply, such as in the fourth quarter of 2007. Farmers' income did not grow as fast as it should have from the first quarter to the third quarter of 2011, despite the sharp rise in producers' prices for agricultural products. This reflects a possible detachment of agricultural producer price from farmers' income at certain times that may be attributable to the increasing complexity of the causes of agricultural price fluctuations.

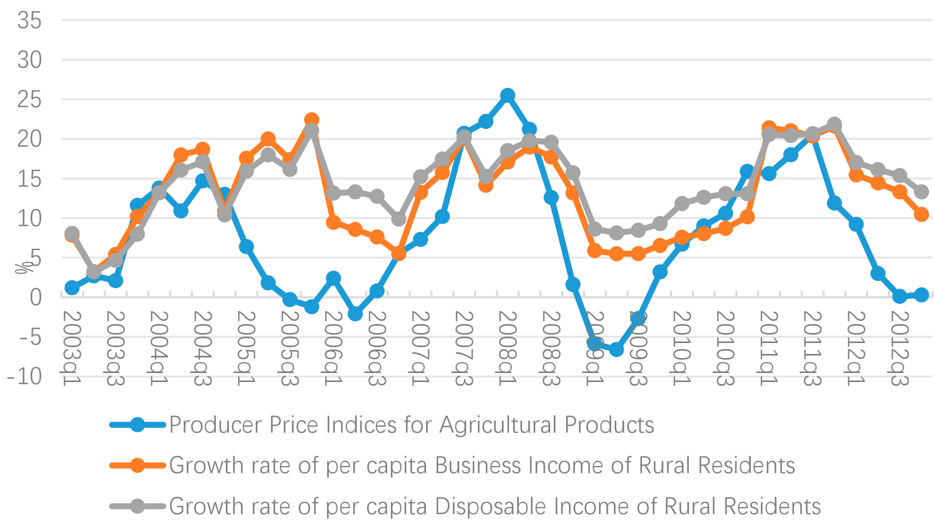


**Figure 6.** Changes in rural residents' income in relation to fluctuations of producer price for agricultural products. Data source: National Bureau of Statistics of China.

## 3. Construction of Theoretical Models and Design of Econometric Model

### *3.1. Construction of Theoretical Models*

Based on the theoretical construction of neoclassical economics and referencing Wu [42], this study considered farmers to be economic actors who rationally allocate resources to maximize their incomes when facing fluctuating agricultural product prices. We assumed that the household economic activities of farmers are categorized into agricultural production and non-agricultural production. Agricultural production includes the production of agricultural products to satisfy basic household needs and the production of surplus agricultural products for sale, while non-agricultural production only considers the production of migrant farmers. Moreover, we assume that farmers seek to maximize short-term income in the absence of pronounced technological progress, and farm households' income comes from agricultural sales, migrant work, and government subsidies.

Subsidies are determined based on area and sales, as China tends to subsidize agricultural products. $L\sigma_1$ represents the subsidized income acquired by farmers based on the planting area, which is determined by multiplying the average subsidy per area ($\sigma_1$), referencing farmers' actual planting area ($L$). $Q\sigma_2$ represents the subsidized income acquired by farmers based on sales, which is determined by multiplying subsidy ($\sigma_2$) with sales ($Q$). Sales reference the amount of production. The objective function of maximizing farmers' net household income is to maximize income from agricultural production income minus production cost, plus subsidy income and net non-agricultural income as follows:

$$\begin{aligned} Max\Pi &= L\sigma_1 + Q\sigma_2 + PQ \\ &-(W_L L + W_H H + W_K K) + \delta W_n H_n + R_n, \end{aligned} \quad (1)$$

where $\Pi$ is the farmer's net household income, and $L$, $H$, and $K$ represent land, labor, and production capital inputs in agricultural production, respectively. $W_L$ is the contracting fee per unit area of land, $W_H$ is the agricultural labor wage, $W_K$ is the market price of the means of agricultural production, and $W_n$ is the net wage rate for non-agricultural industry employment. $\delta$ is the probability of being employed in a non-agricultural industry, $H_n$ is the amount of time employed in the non-agricultural industry, $R_n$ is farm households' other non-productive income, and $P$ is the agricultural product prices. According to the above equation, agricultural product prices directly affect farmers' net income. The higher the price is, the higher the farmers' net income will be. The constraints of this objective function are as follows:

$$S.T.\ Q = AL^{\alpha}K^{\beta}H^{\gamma},\ 0 < \alpha,\ \beta,\ \gamma < 1,\ 0 < \alpha + \beta + \gamma < 1, \quad (2)$$

where $A$ is the technological progress of agricultural production. The condition for maximizing farm households' net income is that the first derivative is zero. In other words, if the above equation is derived from $L$, $K$, and $H$, respectively, the optimal input decision equation of farmers' production is obtained as follows:

$$\frac{\delta\Pi}{\delta L} = \sigma_1 + \sigma_2\frac{\delta Q}{\delta L} + P\frac{\delta Q}{\delta L} - W_L = 0 \quad (3)$$

$$\frac{\delta\Pi}{\delta K} = \sigma_2\frac{\delta Q}{\delta K} + P\frac{\delta Q}{\delta K} - W_K = 0 \quad (4)$$

$$\frac{\delta\Pi}{\delta H} = \sigma_2\frac{\delta Q}{\delta H} + P\frac{\delta Q}{\delta H} - W_H - \delta W_n = 0 \quad (5)$$

