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The Role of Farmland Titling in Urban Agricultural Resilience: Evidence from Metropolitan Guangzhou, China

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Abstract: Urban agriculture has been seen as an essential strategy for enhancing food security and urban resilience and is valued by many countries, but its development faces many challenges. Whether farmland system reform can improve the factor allocation of urban farmer households and then promote the resilience of urban agriculture has not received sufficient attention. Therefore, this article uses property rights theory to explain the logic that farmland titling as a formal institution affects the factor allocation of urban farmer households (UFHs). Furthermore, empirical analysis of whether farmland titling positively affects the UFHs' willingness toward farmland, and capital allocation was performed based on household-level survey data from metropolitan Guangzhou, China. The implications of this research are as follows: emphasizing that the reform of farmland titling is vital for the farmland transaction market, strengthening talent cultivation, and increasing agricultural green input and investment, all of which are beneficial to promote the modernization and sustainability of urban agriculture, thus improving the resilience of urban regions.

Keywords: farmland titling; urban agriculture; resilience; farmer households; factor allocation

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1. Introduction

UNDESA's report noted that 55% of the world's population lived in urban areas in 2018, and this proportion is expected to increase to 68% by 2050. In the future, the growth of urban populations worldwide is expected to be highly concentrated in a few countries, including India, China, and Nigeria [1]. Population growth and rapid urbanization have brought increasingly severe food security problems to many developing countries. Since 2019, the global COVID-19 pandemic has caused massive shocks to the food supplies of many countries [2], and the vulnerability of these food systems have become apparent, arousing concern about the resilience of urban food supplies. As an advanced form of agricultural development, urban agriculture has become a hot topic in agricultural research due to its potential to increase the resilience and sustainability of cities and food systems. Agriculture provides opportunities to improve the food supply [3], in addition to potential ecological benefits such as saving energy and protecting biodiversity [4]. It can also create new employment opportunities, encourage social networks, support national heritage, and promote the healthy development of urban communities [5]. Furthermore, urban agriculture fosters the integration of urban and rural areas with respect to technology, capital, and talent by breaking regional and institutional barriers, effectively promoting the integrated development of urban and rural areas [6]. Therefore, urban agriculture has great potential to build urban resilience and enhance global sustainability [7].

Nevertheless, the development of urban agriculture in low-income and middle-income countries has failed to meet expectations. Its development has been limited by many factors, the first of which is land constraints. In cities, there is little space for growing food, limited land access, and weak land tenure security, especially in the face of competing production functions (such as commercial development) that provide greater profits for landowners [8]. Moreover, considering location, size, and access to necessary resources, land suitable for

producing food is more limited [9]. Second, development is limited by infrastructure constraints. Integrating urban agriculture into complex urban ecosystems requires planning beyond the production site. This planning must consider market connectivity, transportation systems, resource availability, and waste disposal systems, the widespread adoption of which can be severely limited by inadequate infrastructure and support services throughout food systems [10]. Third, socio-economic pressures such as rapid population growth, systemic poverty, and poor governance are critical issues for urban agricultural production in developing countries [11]. Moreover, unpredictable climate change, pests, and diseases negatively impact urban agriculture, resulting in lower yields and less income [12]. Fourth, agricultural development faces institutional constraints. The sustainability of urban agriculture mainly depends on the "institutional environment" in which it operates [13]. Poor governance of critical institutions such as extension services, access to credit, and land transfer restricts the development of urban agriculture. In summary, it is possible to enlarge the scale of agricultural land in urban settings through land institution reform, encourage investment in agriculture and improvement of various supporting facilities, and promote sustainable and green developments in urban agriculture.

After China's reform and opening up, the urbanization process has continued to advance, and the sustainable development of cities and food security has emerged as an urgent issue. In fact, since the 1990s, China has been exploring urban agriculture in its eastern coastal regions, achieving rapid development. In 2012, The Opinions on Accelerating the Development of Urban Modern Agriculture issued by the Ministry of Agriculture defined the development goals as "taking the lead in realizing agricultural modernization, steadily developing grain production, and doing a good job in the construction of the vegetable basket project". Hence, agricultural production remains the primary task of developing modern agriculture in urban areas. At the same time, as the core of the rural basic management system, farmland institutions are central to rural reform and development. The Rural Land Contract Law of the People's Republic of China (PRC) in 2002 stipulates that the ownership of rural land belongs to the collective, and land-use right is divided among the collective households. However, with the rapid development of modern agriculture and the rapid advancement of urbanization, the institutional defects of collective ownership and household contracts are gradually revealed. It is mainly manifested in the unclear property rights of rural land, poor land circulation, the low utilization efficiency of land resources, and imperfect rural land market mechanisms [14]. Therefore, since 2014, China began to require the ownership certificate of rural collective land to be confirmed, and by 2018, the country completed the confirmation of farmland. By issuing legally valid certificates of farmland contractual management rights to farmers(farmland titling), farmers are given more transparent, stable, and complete land contractual management rights. It reduces the risk of land transactions, enhances their confidence in long-term agricultural investment, and strengthens their ecological protection behavior of cultivated land [15]. While in economically developed areas with high degrees of marketization, favorable institutional conditions should be conducive to the implementation and efficacy of farmland titling policy, in addition to promoting the development of urban agriculture and Urban Farmer Households (UFHs).

According to the China Urban Modern Agriculture Development Report of 2019, Shanghai, Beijing, Chengdu, Nanjing, and Dalian are the top five cities based on a comprehensive ranking of five first-level indicators: the product support capability of the "food basket", the level of agricultural ecology and sustainable development, the integrated development level of the three industries, the aggregation level of advanced agricultural production factors, and the level of modern agricultural management. Among the five sub-index rankings, Guangzhou, the capital city of the Pearl River delta region, ranks only third in its level of integration of the three industries and fails to enter the top ten in the other rankings. Therefore, it is necessary and urgent to prioritize the development of urban agriculture in Guangzhou. In 2022, Guangdong Province's Development Plan for Building Urban Modern Agriculture in the Guangdong–Hong Kong–Macao Greater Bay

Area (draft for comments) proposed the objectives of high-quality and efficient agricultural production, comfortable and livable rural life, and a green and low-carbon urban and rural ecology. As the region's vanguard, it is essential to develop solutions for the shortcomings of agricultural development, promote the modernization and transformation of agriculture, and improve farmer income. In particular, finding a way to take full advantage of farmland titling policy and activate the development of rural production factor markets is a critical step in achieving these larger goals.

Based on the above reasons and property rights theory, this article discusses how the formal institution of farmland titling affects the allocation of UFHs' production factors. Furthermore, we empirically assessed how farmland titling affects the willingness toward rural production factor allocation using survey microdata from rural households in Guangzhou. The contributions of this study are as follows: First, we evaluate the impact of farmland titling policy on the willingness of UFHs' production with multi-factor allocation in Guangzhou. Second, we provide a land reform-based strategy for developing countries that seek to promote the integration of UFHs into the development of modern urban agriculture.