Equations (3)–(5) can be further transformed to obtain $L$, $K$, and $H$ when farm households' income is maximized. The specific equations are as follows:

$$L = \frac{\alpha Q(\sigma_2 + P)}{W_L - \sigma_1} \quad (6)$$

$$K = \frac{\beta Q(\sigma_2 + P)}{W_K} \quad (7)$$

$$H = \frac{\gamma Q(\sigma_2 + P)}{W_H + \delta W_n} \quad (8)$$

The results of Equations (6)–(8) show that the optimal $L$, $K$, and $H$ for maximizing farm households' net income are directly proportional to the agricultural product prices ($P$). In other words, the higher the agricultural product prices are, the more farmers will be willing to put into land, capital, and time input in agricultural production. If higher input costs for land, capital, and labor also occur in conjunction with the rise in agricultural product prices, Equation (1) can be transferred into Equation (9) when $W_L = f_1(P)$, $W_K = f_2(P)$, and $W_H = f_3(P)$, and when $f_1(P)$, $f_2(P)$ and $f_3(P)$ are all linear functions of $P$ as follows:

$$\begin{aligned} Max\Pi &= L\sigma_1 + Q\sigma_2 + PQ \\ &-[f_1(P)L + f_2(P)H + f_3(P)K] + \delta W_n H_n + R_n, \end{aligned} \tag{9}$$

where $L$, $K$, and $H$ are all positively correlated with $P$, and $f_1(P)$, $f_2(P)$, and $f_3(P)$ are all linear functions of $P$. Hence, production cost ($f_1(P)L + f_2(P)H + f_3(P)K$) is not a simple linear function of $P$ but is related quadratically and non-linearly. In other words, the impact of agricultural product price fluctuation on farmers' interests is complex. The impact of the agricultural product prices on farmers' income is non-linear if the agricultural product prices increase with the rise in the price of land, the means of production, and labor.

### *3.2. Model Setting and Data Description*

According to the theoretical model, we set the following econometric model to empirically explore the impact of China's agricultural product prices rise on farmers' income:

$$Income_{it} = \alpha_0 + \sum_{l=1}^{k} \rho_l Income_{it-l} + \alpha_1 * Ap_{it} + \alpha_2 * Ap^2{}_{it} + \lambda * D_{ij} + \mu_{it} \tag{10}$$

where subscript $i$ denotes region $i$, and the sample includes 30 provinces and regions in mainland China except Tibet due to incomplete data. Subscript $t$ represents year $t$. The panel data starts in 2003 and extends to 2020 to examine recent rounds of agricultural product price fluctuation in China. $Income$ represents farmers' income, which is measured by referencing rural residents' per capita disposable income, and $Income_{-l}$ is its lag term. $Ap$ is the agricultural product prices as reflected in the producer price index for agricultural products, and $Ap^2$ is its square. $D$ is a set of control variables encompassing per capita investment in rural fixed assets ($Ar$), per capita agricultural loans ($Af$), and per capita agricultural fiscal expenditure ($Ag$), which are all based on the agricultural population. $Income$, $Ar$, $Af$, and $Ag$ variables are all taken logarithms when the model is settled. Education is of long-term significance for increasing farmers' income as educational inequality, and the resulting urban–rural human capital gap are significant constraints on improving farmers' income [43–45]; therefore, rural residents' per capita years of education ($Aedu$) were also controlled.

If the coefficient of the $Ap$ variable is significantly positive in the regression results of Equation (10), and $Ap^2$ is negative, then the impact of the agricultural product prices on farmers' income exhibits an inverted U shape. When the agricultural product prices increase within a certain range, the rise in agricultural product prices can improve farmers' income, but farmers' income does not increase if the agricultural product prices increase is too high. The cross-term of agricultural product prices and corresponding variables is introduced in Equation (11) to further examine the mechanism of agricultural product prices in affecting farmers' income and empirically analyze the differences in the impacts of the rise in agricultural product prices driven by different causes on farmers' income.

$$Income_{it} = \alpha_0 + \sum_{l=1}^{k} \rho_l Income_{it-l} + \alpha_1 * Ap_{it} + \alpha_2 * Ap^2{}_{it} + \varphi Ap_{it} * X_{it} + \lambda * D_{it} + \mu_{it} \tag{11}$$

where $Ap * X$ is the cross-term of agricultural product prices and its corresponding variables. A positive cross-term coefficient ($\varphi$) indicates that the corresponding impact is more obvious, and increased agricultural product prices are more conducive to raising farmers' income and vice versa. $X$ represents the impact factors that affect agricultural product prices, land price ($Lp$), and labor cost ($Lw$). Agricultural land price ($Lp$) was obtained from the land price index for each province, which is published in the Forward database. We measure labor cost ($Lw$) referencing the growth rate of the actual value of employees' average wage in agriculture, forestry, animal husbandry, and fishery units, which is obtained by writing down the nominal value from the fixed-base consumer price index with 2003 as the base period. We also controlled for other factors affecting agricultural product price fluctuation, covering the cost of the means of agricultural production ($Mp$), international agricultural product prices ($Wp$), and the agricultural output gap ($Agap$). $Mp$ was represented by the price index of the means of agricultural production. $Wp$ was measured using the international food price index published by the United Nations Food and Agriculture Organization. We measured $Agap$ referencing the cyclical part of the actual added value of the primary industry, which was separated using the CF (2, 8) filter quantitative research method and converting the actual added value of the primary industry in each region by the growth rate. The data source of $Income$, $Ap$, $Ar$, $Af$, $Ag$, $Lw$, $Mp$, and $Agap$ came from the China Statistical Yearbook and the China Population and Employment Statistical Yearbook. The model only contains one cross-term at a time to successively test the impact of different variables on the role of agricultural product prices in affecting the farmers' income to simplify the model and avoid an overabundance of variables, rendering the model unrecognizable in the empirical test.

Before conducting the formal test, we present the descriptive statistics of the main variables. Table 2 shows the mean, median, standard error, minimum, and maximum of the variables involved in the econometric model.

**Table 2.** Descriptive statistics.

| | Mean | Median | Standard Error | Minimum | Maximum |
|---|---|---|---|---|---|
| $Income$ | 8.90 | 8.95 | 0.59 | 7.90 | 9.75 |
| $Ap$ | 106.15 | 104.50 | 7.38 | 89.00 | 136.90 |
| $Ar$ | 7.03 | 7.13 | 0.67 | 4.14 | 8.63 |
| $Af$ | 8.19 | 8.27 | 0.87 | 4.90 | 10.28 |
| $Ag$ | 6.91 | 7.10 | 0.51 | 5.01 | 7.75 |
| $Aedu$ | 7.49 | 7.58 | 0.70 | 5.14 | 9.74 |
| $Lw$ | 13.22 | 11.64 | 18.75 | −63.93 | 214.55 |
| $Lp$ | 106.28 | 104.58 | 7.10 | 90.64 | 179.90 |
| $Agap$ | 9.22 | 7.77 | 7.72 | −16.57 | 41.91 |
| $Wp$ | 96.42 | 95.51 | 20.21 | 57.79 | 131.88 |
| $Mp$ | 104.58 | 103.05 | 5.84 | 93.30 | 128.10 |

## 4. Results

### *4.1. Preliminary Regression Results and Analyses*

Table 3 presents the results of the empirical test based on Equation (10), using the regression methods for panel data. Models (1)–(3) in Table 3 present the ordinary least squares (OLS), random (RE), and fixed (FE) effects regression results based on panel data, respectively. The traditional OLS, RE, and FE models may all be biased as Equation (10) contains lag terms for the explained variable, and the explanatory variables may be endogenous; therefore, the generalized method of moments (GMMs) regression of the dynamic panel model is shown in model (4) as well (GMM regression of the dynamic panel can be categorized into one- or two-step GMM regression. One-step GMM regression is commonly employed in empirical applications due to downward bias in the standard deviation of the two-step regression [46]. In addition, the one-step system GMM uses more information when additional instrumental variables are valid, and its regression results are more efficient than the one-step difference GMM [47,48]. Therefore, we chose a one-step system GMM regression as the model for this study.). The regression results in Table 3 reveal that the $Ap$ coefficient is significantly positive and the $Ap^2$ coefficient is significantly negative, based on the traditional OLS, RE and FE methods and the GMM regression of the dynamic panel. The results indicate that the function of farmers' income on agricultural product prices is a concave down parabola, indicating that the impact of agricultural product prices on farmers' income is non-linear. The rise in agricultural product prices within a certain range raises farmers' income, but when the rise is too high (exceeding a critical point), it does not contribute to increasing farmers' income.

**Table 3.** Impact of rising agricultural product prices on farmers' income.

| | **(1)**<br>**OLS** | **(2)**<br>**FE** | **(3)**<br>**GMM** | **(4)**<br>**GMM** |
|---|---|---|---|---|
| $Income_{-1}$ | 1.2110<br>(32.47) *** | 1.0820<br>(33.73) *** | 1.1247<br>(31.44) *** | 1.0817<br>(64.36) *** |
| $Income_{-2}$ | −0.2871<br>(−4.80) *** | −0.3199<br>(−6.92) *** | −0.2611<br>(−10.80) *** | −0.3188<br>(−8.25) *** |
| $Income_{-3}$ | 0.0433<br>(1.14) | 0.2183<br>(5.92) *** | 0.0819<br>(2.27) ** | 0.2172<br>(5.95) *** |
| $Ap$ | 0.0109<br>(4.10) *** | 0.0134<br>(6.01) *** | 0.0137<br>(4.38) *** | 0.0135<br>(4.93) *** |
| $Ap^2$ | −0.0043<br>(−3.48) *** | −0.0052<br>(−5.01) *** | −0.0055<br>(−3.81) *** | −0.0052<br>(−4.19) *** |
| $Ar$ | 0.0023<br>(1.25) | 0.0053<br>(2.25) ** | 0.0161<br>(1.82) * | 0.0052<br>(1.99) * |
| $Af$ | 0.0007<br>(0.41) | 0.0035<br>(1.91) * | 0.0062<br>(1.68) * | 0.0038<br>(2.20) ** |
| $Ag$ | 0.0068<br>(2.21) ** | 0.0093<br>(1.78) * | 0.0394<br>(6.60) *** | 0.0099<br>(1.72) * |
| $Aedu$ | 0.0047<br>(2.77) *** | 0.0147<br>(3.65) *** | 0.0177<br>(3.00) *** | 0.0149<br>(4.80) *** |
| Constant term | −0.3967<br>(−2.67) *** | 0.6589<br>(4.98) *** | −0.8423<br>(−4.48) *** | −0.8046<br>(−4.93) *** |
| AR(1) | | | 0.001 | 0.000 |
| AR(2) | | | 0.000 | 0.000 |
| AR(3) | | | 0.001 | 0.001 |
| AR(4) | | | 0.041 | 0.567 |
| Hansen | | | 1.000 | 1.000 |
| Cross-section fixed effect | | | Yes | Yes |
| Time fixed effect | | | No | Yes |
| Number of samples | 30 × 18 | 30 × 18 | 30 × 18 | 30 × 18 |

Note: *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. $t$-values are in parentheses. The third-order lag terms for the dependent variable are set in the model according to the results of the AR test, and the AR(1), AR(2), AR(3), AR(4), and Hansen tests report the $p$-values of the corresponding statistics, demonstrating that the dynamic panel model setting and instrumental variables are valid.

In addition, the $Ar$ coefficient in Table 3 is significantly positive, indicating that rural investment is conducive to improving farmers' income. Accelerating investment in agriculture and rural areas is a significant driving force for promoting agricultural development and increasing farmers' income since a lack of investment has always been one of the core challenges in developing China's agriculture, rural areas, and farmers. $Af$ and $Ag$ coefficients are significantly positive, indicating that financial and fiscal support for agriculture are important means to improve farmers' income, which aligns with the findings of Gao et al. [49] and Zhu and Lu [50], among others. The $Aedu$ coefficient is also significantly positive. Some studies have demonstrated that underinvestment in education is an important constraint on farmers' income increasing and improving human capital in education will increase farmers' income [51,52].

*4.2. Model Regression and Analysis of Different Causes*

The regression results in Table 3 reveal that agricultural product prices have a non-linear effect on farmers' income. Models (5)–(9) in Table 4 empirically test the impact of agricultural product price increases driven by different causes on farmers' income based on Equation (11). The $Ap$ coefficient is still significantly positive, and its quadratic coefficient, $Ap^2$, is significantly negative. The regression results of $Ar$, $Af$, $Ag$, and $Aedu$ also basically mirror those in Table 3. We next focused on the regression of the cross-term of agricultural product prices and its impact factors, $Ap * X$.