2. Literature Review

2.1. Urban Agriculture and Resilience

More and more extensive evidence shows that urban agriculture has the potential to enhance urban resilience [16]. The most apparent way urban agriculture can contribute to urban resilience is by enhancing the urban food security and healthy nutrition of the urban poor by providing fresh produce locally [17]. Food production can play an essential role in supplementing the diets of poor urban households with limited access to fresh food [18]. Urban agriculture has also increased consumers' fresh, healthy, and cheap food supply in other cities, since much of the food produced by UFHs is bartered or sold locally. In addition, urban agriculture can help improve the urban environment and increase city resilience. Urban agriculture produces food near the city, which shortens the distance to transport food, thus reducing energy use and greenhouse gas emissions [19]. The productive reuse of urban wastewater helps reduce the demand for freshwater supply, discharges wastewater to rivers, canals, and other surface water sources, and thus reduces pollution [20]. Furthermore, urban agriculture maintains the agricultural and forestry space and other areas, thus increasing urban vegetation coverage [21]. It can reduce the impact of climate change caused by floods, landslides, and other disasters and improve urban biodiversity and living conditions [22]. Urban agriculture can also create jobs and help fight unemployment and poverty. Its unbiased nature regarding employment creation and savings for both males and females has positive implications for gender equality and social equity [23]. Therefore, it is also conducive to creating strong and resilient communities.

2.2. The Allocation of Production Factors of UFHs

Urban agriculture takes place close to cities, and its production, ecology, and living functions are necessary for stable and healthy city development [24]. However, against the background of rapid urbanization, agriculture in urban areas is continuously squeezed by urban construction [25]. On the other hand, relying on a city's scientific and technological resources and market demand can enable more robust agricultural versatility [26]. Therefore, the factors affecting the development of urban agriculture are comprehensive and complex, including resource endowment, regional economic evolution, population change, policies and decrees, and the decision-making behavior of rural households, among others [27].

The allocation of production factors of UFHs can be characterized as follows. First, the function of farmland as a critical factor for agriculture production has been dramatically weakened in urban areas. Nevertheless, employment instability, the high cost of living in cities, and healthcare and education costs encourage UFHs to retain rural land to avoid future risks. Therefore, farmland continues to play a social security function. In addition,

the emotions of farmer households towards their farmland further restrain their land transfer decisions [28]. Secondly, the off-farm employment of UFHs is often characterized by local urbanization due to a surplus labor force. Therefore, the distance to off-farm work is correlated with farmland leasing behavior. While off-farm employment promotes the transformation of rural households, it raises the problem of farmland abandonment caused by the off-farm transfer. Thirdly, changes in the allocations of labor and farmland are also accompanied by intergenerational replacement; young and middle-aged rural residents pay more attention to future and development property rights than survival rights [29]. Moreover, urban areas are also influenced by traditional rural social and cultural networks due to the entry of migrants, forming complex social networks dominated by business relationships, blood relationships, and geographical relationship networks. These issues have a complex impact on the allocation of rural factors [30]. Regarding development prospects, researchers believe that urban economic development significantly impacts urban agriculture, and the traditional smallholder economy is no longer suitable for the development of modern urban agriculture [31].

2.3. Farmland Titling and the Allocation of Rural Households' Production Factors

First, we consider the relationship between farmland titling and farmland transfer. Researchers generally agree that certified farmland property rights are conducive to the long-term and stable farmland management expectations of rural households [32–34]. Certified farmland can encourage households to solve demand conflicts of scarce land resources through the market, reducing transaction costs and farmland disputes and thus contributing to farmland transfer [35,36]. However, some researchers have pointed out that farmland is a personhood property and, therefore, that paying too much attention to the legal definition and strengthening of farmland property rights may not necessarily achieve the expected effects with respect to the implementation of property rights [37]. Furthermore, for rural households, farmland titling strengthens their nature and identity, property monopoly, survival dependence, and incumbency control over contracted farmland [38], thus further strengthening and enhancing the endowment effect of rural households on farmland and inducing households to continuously increase the reservation price of transferred farmland. In turn, these forces may inhibit farmland transfer [39,40].

Second, we consider the relationship between farmland titling and off-farm work. Since its initial reform and opening up, China has enacted rural reforms that promote labor out-migration. This empirical fact highlights the difficulties in comprehensively and correctly analyzing China's labor migration patterns without considering farmland system reform. However, research on the impact of farmland property rights on labor migration has yet to reach a consensus. Some researchers believe that farmland titling is helpful to enhance rural households' farmland property rights, and migrant laborers that no longer have to worry about losing their farmland and feel more at ease about out-migration. From this perspective, increasing the stability of farmland property rights promotes rural labor migration [41–43]. However, some researchers have argued that, when farmland property rights are relatively incomplete, the contribution of these rights toward providing stable expectations for rural households is limited. Some studies have shown that the new round of farmland titling in China has almost no impact on labor migration [44]. Some researchers believe that abundant farmland significantly inhibit rural labor migration, while unstable farmland rights promote rural labor migration instead [45]. Farmland titling also inhibits non-agricultural labor migration by increasing rural households' capital and labor input [46,47]. In addition, some researchers have noted that the impact of the stability of property rights on labor migration is closely related to the local social environment. For example, research from Argentina found that farmland titling did not lead to rural labor out-migration. This finding might be explained by the fact that there were no other special institutional restrictions on labor migration before or after farmland titling [48].

Third, we discuss farmland titling and investment in agricultural production. Many researchers believe that farmland titling promotes agrarian investment by rural households,

as embodied by the following three tenets: (1) the enhancement of farmland title security improves the expectation of farmland title stability and stimulates investment intention [49,50]; (2) the improvement of the exchangeability of farmland increases the investment value of farmland and increases the investment confidence of rural households [51]; and (3) increase in the value of farmland mortgages stimulates the availability of credit for rural households and increase their agricultural investment capacity [52]. However, other researchers believe that the effects of farmland titling on rural households' agricultural investment behaviors are insignificant or even negative. Carter et al. (2003) found that the stability of farmland property rights promoted demand for agrarian investment only when rural households were not constrained by liquidity. Otherwise, there may be no significant correlation between farmland property rights security and agricultural investment [53]. Gerezihar (2014) found that the mortgage value of a small area of farmland was low, and farmland titling negatively affected specific farmland investments and inhibited the agricultural investment of rural households [54].

Overall, previous studies have failed to reach a consensus regarding the impact of farmland titling on the allocation of rural households' production factors, especially in the specific context of urban areas. Compared with rural areas far away from cities, the factor allocation of UFHs has different characteristics. As an institutional factor, how does farmland titling affect the multi-factor allocation of UFHs and then affect the resilience of urban agriculture? However, this internal logic has not been effectively explored, either in theory or empirically. Therefore, this article theoretically and empirically analyzes the current situation and the willingness of UFHs towards the allocation of production factors against the background of farmland titling implementation, ultimately proposing countermeasures and suggestions for the modern agricultural transformation of UFHs, which are profound for the resilience of urban agriculture.

3. Theoretical Analysis

According to the analysis framework of neoclassical economics, rural households are considered rational-economic. Under a specific external market environment and resource endowment, these actors make optimal allocations of labor, land, capital, and other production factors to achieve maximum utility. Based on the above framework and the paradigm of new institutional economics, this article addresses farmland titling as an institutional factor in UFHs' decision-making frameworks. This perspective expands rural households' rational assumptions to consider emotional, psychological, and ecological factors and analyzes how farmland titling affects UFHs' production factors allocation.