**Table 4.** Impact of rise in agricultural product prices driven by different causes on farmers' income.

| | (5)<br>$X = Lp$ | (6)<br>$X = Lw$ | (7)<br>$X = Wp$ | (8)<br>$X = Mp$ | (9)<br>$X = Agap$ |
|---|---|---|---|---|---|
| $Income_{-1}$ | 1.1236<br>(47.93) *** | 1.0817<br>(61.22) *** | 0.5176<br>(56.09) *** | 1.0130<br>(50.11) *** | 1.0696<br>(60.56) *** |
| $Income_{-2}$ | −0.3767<br>(−7.17) *** | −0.3113<br>(−7.93) *** | 0.1796<br>(19.78) *** | −0.2021<br>(−4.08) *** | −0.3106<br>(−7.34) *** |
| $Income_{-3}$ | 0.2262<br>(4.99) *** | 0.2099<br>(5.84) *** | 0.2530<br>(30.42) *** | 0.1672<br>(3.64) *** | 0.2221<br>(5.43) *** |
| $Ap$ | 0.0125<br>(3.42) *** | 0.0141<br>(4.89) *** | 0.0028<br>(3.36) *** | 0.0128<br>(3.52) *** | 0.0129<br>(4.48) *** |
| $Ap^2$ | −0.0060<br>(−4.02) *** | −0.0057<br>(−4.27) *** | −0.0006<br>(−1.52) | 0.0001<br>(0.07) | −0.0051<br>(−3.83) *** |
| $Ap * X$ | 0.0027<br>(1.72) * | 0.0022<br>(2.20) ** | −0.0012<br>(−7.23) *** | −0.0109<br>(−4.75) *** | 0.0004<br>(0.24) |
| $Ar$ | 0.0078<br>(2.33) ** | 0.0052<br>(1.84) * | 0.0012<br>(1.54) | 0.0091<br>(2.78) ** | 0.0056<br>(2.05) ** |
| $Af$ | 0.0073<br>(2.62) ** | 0.0035<br>(2.06) ** | 0.0008<br>(1.50) | 0.0019<br>(1.00) | 0.0037<br>(1.94) * |
| $Ag$ | 0.0007<br>(0.11) | 0.0097<br>(1.82) * | −0.0083<br>(−5.20) *** | 0.0122<br>(2.07) ** | 0.0088<br>(1.68) * |
| $Aedu$ | 0.0197<br>(4.30) *** | 0.0148<br>(4.97) *** | 0.0024<br>(1.53) | 0.0178<br>(5.44) *** | 0.0137<br>(4.36) *** |
| Constant term | −0.6144<br>(−2.45) ** | −0.8174<br>(−4.88) *** | 0.2563<br>(4.69) *** | −1.4659<br>(−4.62) *** | −0.7449<br>(−4.51) *** |
| AR(1) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(2) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(3) | 0.019 | 0.001 | 0.000 | 0.000 | 0.001 |
| AR(4) | 0.625 | 0.723 | 0.000 | 0.876 | 0.333 |
| Hansen | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Cross-section fixed effect | Yes | Yes | Yes | Yes | Yes |

**Table 4.** *Cont.*

| | (5) $X = Lp$ | (6) $X = Lw$ | (7) $X = Wp$ | (8) $X = Mp$ | (9) $X = Agap$ |
|---|---|---|---|---|---|
| Time fixed effect | Yes | Yes | Yes | Yes | Yes |
| Number of samples | 30 × 18 | 30 × 18 | 30 × 18 | 26 × 18 | 30 × 18 |

Note: *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. *t*-values are in parentheses. The AR(1), AR(2), AR(3), AR(4), and Hansen tests report the *p*-values of the corresponding statistics, demonstrating that the dynamic panel model setting and instrumental variables are valid. Due to the unavailability of the price index of the means of agricultural production for the four municipalities of Beijing, Shanghai, Tianjin, and Chongqing, which are directly under the Central Government, the test of model (8) excludes these four municipalities.

Model (5) introduces the cross-term of the agricultural product prices and agricultural land price, $Ap * Lp$, which is significantly positive. This suggests that the benefits of land price increasing are likely to be acquired by farmers due to contractual rights to the land when increased agricultural product prices are caused by agricultural land price rising, which contributes to increasing farmers' income. Many farmers, who are decentralized and whose managed tillable land is household-contracted, are engaged in China's agricultural production. When an agricultural land price increase causes agricultural product prices to rise, this price increase actually reflects the cost of agricultural land [35], and the benefits of the price increase are also acquired by farmers managing their own household-contracted land, subsequently improving farmers' income. Model (6) introduces the cross-term of the agricultural product prices and labor cost, $Ap * Lw$, revealing a significantly positive coefficient, which indicates that increased in agricultural product prices caused by the rising rural labor cost improves farmers' income. The rising price of rural labor increases farmers' business income by raising agricultural product prices, which has improved farmers' disposable income. Rural labor is divided into household and hired labor. When the labor force used in agricultural production is household labor, increased agricultural product prices due to this rising cost are directly converted into farmers' net income. When agricultural production employs hired labor, the benefits of rising wages for hired labor will also be converted into increased salary income for farmers since the main proportion of the agricultural labor force is still farmers, subsequently increasing farmers' disposable income.

Notably, increased agricultural product prices may also be affected by international agricultural product prices and the price of the means of agricultural production. Models (7) and (8), respectively, introduce the associated cross-terms. The coefficients of $Ap * Wp$ and $Ap * Mp$ are both negative and significant. Generally, international agricultural product prices will exogenously impact the agricultural market of importing countries and will not cause obvious changes in the distribution of benefits. However, when international agricultural product prices experience a rapid rise at the present stage, it often induces domestic residents to speculate on agricultural products, which increases domestic agricultural product prices [53]. In this case, farmers will not acquire the benefits of rising agricultural product prices, and import costs may also rise, undermining farmers' disposable income. The coefficient of $Ap * Mp$ is also significantly negative, indicating that increased agricultural product prices driven by agricultural materials will not compensate for the cost of acquiring the means of production and will not increase farmers' income as farmers will not acquire associated benefits. Model (9) introduces the cross-term of the agricultural output gap and agricultural product prices ($Ap * Agap$), revealing a positive but insignificant coefficient. This indicates that when the supply–demand imbalance establishes an output gap that increases agricultural product prices, the impact of agricultural product prices increasing on farmers' income is insignificant. This result may be attributable to the fact that various demand factors are intertwined with one another, but the distribution of benefits exhibits an opposite preference that neutralizes the impact of the demand-driven increase in agricultural product prices on farmers' income.

Based on empirical results above, we can describe impact of rise in agricultural product prices driven by different causes on farmers' income as Figure 7.