Understanding the initial logic of UFHs' production multi-factor allocation is important. Urban agriculture areas are adjacent to urban areas and have convenient transportation conditions, and urban economic development provides more employment opportunities. Therefore, the UFHs' agricultural production is affected by three traditional production factors: land, labor, and capital [55]. First, farmland rights are unstable, due to the dual impact of urban expansion and the benefits of non-agricultural farmland use. Unstable farmland rights led to extensive management with insufficient investment or low profit [56] and encourage a possession preference to retain quasi-ownership, as reflected by abandonment or lack of willingness to transfer out. Secondly, labor surplus and agricultural production labor quality are weak. Due to the limited scale and low efficiency associated with the fragmentation of farmland, UFHs often have a labor surplus. Usually, competent labor forces go out to obtain wage income, while women and the elderly make up the majority of those who stay at home and participate in farming [57]. Third, capital investment is non-agricultural and short-term. Due to factors such as low agriculture profit, insufficient stability of farmland property rights, and part-time labor employment, rural households are often more willing to invest in rural tourism, transport vehicles, and other general fixed assets in rural areas. Following the above logic, it seems that urban agricultural developments lack the foundation for a spontaneous transformation to modern agriculture.

Then, institutional factors should be induced in the decision-making frameworks of UFHs. As a change in the institutional environment, farmland titling provides a digital scientific measurement and record of farmland contracted by farmers and the issuance of written certificates. Implementing this policy endows rural households with stable and predictable farmland property rights and raises the cost of other subjects' encroachment on rural households' farmland rights and interests. Barzel notes that people's property rights to assets are not permanent but are a function of their direct efforts to protect them, other peoples' attempts to seize them, and the degree of government protection [58]. The government has strengthened rural households' farmland property rights through farmland titling, and a stable and precise definition of property rights is conducive to reducing transaction costs and promoting transactions. In this way, it is expected to strengthen and stimulate the allocation of factor markets and promote developments conducive to modern agriculture.

Furthermore, the process and basic logic of UFHs' decision making are directed towards multiple utilities, including economy, emotion, psychology, and ecology. It is assumed that UFHs expect modern agricultural production to enhance urban resilience through three methods: (1) the enlargement of farmland scale by farmland transfer and reduction in unit production costs to improve production efficiency; (2) the allocation of the labor force to non-agriculture departments with relatively higher salary incomes; and (3) the adoption of agricultural machinery instead of human labor, together with the scale of operation, to increase efficiency [59]. Adopting green technology to enable ecologically safe and high-quality production can benefit farmland fertility and long-term management. Moreover, it should be mentioned that the social networks of UFHs are more open compared to those in rural areas far away from urban areas. However, the social networks inside communities are still resilient to support the UFH's risks of urban employment and income fluctuations caused by market uncertainty. In addition, UFHs also have community attachments and endowment effects due to property rights preferences and loss aversion. Therefore, farmland titling strengthens farmland property rights, and UFHs with multiple utility goals may prefer not to rent out farmland to satisfy the psychological and emotional benefits of control. Still, they may wish to rent farmland to obtain returns to scale. Regarding farmland conservation, the long-term expectation is that the stability of property rights encourages rural households to protect farmland, reduce the possibility of abandoned farmland, invest in fixed agricultural assets, and adopt green production methods, such as organic fertilizers, for agricultural production [60]. However, due to a surplus labor force, farmland titling can stabilize UFHs' farmland property rights and reduce the risk of absentee status, potentially encouraging off-farm migration [61]. There are many migrant workers in urban areas, transportation is convenient, and the employment of agricultural labor is flexible. Moreover, the use of mechanized equipment in grain production has replaced labor, which has also alleviated the labor demand. Therefore, the allocation of important factors of urban agriculture discussed in this article does not include labor mobility. The conceptual framework is shown as Figure 1.

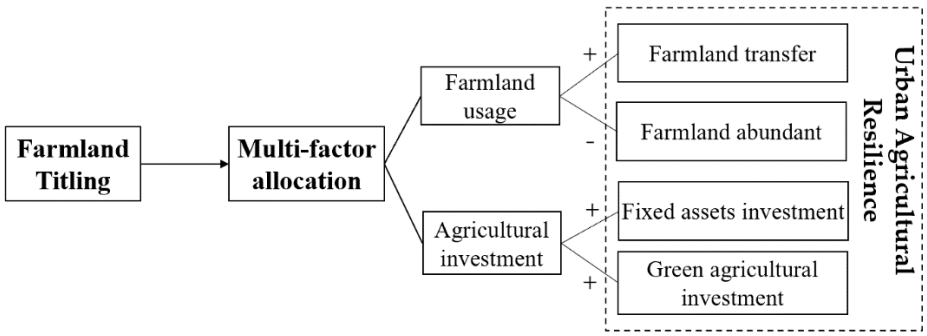
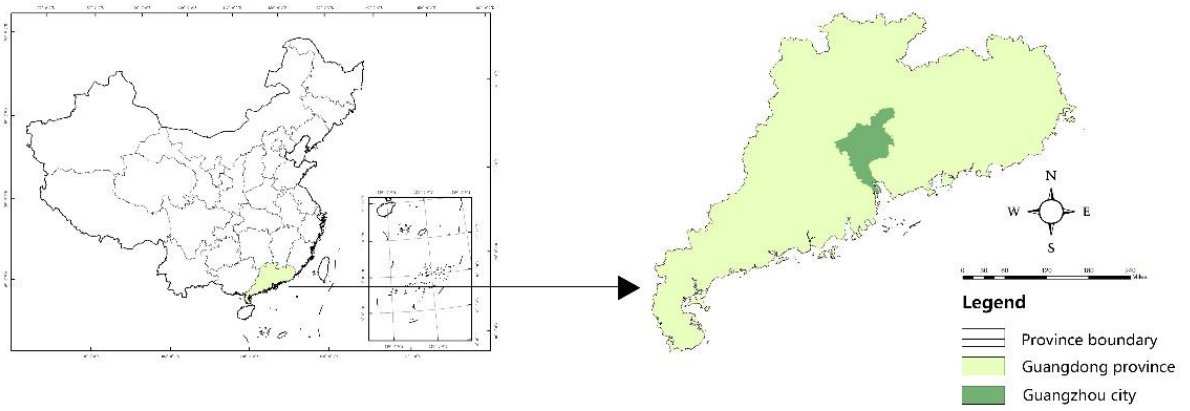


Figure 1. Conceptual framework.

4. Study Area

Guangzhou is located in the south of the Chinese mainland, the south-central region of Guangdong Province, and the northern edge of the Pearl River Delta, close to the estuary of the lower reaches of the Pearl River Basin (Figure 2). The climate is humid subtropical monsoon, with average temperatures of 21.8–23.1 °C and an average precipitation of 1421.2–2638.3 mm. As of 2020, Guangzhou has 11 districts under its jurisdiction, with a land area of 7434.40 km^2, a cultivated land area of 878.31 km^2, a built-up area of 1350.41 km^2, and a population density of 2521 km^{-2}. As one of the central cities in the Guangdong–Hong Kong–Macao Greater Bay Area, Guangzhou has experienced urban–rural integration, industrial transformation, and rapid economic development, with steady growth in primary, secondary, and tertiary industries. In terms of agriculture, the sown area of grain crops in the city was 263.10 km^2 in 2020, comprised mainly of rice, sugarcane, peanuts, and other crops; and sown areas accounted for 10.27%, 2.10%, and 2.08%, respectively. The total income of urban agriculture was 261.260 billion CNY, an increase of 9.60% over the same period the previous year.



Notes: This figure is based on a standard map downloaded from the standard map service system of the Ministry of Natural Resources of the People's Republic of China with approval number GS (2019) 1822. The base map has not been modified.

Figure 2. Geographical location of Guangzhou.

However, from 2000 to 2018, the cultivated land in Guangzhou decreased from 1591.15 km^2 to 878.31 km^2, and rural agricultural employees decreased from 898,800 to 510,100. In addition, there are the following shortcomings in its agricultural development.

On the one hand, Guangzhou has a significant income gap between urban and rural areas. According to data from the third national agricultural census, Guangzhou Statistical Yearbook and Guangzhou Agriculture Bureau released in 2017, the ratio of per capita disposable income between urban and rural households in Guangzhou decreased from 2.60: 1 in 2010 to 2.18: 1 in 2020. However, the gap is still significant, and the increase of farmers' income needs further improvement.

On the other hand, Guangzhou's agricultural development also faces a series of problems. First, the rate of farmland transfer is low, with small-scale management accounting for the vast majority. The per capita arable land area of agricultural personnel is 0.147 hectares, far lower than the national average. The proportion of farmland transfer area is 43.04%. Large-scale agricultural operating households accounted for only 2.02%. Second, the agricultural labor force has apparent characteristics of concurrent employment. Full-time farmers in the city account for only 46.43% of the total, with 34.75% of farmers aged 55 and above. The average agricultural income of households accounts for only 3.29%. Third, agrarian investment is insufficient, and the degree of mechanization and facilities is low.

Therefore, in this case, it is of great significance to research how to improve the quality and efficiency of agricultural development, increase the incomes of rural households, promote coordinated development in urban and rural areas, and promote innovative developments of urban agriculture in Guangzhou.

4.1. Macro-Performance of the Allocation of Rural Production Factors in Guangzhou

Since the implementation of the farmland titling policy, researchers have studied the impact of farmland titling policy from different perspectives. This article evaluates the implementation effect of farmland titling in Guangzhou, focusing on its impact on the allocation of production factors. By collecting data from the Guangdong Rural Statistical Yearbook and Guangzhou Statistical Yearbook from 2014 to 2020, this article assessed three factors' allocation: farmland transfer, rural labor allocation, and agricultural production investment.

4.1.1. Farmland Transfer

Data on farmland transfer rates in Guangzhou were obtained from 2014 to 2020, as shown in Figure 3. The rate of farmland transfer has been on the rise; especially since 2018, with annual farmland transfer growth rates of 2019 and 2020 reaching 51.9% and 65.15%, respectively.

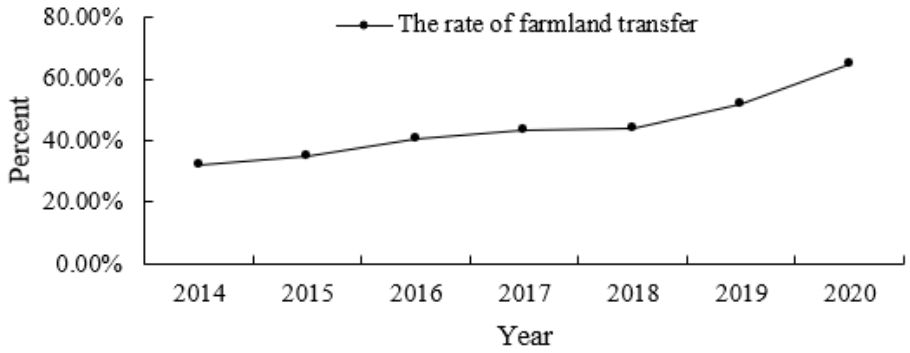


Figure 3. Trends in farmland transfer rate in Guangzhou.

4.1.2. Rural Labor Allocation

The change in the proportion of rural labor out-migration in Guangzhou from 2014 to 2020 is shown in Figure 4. As can be seen from the figure, the ratio of rural labor out-migration was low and relatively stable before 2018. However, the proportion of rural labor out-migration began to decline gradually after 2018. It was 13.41% in 2018, then dropped to 12.38% in 2019 and 11.88% in 2020. This trend supports our analysis in the theoretical section; it implies that the allocation of important factors of urban agriculture discussed in this article can exclude labor mobility.

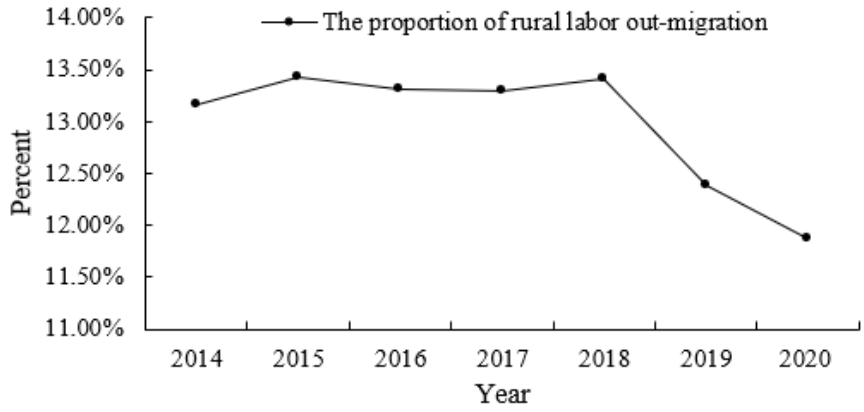


Figure 4. Trends in the proportion of rural labor out-migration in Guangzhou.

4.1.3. Investment in Agricultural Production: Pesticides and Fertilizers

The average usage of pesticides and fertilizers per mu in agricultural production in Guangzhou from 2014 to 2020 is shown in Figure 5. The average use of pesticides and fertilizers gradually increased from 2014 to 2017. However, since 2017, the usage of

pesticides and fertilizers has exhibited a significant downward trend and a relatively large decline rate. As a result, the average amount of pesticides per mu dropped to 1.97 kg in 2020, 15.97% lower than in 2017. Likewise, the average amount of chemical fertilizer per mu dropped to 182 kg in 2020, 13.13% lower than in 2017.

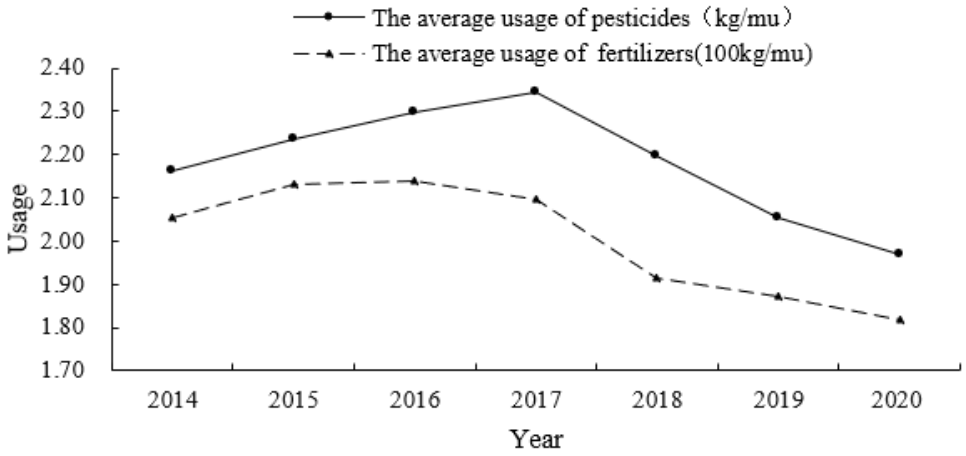


Figure 5. Trends in pesticide and fertilizer usage in agricultural production in Guangzhou.