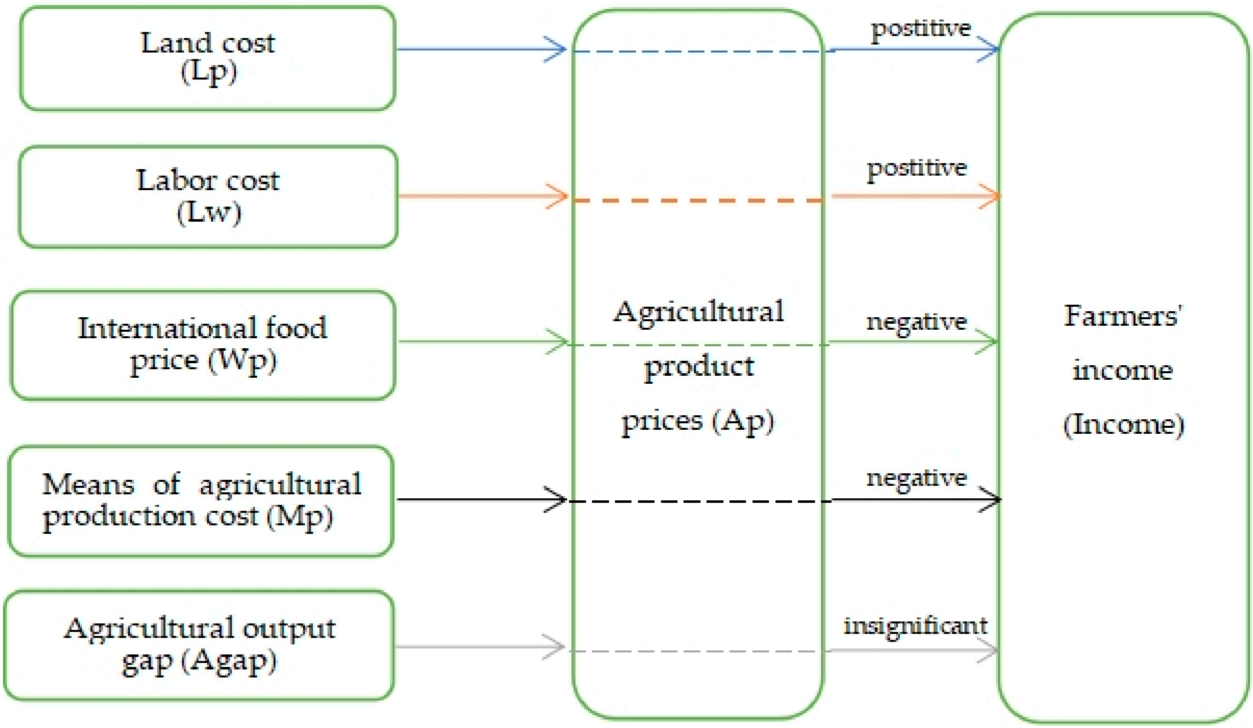


**Figure 7.** Impact of rise in agricultural product prices driven by different causes on farmers' income.

*4.3. Robustness Tests*

The next robustness test is based on the following two aspects to further confirm that the test results of this study were reliable. (1) Samples of three municipalities were removed. Beijing, Shanghai, and Tianjin may have an impact on the regression results examining income distribution. Not only are the urbanization rate, education, financial development, fiscal expenditure, and per capita GDP of the three municipalities significantly higher than those of most provinces, but the fluctuations in agricultural product prices also differ from those of other provinces, indicating that the three municipalities may be outliers in the regression. Therefore, data excluding the three municipalities are used to recalculate Equations (10) and (11). (2) The 2020 samples were removed. The COVID-19 pandemic in 2020 had an enormous exogenous impact on the agricultural product market, and the agricultural product market (particularly agricultural product prices) underwent a subsequently large fluctuation. The changes in agricultural product prices in that year significantly differed from previous years, causing a structural breakpoint. Therefore, this test excludes 2020 samples to recalculate Equations (10) and (11) using the panel data from 2003 to 2019.

Tables 5 and 6 report the results of the robustness tests, revealing that the coefficients of $Ap$ are all significantly positive and those of $Ap^2$ are all negative when excluding samples of the three municipalities and those in which the structural breakpoint occurred in 2020. The sign and significance of the $Lp$, $Lw$, $Wp$, $Mp$, and $Agap$ coefficients and the sign and significance of the coefficients of their cross-terms with $Ap$, also generally align with the data in Table 4, confirming that the empirical results are robust. The effect of agricultural product prices on farmers' income is non-linear. Differing effects occur on farmers' incomes from rising agricultural product prices related to different causes, and agricultural land price increases and agricultural product price rises driven by rural labors cost are conducive to increasing farmers' income.

**Table 5.** Robustness test (I) on the impact of rising agricultural product prices on farmers' income.

| Explanatory Variables | Samples with Beijing, Shanghai, and Tianjin Removed | | | | | |
|---|---|---|---|---|---|---|
| | **(10)** | **(11) X = Lp** | **(12) X = Lw** | **(13) X = Wp** | **(14) X = Mp** | **(15) X = Agap** |
| $Income_{-1}$ | 1.0735 (53.36) *** | 1.0985 (39.75) *** | 1.0685 (51.25) *** | 0.5334 (46.02) *** | 1.0130 (50.11) *** | 1.0707 (51.96) *** |
| $Income_{-2}$ | −0.3040 (−6.42) *** | −0.3783 (−7.27) *** | −0.2923 (−6.34) *** | 0.1602 (13.15) *** | −0.2021 (−4.08) *** | −0.3180 (−6.34) *** |
| $Income_{-3}$ | 0.2041 (4.63) *** | 0.2447 (5.26) *** | 0.1990 (4.91) *** | 0.2572 (20.73) *** | 0.1672 (3.64) *** | 0.2235 (4.71) *** |
| $Ap$ | 0.0120 (4.44) *** | 0.0100 (2.76) ** | 0.0128 (3.88) *** | 0.0027 (3.07) *** | 0.0128 (3.52) *** | 0.0158 (5.71) *** |
| $Ap^2$ | −0.0045 (−3.60) *** | −0.0051 (−3.44) *** | −0.0051 (−3.37) *** | −0.0003 (−0.85) | 0.0001 (0.07) | −0.0066 (−5.19) *** |
| $Ap * X$ | | 0.0031 (1.94) * | 0.0033 (2.87) *** | −0.0015 (−7.21) *** | −0.0109 (−4.75) *** | 0.0022 (1.44) |
| $Ar$ | 0.0090 (2.15) ** | 0.0178 (3.81) *** | 0.0103 (2.58) ** | 0.0013 (0.71) | 0.0091 (2.78) ** | 0.0102 (2.41) ** |
| $Af$ | 0.0036 (1.39) | 0.0036 (1.50) | 0.0018 (0.91) | 0.0007 (0.77) | 0.0019 (1.00) | 0.0026 (1.19) |
| $Ag$ | 0.0126 (2.32) ** | 0.0021 (0.32) | 0.0138 (2.47) ** | −0.0109 (−5.13) *** | 0.0122 (2.07) ** | 0.0133 (2.52) ** |
| $Aedu$ | 0.0215 (3.76) *** | 0.0239 (5.05) *** | 0.0188 (5.37) *** | 0.0027 (1.42) | 0.0178 (5.44) *** | 0.0166 (4.66) *** |
| Constant term | −0.7457 (−4.73) *** | −0.4168 (−1.62) | −0.7575 (−3.98) *** | 0.2623 (4.49) *** | −1.4659 (−4.62) *** | −0.9080 (−5.68) *** |
| AR(1) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(2) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(3) | 0.015 | 0.039 | 0.009 | 0.000 | 0.000 | 0.002 |
| AR(4) | 0.816 | 0.580 | 0.818 | 0.000 | 0.876 | 0.612 |
| Hansen | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Cross-section fixed effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Time fixed effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Number of samples | 27 × 18 | 27 × 18 | 27 × 18 | 27 × 18 | 26 × 18 | 27 × 18 |

Note: *, **, and *** indicate that the coefficients are significant at the 10%, 5%, and 1% levels, respectively. *t*-values are in parentheses. The AR(1), AR(2), AR(3), AR(4), and Hansen tests report the *p*-values of the corresponding statistics, demonstrating that the dynamic panel model setting and instrumental variables are valid. In Table 4, the samples of the four municipalities of Beijing, Shanghai, Tianjin, and Chongqing are excluded from the tests of the impact of agricultural products' price rise driven by the rise in the means of production cost on farmers' income as the price indices of the means of agricultural production are not available for these four municipalities. Therefore, it is unnecessary to delete these four municipalities for the robustness test, and model (14) in Table 5 also excludes these samples.

**Table 6.** Robustness test (II) on the impact of rising agricultural product prices on farmers' income.

| Explanatory Variables | Samples of 2020 Removed | | | | | |
|---|---|---|---|---|---|---|
| | **(16)** | **(17) X = Lp** | **(18) X = Lw** | **(19) X = Wp** | **(20) X = Mp** | **(21) X = Agap** |
| $Income_{-1}$ | 1.0823 (60.64) *** | 1.0977 (49.43) *** | 1.0812 (57.70) *** | 0.5428 (39.49) *** | 1.0224 (44.76) *** | 1.0670 (60.17) *** |

**Table 6.** *Cont.*

| Explanatory Variables | Samples of 2020 Removed | | | | | |
|---|---|---|---|---|---|---|
| | **(16)** | **(17)** **$X = Lp$** | **(18)** **$X = Lw$** | **(19)** **$X = Wp$** | **(20)** **$X = Mp$** | **(21)** **$X = Agap$** |
| $Income_{-2}$ | −0.3088 (−7.15) *** | −0.3593 (−7.48) *** | −0.3006 (−7.08) *** | 0.1521 (11.05) *** | −0.2040 (−3.90) *** | −0.2993 (−6.66) *** |
| $Income_{-3}$ | 0.2064 (5.13) *** | 0.2366 (5.61) *** | 0.1993 (5.12) *** | 0.2549 (21.88) *** | 0.1595 (3.23) *** | 0.2133 (4.85) *** |
| $Ap$ | 0.0122 (4.31) *** | 0.0118 (3.94) *** | 0.0132 (4.44) *** | 0.0022 (1.74) * | 0.0117 (3.04) *** | 0.0109 (3.37) *** |
| $Ap^2$ | −0.0046 (−3.50) *** | −0.0046 (−3.34) *** | −0.0052 (−3.77) *** | 0.0000 (−0.05) | 0.0009 (0.45) | −0.0041 (−2.67) ** |
| $Ap * X$ | | 0.0003 (2.77) ** | 0.0020 (1.73) * | −0.0016 (−6.42) *** | −0.0114 (−4.40) *** | −0.0004 (−0.23) |
| $Ar$ | 0.0062 (1.98) * | 0.0100 (2.18) ** | 0.0063 (1.88) * | 0.0026 (2.80) *** | 0.0095 (2.71) ** | 0.0066 (2.05) ** |
| $Af$ | 0.0039 (2.21) ** | 0.0044 (1.76) * | 0.0036 (2.06) ** | 0.0010 (0.89) | 0.0023 (1.16) | 0.0036 (1.86) * |
| $Ag$ | 0.0108 (1.86) * | 0.0065 (1.03) | 0.0111 (1.99) * | −0.0138 (−6.74) *** | 0.0138 (2.27) ** | 0.0103 (1.89) * |
| $Aedu$ | 0.0145 (4.91) *** | 0.0185 (5.11) *** | 0.0146 (4.98) *** | 0.0046 (2.37) ** | 0.0173 (5.55) *** | 0.0135 (4.40) *** |
| Constant term | −0.7475 (−4.50) *** | −0.7340 (−4.21) *** | −0.7861 (−4.55) *** | 0.2738 (3.91) *** | −1.4671 (−4.60) *** | −0.6568 (−3.66) *** |
| AR(1) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(2) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| AR(3) | 0.002 | 0.007 | 0.002 | 0.000 | 0.000 | 0.001 |
| AR(4) | 0.643 | 0.975 | 0.775 | 0.000 | 0.832 | 0.405 |
| Hansen | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Cross-section fixed effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Time fixed effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Number of samples | 30 × 17 | 30 × 17 | 30 × 17 | 30 × 17 | 26 × 17 | 30 × 17 |

Note: *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. *t*-values are in parentheses. The AR(1), AR(2), AR(3), AR(4), and Hansen tests report the *p*-values of the corresponding statistics, demonstrating that the dynamic panel model setting and the instrumental variables are valid.