Given the above analysis, when farmland titling was completed by the end of 2018, the allocation of agricultural production factors in Guangzhou exhibited a noticeable change trend, with the rate of farmland transfer increasing, the proportion of rural labor out-migration lightly decreasing, and the agricultural investment of pesticides and fertilizers decreasing. The above changes are observed from the macro level, but further examination is required to determine whether they are causally related to farmland titling policy. As the main operators of agricultural production, rural households' allocation behavior towards agricultural production factors can be viewed as a macroscopic manifestation of these trends. Therefore, theoretical and empirical research can be carried out from the perspective of rural households.

4.2. Implementation of Farmland Titling Policy in Guangzhou

According to the Implementation Plan for Registration and Certification of Rural Land Contract Management Rights of Guangzhou, farmland titling reform is based on the second-round contract ledger, farmland, and household registration data. However, modern information technology is leveraged through data collection, base map production, field investigation, internal processing, posting, signature and confirmation, and verification and certification, among other processes. The farmland contract management department records the plot, area, spatial location, and other changes to the contracted farmland of rural households in the register. In addition, the provincial agricultural department uniformly prints certificates stamped by the county-level government, which are then issued to rural households (Figure 6) [62].

Guangzhou has 11 districts, 124 towns (streets), 1296 economic unions, and 11,013 economic associations. Therefore, the city should confirm a farmland area of 849.33 km^2 with 566 thousand contracting households. In 2014, the Guangzhou Agriculture Bureau (Municipal Agriculture Office) established a leading group and working organization for farmland titling, registration, and certification, with Conghua District selected as a pilot region. In 2015, the Implementation Plan for Registration and Certification of Rural Land Contract Management Rights in Guangzhou was promulgated, and farmland titling was fully rolled out in the city. In the same year, the farmland area of the entire city was measured as 218,27 km^2, accounting for 25.7% of the expected total. In particular, the measured farmland area of Conghua District is 18.33 km^2, basically completing the farmland measurement task. At the end of January 2017, the farmland area of the city was measured to reach 559.47 km^2, accounting for 65.25% of the expected area. By 2020,

Guangzhou had completed farmland titling, registration, and certification, covering an area of 1010.87 km^2 and issuing 648,050 certificates [63].

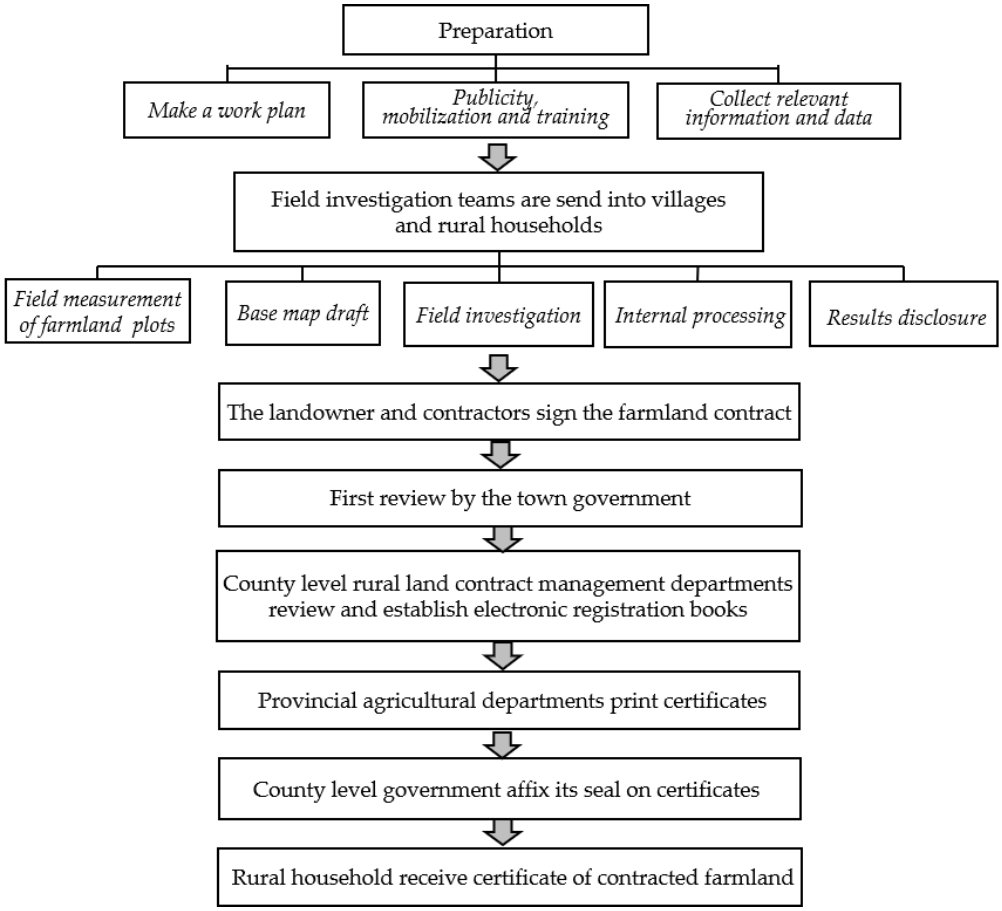


Figure 6. Flowchart of farmland confirmation in Guangzhou.

5. Data Source and Variable Selection

5.1. Data Source

The data used in this study come from a questionnaire survey of UFHs in Guangzhou. In mid-2018, the research group selected two districts in Guangzhou that had not completed farmland titling to conduct a household-level survey and used simple random sampling method. A total of six administrative villages were randomly selected from each district, and 18 rural households were randomly surveyed from each village. Finally, the research group collected 216 questionnaires, of which 204 thoroughly answered the relevant study questions and were considered valid.

5.2. Variables

First, explained variables include the willingness of UFHs towards production factor allocation. UFHs' willingness was gauged based on "willingness of farmland transfer-out", "willingness of farmland transfer-in", "willingness to abandon farmland", "willingness to increase investment in agricultural fixed assets", and "willingness to use organic fertilizer" in the next year. The above items were all assessed using Likert's three-point or five-point scale.

Second, the explanatory variable is farmland titling, measured using the item "Do you receive the certificate of farmland titling?" If yes, the value is 1; otherwise, it is 0.

Third, we identified control variables. According to existing research, factor allocation in rural households is affected by farmland characteristic variables and family characteristic variables. Therefore, the following control variables were selected in this article. Individual

characteristic variables included householder's age, gender, education level, and village cadres identity. Household characteristic variables included the number of family members in the labor force, the proportion of agricultural income, the adjustment of farmland, contracted farmland area, and the number of plots. In addition, we also controlled for village income and traffic conditions.

The method of variable assignment and descriptive statistical results are shown in Table 1.

Table 1. Statistical description of variables (n = 204).

Variable.	Definitions.	Mean.	S.d.	Min.	Max.
Farmland titling	Whether a certificate of farmland titling has received (1 = Yes; 0 = No).	0.382	0.487	0	1
Willingness of transfer-in farmland	Willingness to transfer-in of farmland next year (1 = no; 2 = uncertain; 3 = Yes).	1.588	0.714	1	3
Willingness of transfer-out farmland	Willingness to transfer-out of farmland next year (1 = no; 2 = uncertain; 3 = Yes).	1.461	0.690	1	3
Willingness of abandon farmland	Willingness to abandon farmland next year (1= absolutely disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = absolutely agree).	1.794	0.908	1	5
Willingness of agricultural investment	Willingness to increase investment in fixed agricultural assets next year (1 = absolutely disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = absolutely agree).	3.456	0.974	1	5
Willingness of green agriculture	Willingness to use organic fertilizer next year (1 = absolutely disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = absolutely agree).	3.971	1.012	1	5
Age	Age of householder (years).	51.441	12.537	21	84
Gender	Gender of householder (1 = Male; 0 = Female).	0.701	0.459	0	1
Education	Education level of householder (years).	7.765	3.288	0	16
Village cadre	Whether the householder is a village cadre (1 = Yes; 0 = No).	0.113	0.317	0	1
Risk preference	Lottery experiment of householder (score of 1–5 represents risk preference).	2.103	1.205	1	5
Farmland Area	Contracted farmland area (mu).	5.950	9.785	0.03	55
Farmland Plots	Number of contracted parcels (plots).	4.755	3.175	1	25
Labor force	Number of household labor force members (people).	3.358	1.694	0	9
Family income	Ln (Total household income (CNY)).	11.175	1.240	2.565	15.614
Village income	Ln (Village per capita income (CNY)).	9.309	0.524	8.412	10.177
Village traffic	Time to town center by traffic (hours).	0.382	0.487	0	1

6. Empirical Analysis

6.1. Model Design

This article examines the impact of farmland titling on the willingness of UFHs' factor allocation, which can be expressed as the following Formula (1):

$$Y_{ij}^{*} = \beta_0 + \beta_1 titling_i + \beta_2 X_i + \varepsilon \quad (1)$$

where Y_{ij} represents the willingness of the ith UFH, including the willingness of transfer-in farmland when $j = 1$, the willingness of transfer-out farmland when $j = 2$, willingness to abandon farmland when $j = 3$, the willingness of investment in agriculture when $j = 4$, and willingness of green agriculture when $j = 6$. $Titling_i$ represents whether the ith UFH

has a certificate of farmland titling, X_i represents control variables, β_1, β_2 are parameters to be estimated, β_0 is a constant term, and ε is a random error term.

Since the explained variables—willingness of farmland transfer-in, farmland transfer-out, farmland abandonment, agricultural investment, and green agriculture—are all ordinal variables, the Ologit model is used for estimations.

6.2. Benchmark Model

As shown in Table 2, the results in columns (1), (3), and (5) indicate that farmland titling has significant effects in promoting UFHs' willingness to transfer-in farmland, reducing their willingness of abandon farmland, and promoting the willingness of green agriculture. The results in columns (2) and (4) demonstrate that farmland titling has no significant impact on UFHs' willingness of transfer out farmland or agricultural investment.

Table 2. Farmland titling and willingness of urban agricultural factor allocation.

Variable.	(1)	(2)	(3)	(4)	(5)
	Farmland Transfer-In	**Farmland Transfer-Out**	**Farmland Abandonment**	**Agricultural Investment**	**Green Agriculture**
Farmland titling	1.048 ***	–0.265	–0.660 *	0.324	1.020 ***
	(0.333)	(0.337)	(0.339)	(0.340)	(0.346)
Age	0.013	–0.009	–0.020	0.001	–0.004
	(0.014)	(0.014)	(0.013)	(0.012)	(0.013)
Gender	–0.421	0.209	0.314	0.205	–0.677 *
	(0.342)	(0.351)	(0.368)	(0.346)	(0.355)
Education	0.048	–0.054	0.029	0.034	0.049
	(0.063)	(0.061)	(0.062)	(0.056)	(0.058)
Village cadre	–0.607	1.138 **	0.989 *	–0.404	–0.442
	(0.465)	(0.518)	(0.587)	(0.471)	(0.506)
Risk preference	0.055	–0.020	–0.276 **	0.145	0.331 **
	(0.127)	(0.129)	(0.123)	(0.135)	(0.142)
Farmland area	–0.022	–0.008	–0.062 ***	0.066 ***	0.023
	(0.022)	(0.022)	(0.023)	(0.023)	(0.021)
Farmland plots	0.006	–0.010	0.179 **	0.001	–0.004
	(0.085)	(0.073)	(0.070)	(0.054)	(0.059)
Labor force	–0.145	–0.076	–0.123	–0.105	–0.150
	(0.106)	(0.103)	(0.108)	(0.096)	(0.096)
Family income	0.158	0.107	0.040	–0.121	–0.129
	(0.158)	(0.152)	(0.153)	(0.119)	(0.117)
Village income	–0.274	–0.555	–0.049	0.027	0.712 **
	(0.364)	(0.356)	(0.347)	(0.401)	(0.310)
Village traffic	–2.010	0.164	–3.075 **	–4.993 ***	3.148 **
	(1.297)	(1.226)	(1.346)	(1.060)	(1.319)
Wald chi2(12)	24.69	10.27	36.40	44.95	48.61
Pseudo R^2	0.070	0.032	0.075	0.086	0.108
Observations	204	204	204	204	204

Note: Robust Standard Errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

From the marginal effect in Table 3, it can be seen that, when other conditions are controlled, the probability of UFH indicating "yes" to the willingness of farmland transfer-in is increased by 11.4% compared with the probability before farmland titling. The probability of responding "absolutely disagree" towards the willingness to abandon farmland increased by 14.1%. The probability of responding "absolutely agree" towards the willingness to green agriculture increased by 19.2%.

Table 3. Farmland titling and willingness of urban agricultural factor allocation: marginal effect.

Items	(1) Farmland Transfer-In	(2) Farmland Transfer-Out	Items	(3) Farmland Abandonment	(4) Agricultural Investment	(5) Green Agriculture
1	–0.230 ***	0.057	1	0.141 **	–0.009	–0.018 **
	(0.066)	(0.072)		(0.070)	(0.010)	(0.008)
2	0.116 ***	–0.031	2	–0.040 *	–0.038	–0.056 **
	(0.033)	(0.039)		(0.022)	(0.041)	(0.024)
3	0.114 ***	–0.026	3	–0.077 *	–0.021	–0.090 ***
	(0.039)	(0.034)		(0.040)	(0.022)	(0.031)
			4	–0.018	0.047	–0.027 *
				(0.011)	(0.049)	(0.014)
			5	–0.006	0.022	0.192 ***
				(0.004)	(0.023)	(0.059)

Note: Robust Standard Errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

6.3. Robustness Test

First, we used the model replacement. If the results of OLS and Ologit are similar, OLS may be simpler and easier to explain [64]. To check the robustness of the benchmark model, we used OLS instead of Ologit models to regress. The results are shown in Table 4, farmland titling significantly positively impacts UFHs' willingness to farmland transfer-in at the level of 1%, and UFHs' willingness of green agriculture at the level of 5%. Although the influence of farmland titling on UFHs' farmland abandonment is insignificant, the direction and magnitude of its coefficient are consistent with the benchmark model, demonstrating that the results of the benchmark model are stable.

Table 4. Robustness test based on OLS model.