### 4.4. Further Analyses

The above results show that when agricultural product prices rise is not large, it will increase farmers' income. However, this effect can be reversed if agricultural product prices reach beyond a critical threshold. This may be attributable to the dominant factors driving agricultural product price fluctuation differing at high or low agricultural product prices. We employed panel quantile regression to examine the difference in driving forces at high or low prices. Table 7 presents the regression results of the model with 0.10, 0.25, 0.50, 0.75, and 0.90 quantile points, respectively, using the provincial panel data from 2003 to 2020. Agricultural product prices are the explained variable, and agricultural price expectation, agricultural land cost, agricultural labor cost, international food price, price of the means of agricultural production, and agricultural output gap are the explanatory variables.

**Table 7.** Quantile regression results.

| | (22) | (23) | (24) | (25) | (26) |
|---|---|---|---|---|---|
| | q = 0.10 | q = 0.25 | q = 0.50 | q = 0.75 | q = 0.90 |
| $E_t(Ap_{t+1})$ | 0.1253<br>(1.86) * | 0.0857<br>(1.74) * | 0.1271<br>(2.20) ** | 0.2215<br>(3.51) *** | 0.2154<br>(1.84) * |
| $Ap_{-1}$ | 0.0031<br>(2.03) ** | 0.0101<br>(2.14) ** | 0.0075<br>(2.07) ** | 0.3217<br>(2.11) ** | 0.3709<br>(1.82) * |
| $Lp$ | 0.2090<br>(1.79) * | 0.1872<br>(2.19) ** | 0.2089<br>(1.90) * | 0.2355<br>(2.01) ** | 0.2047<br>(1.82) * |
| $Lw$ | 0.0029<br>(1.84) * | 0.0033<br>(2.37) ** | 0.0002<br>(0.91) | 0.0002<br>(0.76) | 0.0007<br>(1.62) |
| $Wp$ | 0.0124<br>(1.39) | 0.0194<br>(2.72) *** | 0.0200<br>(1.09) | 0.1655<br>(4.75) *** | 0.2577<br>(3.69) *** |
| $Mp$ | 0.3685<br>(5.46) *** | 0.3903<br>(4.84) *** | 0.4254<br>(5.19) *** | 0.5487<br>(5.32) *** | 1.0065<br>(4.85) *** |
| $Agap$ | −0.0817<br>(−1.00) | −0.1096<br>(−1.11) | −0.0946<br>(−1.26) | −0.0725<br>(−0.92) | −0.0254<br>(−0.21) |
| Constant term | 6.1562<br>(7.62) *** | 2.8026<br>(10.05) *** | 9.2469<br>(9.41) *** | 7.7722<br>(2.09) ** | 7.3804<br>(3.71) ** |

Note: *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. *t*-values are in parentheses. The cross-section of samples represents 26 provincial administrative regions, covering 2003–2020.

The quantile regression results in Table 7 reveal that the coefficients of rational ($E_t(Ap_{t+1})$) and adaptive ($Ap_{-1}$) expectations are mostly significantly positive. However, comparing the coefficients of the two indicates that the coefficients of $E_t(Ap_{t+1})$ are larger when the quantile points are 0.10, 0.25, and 0.50, while those of $Ap_{-1}$ are relatively larger when the quantile points are 0.75 and 0.90. This result indicates that rational expectations have a dominant influence when agricultural product prices increase slowly, but adaptive expectations will dominate under the psychology of "buy high, sell low" if agricultural product prices rise rapidly.

The coefficients of the agricultural output gap ($Agap$) in models (22)–(26) are all insignificant, indicating that demand is not a dominant factor driving agricultural product price fluctuation when the price rises faster or more slowly. The coefficient of $Lp$ is significantly positive, indicating that rising agricultural land price positively affects agricultural product prices, with no sign of becoming larger as the quantile point rises. The coefficient of labor cost ($Lw$) is positive at most of the quantile points, but it is larger at the lower quantile points when comparing the regression results at different quantile points, indicating that higher labor cost drives a flat increase in agricultural product prices. However, labor cost is often not the primary cause when the price rises too rapidly. The coefficient of the means of agricultural production ($Mp$) is significantly positive, indicating that a rapid rise in the price of means of production is indeed a significant driving factor of price rise. The higher the quantile point is, the larger the $Mp$ coefficient will be, comparing the results at different quantile points. This suggests that agricultural product prices rising fast is often likely to be driven by a faster price rise in the means of agricultural production. The regression results of international agricultural product prices ($Wp$) are similar to those of $Mp$, with significantly positive coefficients, which become larger as the quantile points increase. This suggests that large increases in China's agricultural product prices tend to be externally affected by increases in international agricultural product prices. This is primarily attributable to sharply rising international agricultural product prices directly increasing domestic agricultural product prices through imports, which may also induce domestic speculation and other practices that bolster the rise in domestic agricultural product prices. Table 7 indicates that excessive rise in agricultural product prices is often accompanied by causes including the international market impact and a rapid price rise in the means of agricultural production. The studies above demonstrate that these causes are not conducive to raising farmers' income, which also explains why agricultural product prices rising too rapidly does not increase farmers' income.

*4.5. Discussion*

There exists a classic economic proposition known as "cheap grain harms peasants". This proposition suggests that during a bumper harvest, the price of agricultural products decreases, leading to a reduction in farmers' income. If this proposition is indeed valid, it can be inferred that an increase in agricultural product prices will result in an increase in farmers' income. However, existing empirical studies on this issue have produced inconsistent conclusions. While many studies affirm the positive impact of increasing agricultural prices on poverty reduction and farmers' income, some have found that rising agricultural prices may exacerbate farmers' poverty [10,11]. This study introduces a new theoretical model proposing that the impact of agricultural prices on farmers' income is non-linear, exhibiting a "threshold effect". An empirical test using China's inter-provincial panel data from 2003 to 2020 confirms this perspective. It suggests that, within a certain range, an increase in agricultural prices benefits farmers' income. However, beyond a certain level, further increases in agricultural prices do not benefit farmers' income. The non-linear impact of rising agricultural prices on farmers' income, which initially increases and then reverses to a negative impact, helps to explain the divergent conclusions in the existing literature.