Variable	Willingness				
	(3) Farmland Transfer-In	(4) Farmland Transfer-Out	(5) Farmland Abandonment	(6) Agricultural Investment	(7) Green Agriculture
Farmland titling	0.381 ***	–0.112	–0.176	0.081	0.345 **
	(0.115)	(0.106)	(0.145)	(0.150)	(0.158)
Control variable	YES	YES	YES	YES	YES
Constant	1.525	2.904 ***	2.520 *	3.996 ***	1.082
	(0.944)	(1.024)	(1.423)	(1.533)	(1.379)
Observations	204	204	204	204	204
R^2	0.139	0.064	0.127	0.181	0.219

Note: Robust Standard Errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Secondly, we used Propensity Score Matching (PSM) to alleviate selection bias or omitted variables. Possessing farmland titling certificates at the household level may not be entirely random. For example, if the certificate's contents need to be returned for modification due to different reasons, they may fail to receive the certificate on time [65]. Therefore, it means that the baseline model may be subjected to selection bias or omitted variables. Previous studies have shown that the use of Propensity Score Matching (PSM) can alleviate this bias. Therefore, this article adopted the kernel matching method. The matching results are shown in Figures 7 and 8, and multiple linear regression estimation

was performed on the matched samples. The results in Table 5 show that farmland titling has a significant positive impact on UFHs' willingness of farmland transfer-in and on UFHs' willingness toward green agriculture. The direction and coefficient of impact on UFHs' farmland abandonment are consistent with the benchmark model and the previous regression results, which verifies the robustness of the benchmark model's results again.

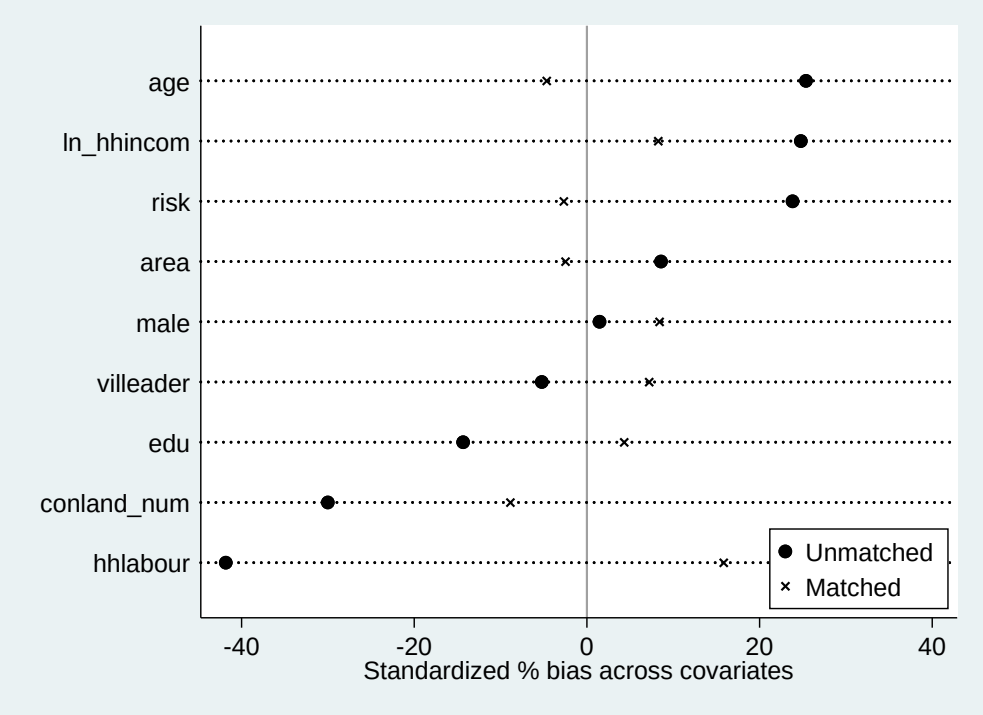


Figure 7. Standardized deviation of variables before and after PSM matching.

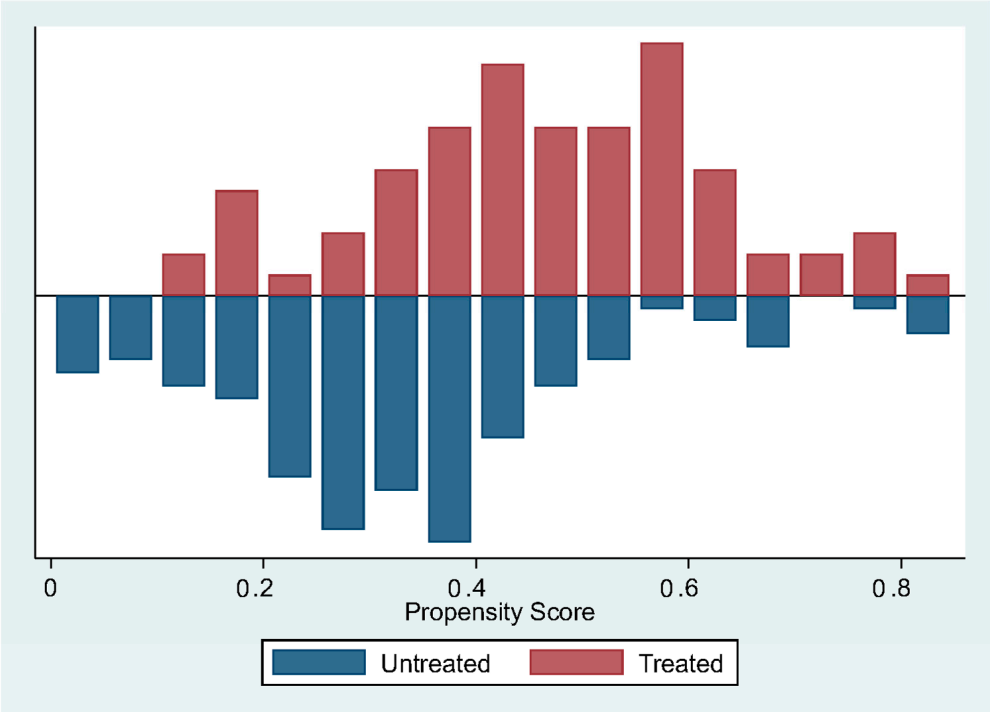


Figure 8. Common value range of PSM.

Table 5. Paired regression results after using PSM.

Variable	Willingness				
	(3)	(4)	(5)	(6)	(7)
	Farmland Transfer-In	Farmland Transfer-Out	Farmland Abandonment	Agriculture Investment	Green Agriculture
Farmland titling	0.246 *	–0.117	–0.140	0.092	0.401 **
	(0.143)	(0.110)	(0.156)	(0.162)	(0.176)
Control variable	YES	YES	YES	YES	YES
Observations	198	198	198	198	198
R^2	0.137	0.080	0.137	0.242	0.187

Note: Robust Standard Errors in parentheses, * $p < 0.1$, ** $p < 0.05$.

6.4. Heterogeneity

This article further analyzes the heterogeneity of householder's characteristics differences in the impact of farmland titling on factor allocation. First, we considered the householder ages of UFHs. Previous studies have shown that older householders tend to be conservative, have lower risk tolerance, and be generally unwilling to expand production scale and adopt new things [66,67]. Therefore, this article divided the samples into two groups by mean of householder's age for a heterogeneity analysis. Secondly, householder's education level is an essential human capital and plays a significant role in UFH' decision making [68]. The higher the education level of the householder, the stronger the ability to accept new technologies and new things, and the better the ability to improve farmland use efficiency [69]. Therefore, this article divided the samples into two groups based on householder's average education level for a heterogeneity analysis.

Table 6 shows the heterogeneity analysis results of farmland titling on UFHs' multi-factor allocation willingness. The table only reports the regression coefficient results of farmland titling in each model, and the selection of model and control variables is consistent with those in Table 2. Firstly, the results show that the impact of farmland titling on the willingness of rural households in the higher age group is more multi-dimensional. In the high-age group, farmland titling positively affects UFHs' farmland transfer-in willingness, and agricultural greening willingness, while having negative effects on UFHs' farmland transfer-out willingness and farmland abandonment willingness. However, in the low-age group, farmland titling only positively affects UFHs' farmland transfer-in willingness, farmland investment willingness, and agricultural greening willingness. Moreover, the positive impact is more significant in the low-age group. Secondly, compared with the low-education group, the positive impact of farmland titling on UFHs' farmland transfer-in willingness, and green agriculture willingness are more in the high-education group. Furthermore, there are apparent differences in willingness of farmland transfer-out. Farmland titling inhibits farmland transfer-out in high-age group.

Table 6. Heterogeneity analysis: householder's age and education level.

Variable		Age		Educational Level	
		Low	High	Low	High
Willingness	Farmland transfer-in	1.533 *** (0.566)	0.845 * (0.447)	0.882 * (0.500)	1.103 ** (0.480)
	Farmland transfer-out	0.201 (0.481)	–0.912 * (0.526)	–0.135 (0.536)	0.040 (0.502)
	Farmland abandonment	–0.028 (0.510)	–1.013 * (0.538)	–0.907 (0.577)	–0.552 (0.512)
	Agricultural investment	1.098 ** (0.507)	–0.326 (0.464)	–0.178 (0.549)	0.831 (0.547)
	Green agriculture	0.959 * (0.568)	0.924 ** (0.458)	0.130 (0.595)	1.146 ** (0.477)
Observations		92	112	92	112

Note: Robust Standard Errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

7. Discussion

The outward expansion of large cities has meant increasing and more complex interactions with the surrounding rural areas and gradual changes in their land uses and occupations. Therefore, metropolitan areas where urban and rural activities are juxtaposed have appeared. They are characterized by dynamic allocations of commodities, capital, land, people, pollution, and a range of processes leading to the intensification of urban–rural linkages [70,71]. In recent years, metropolitan areas as transitional zones have received attention in some countries, and they argue that metropolitan agriculture and its marginalized rural households need to be recognized as key in addressing the challenges of sustainable urbanization and food security [72]. For those metropolitan communities still involved in smallholder farming, the land use transformation processes have unfolded in several ways: land acquisition for industrial, commercial, real estate, and infrastructure development. The competition for land use is increasingly fierce, and the vulnerability of small-scale rural households is increasing [73]. Some UFHs have limited farmland resource capabilities, and the scale of contracting farmland is small. It is difficult to use mechanized operations, resulting in low production efficiency. In addition, they have weak economic strength, a lack of competitive advantages, weak resistance to risks, affecting their agricultural production investment, and making it hard to obtain reasonable profits. Therefore, some labor force goes out to work and turns to non-agricultural sectors to earn income. The above issues directly impact the development and modernization of metropolitan areas, which is not conducive to establishing urban resilience and sustainability. Many studies have found that the improvement of farmland property rights can effectively protect the interests of rural households and help to improve the behavior incentives and expectations for future output of rural households.

Many countries widely support farmland system reform and consider farmland use rights to be one of the most critical factors determining the viability of urban agriculture [74]. Urban agricultural activities face intense competition for farmland with industrial and other economic activities and housing demand. While in most developing countries, few rural households own farmland, the rest are forced to choose informal farmland use rights that allow them to use their farmland quickly, at low prices, or for no fees [75]. The large-scale existence of informal land property rights implies that the land tenure of urban agriculture is highly insecure, a crucial obstacle to improving urban agriculture and encouraging factor investments in urban agriculture [76]. Worldwide, countries have implemented different land property rights systems to solve the above problems. Sweden, a developed country, has two completely different lease forms [77], which provide different levels of security and rights and involve different lease costs, guaranteeing the safety of farmland lease rights and promoting urban agricultural production [78]. In South Africa, a developing country, Johannesburg formulated the "Food Elasticity Policy" in 2012. This policy promoted urban agriculture in ways ranging from training and skill development, packaging, and retail centers to providing urban farmland for urban agricultural production to address the regularization of rural households' farmland rights [79]. The city established five empowerment zones in the city's suburbs where farmers can rent farmland and distribute municipal land through agricultural centers to rural households for agricultural production [80]. In China, with the implementation of the farmland titling policy, the vitality of rural development is constantly stimulated. However, realizing system objectives closely relates to regional endowment conditions and social development levels. Previous studies have not reached a consensus regarding the impact of farmland titling on multi-factor allocation. Compared with rural areas far away from cities, the impact of farmland titling on UFHs' multi-factor allocation in metropolitan regions has distinct characteristics.

8. Conclusions

The contribution of this article is to clarify the theoretical logic that farmland titling affects the willingness of UFHs' factor allocation based on property rights theory. Using survey data of rural households in Guangzhou in 2018, this paper empirically analyzes

the impact of farmland titling on the UFHs' factors allocation. Then, this article tests the robustness of the benchmark model results and its heterogeneity of householder's age and educational level. The results show that, firstly, farmland titling promotes UFHs' willingness to farmland transfer-in and green agriculture and effectively inhibits UFHs' willingness to abandon farmland. Secondly, by replacing the regression model and using PSM for robustness test, the results show that the benchmark model's results are reliable. Thirdly, the heterogeneity analysis shows that the negative impact of farmland titling on UFHs' willingness to abandon farmland is significant in the high-age group. However, the positive impact of farmland titling on farmland transfer-in willingness, agricultural investment willingness, and agricultural greening willingness is more in the low-age group. Compared with the group of low education level, farmland titling has a more positive impact on UFHs' willingness of farmland transfer-in, and willingness of green agriculture in the group of high education levels.

The practical significance of this article lies in evaluating the effects of farmland titling policy in Guangzhou, China, and in exploring the logic by which farmland property rights affect factor allocation in metropolitan areas. The results of our research have practical implications for the promotion of urban agriculture in developing countries. This article gives related suggestions for policymakers. First, promoting reform of the farmland system, protecting UFHs' transfer of farmland, releasing the vitality of the farmland market, and improving the urban construction structure ensures a stable supply of farmland for urban agriculture. Second, constant support of the cultivation of agricultural and rural talents activates endogenous power, speeds up the cultivation of new professional farmers, and builds a team of modern urban agricultural talents. Third, UFHs' can benefit from strengthening agricultural financial input, improving policies that benefit farmers and the rural social security system, and building a reasonable and modern rural financial service system to help farmers invest in green agriculture. At the same time, this study also has significance for developed countries. In many developed countries, private ownership of land is practiced. Land can be freely bought, sold, leased, and mortgaged, forming a reasonable land transaction market with a good land investment environment and sufficient agricultural investment motivation [81]. For developed countries, urban agriculture mainly faces the sustainability challenge [82]. In addition, land security is considered to affect urban agriculture's long-term sustainability directly. Therefore, maintaining the land property rights policy and promoting the stability of farmland lease transactions promote ecological and green production conducive to urban agriculture's resilience.

The limitations of this article are as follows. First, the sample size is relatively small and may limit its generalizability and representativeness. According to the Guangzhou Statistical Yearbook (2018), the average "Number of household labor force members" is 3.28 (3.358 in current study), and the urban farmer households' "Contracted farmland area" in the sample is also acceptable (5.95 mu), which can partly support our sample's representative. Second, according to the year of data collection, the impact effects in this paper are necessarily short-term. Research on the long-term effects of this policy should be continued in the future. Third, the policy suggestions proposed at the end of this article are relatively general. In the future, more targeted policy suggestions can be explored through additional research or field experiments.

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