We tried to analyze the aforementioned result and examine the underlying causes of rising agricultural prices. Existing studies have looked at rising agricultural prices from the perspectives of demand pull, cost drive, and external shocks [32,35,36,53]. However, there is a lack of research on how rising agricultural prices driven by different causes affect farmers' income. An intuitive understanding is that in agricultural production, where the self-employed model is more prevalent, the factors of labor and land are owned by farmers, while machinery, feed, and fertilizers usually need to be purchased from urban enterprises. As a result, the increase in the cost of agricultural labor and land is a natural consequence of the dual structural transition, which in turn leads to higher prices for agricultural products. This has a positive impact on farmers' income. Conversely, the means of agricultural production, such as agricultural machinery, feed, and fertilizers, are frequently provided by urban enterprises. International agricultural product price fluctuations are caused by changes in foreign markets. If the prices of means of agricultural production and international agricultural product prices rise, the gains may not lead to an increase in farmers' income but benefit domestic urban enterprises and foreign residents instead. By constructing the cross terms of agricultural product prices and their driving factor variables, we analyzed the differences in the impact of rising agricultural product prices driven by different causes on farmers' income. The empirical results show that when the rise in agricultural product prices is mainly driven by agricultural land and labor costs, it is more conducive to farmers' income growth. However, if the rise in agricultural product prices is more derived from international market shocks and the increase in the price of means of agricultural production, it is not conducive to increasing farmers' income.

Prior research has also indicated that the primary drivers of price increases vary between instances where prices have experienced a significant increase and those where the increase has been more modest [54]. We believe that this relationship is also likely to hold true for agricultural price increases. As the prices of agricultural labor and land rise relatively slowly, the resulting price increases for agricultural products are often moderate. In contrast, due to the fluctuating supply and demand of agricultural products in the international market, international agricultural prices may rise rapidly. Additionally, changes in the supply and demand of means of agricultural production and policy adjustments may lead to a rapid rise in prices of means of agricultural production, potentially leading to a rapid rise in agricultural prices. Based on the findings of quantile regression on panel data, this paper reveals that a small increase in agricultural product prices often results from rising agricultural labor costs, which explains why such small price increases have a positive impact on farmers' income. Furthermore, our findings indicate that a large increase in agricultural product prices is typically driven by the rise in the cost of means of agricultural production and international agricultural prices. These findings also shed light on the underlying reasons behind the threshold effect of agricultural product price increases on farmers' income.

## 5. Conclusions, Policy Recommendations, and Limitations

The continuous rounds of increased agricultural product prices in China since 2003 have attracted widespread attention. The degree of benefits obtained by farmers from agricultural product prices has been questioned as the rise in price during that period has been accompanied by input cost increases and international market price impact. This study empirically explored the impact of agricultural product price fluctuation on farmers' income and the heterogeneous impact of agricultural product price rise driven by different causes on farmers' income based on provincial panel data from 2003 to 2020. The relevant conclusions are threefold. (1) There is a threshold effect on the impact of the rise in agricultural product prices on farmers' income. Agricultural product prices raise farmers' income when the agricultural product prices are not too high, but it will negatively affect farmers' income instead if the agricultural product prices rise too much. (2) Differing impacts on farmers' incomes occur from agricultural product prices increases that are driven by different causes. Increased agricultural product prices driven by rising agricultural land and labor costs can improve farmers' income. However, if the agricultural product prices' rise originates from international market impact and increases in the price of the means of agricultural production, the price increase will not improve farmers' income. (3) The factors of international market impact and the rapid rise in the price of the means of agricultural production when agricultural product prices rise too quickly indicate that when agricultural product prices rise too much, farmers' income does not increase.

The findings of this study have important policy implications. First, while it is important to allow some natural price fluctuation to reflect market conditions, it is also crucial to ensure that these changes do not harm farmers' livelihoods. To maintain a stable agricultural market, strategies should focus on facilitating market mechanisms that can help farmers benefit from price increases without causing significant disruptions. This could involve policies that encourage diversification of agricultural markets, improve farmers' access to the latest market information, and enhance the resilience of agricultural supply chains. Additionally, fostering an environment where farmers can adapt to market changes through education and technology adoption is vital. Second, responsive policy measures should be introduced expediently when agricultural product prices rise too quickly to stabilize agricultural product prices. In particular, the causes of agricultural price increases should be analyzed in depth so that appropriate measures can be implemented according to the causes. It is essential to establish and improve agricultural product price protection and market risk diversification policies through agricultural product price insurance, strengthening the construction of the agricultural product futures market, and related measures. Finally, an agricultural product price increase that is driven by rising agricultural land prices and rural labor costs can raise farmers' income, but rising agricultural product prices caused by the increased price of the means of agricultural production and the international market will not increase farmers' income. This requires full consideration of the rising costs of the means of agricultural production and agricultural imports when formulating agricultural product price subsidy policies to ensure that a reasonable return can be acquired when the amount of subsidy can cover extra factor costs. This is expected to increase farmers' incentives to increase agricultural production. In particular, given the current continuous and irreversible rise in agricultural labor and land costs, it is also crucial to control the cost of the means of agricultural production through other means. For example, the development of well-facilitated farmland can be accelerated; subsidies for crop rotation, fallow land, and environmental protection can be increased; and economic compensation can be provided to farmers who proactively stop using chemical fertilizers and pharmaceuticals that reduce yields to control the input cost for the means of agricultural production and ensure farmers' income.

As a limitation, our analysis may not fully capture the complexity of the agricultural landscape in China, and we recommend that future research explore these regional disparities in more detail. It is important to acknowledge that while this study provides a macroscopic analysis of the relationship between agricultural product price increases and farmers' income in China, it does not fully account for the country's significant regional diversity. China's vast geographical expanse, varied economic development, and diverse climatic conditions contribute to a rich tapestry of agricultural practices and price dynamics across different regions. For instance, coastal provinces with greater access to international markets and higher levels of agricultural mechanization may respond differently to price fluctuations compared with inland provinces, where traditional, labor-intensive farming practices are more common. A more granular approach, potentially employing county-level data or conducting in-depth case studies in diverse regions, could provide a more nuanced understanding of how agricultural price increases impact farmers' income across different contexts. Moreover, future studies could benefit from incorporating additional variables that reflect regional differences in agricultural production, such as levels of mechanization, access to markets, and natural factors, such as climate conditions, to better understand their influence on agricultural income. Additionally, qualitative research methodologies, including interviews and focus groups with farmers from different regions, could offer further insights into the local impacts of national price trends.

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