Financial Development and Rural Transformation: Evidence from County-level Data in China

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Abstract

China has achieved remarkable success in agricultural development, including increased agricultural productivity and rural incomes, over the past four decades. While it is believed that rural financial development is essential to promote the transformation process, little is known about how it has played the role. In this paper, we construct agricultural production account for a panel of 1465 rural counties and apply it to investigate rural financial development in China and its impact on agricultural labor productivity. Drawing on a natural experiment of the Postal Saving Bank of China (PSBC) reform (which incorporate both establishing new branches across regions and authorizing branches to provide credit services), we construct a generalized staggered difference-in-difference (GSDID) as the empirical strategy to identify the causality. We show that rural financial development, in terms of the PSBC reform, has contributed to 8.2% increase in agricultural labor productivity for the 1993-2016 period, driven by 11.6% in agricultural productivity and -3.4% decrease in total capital deepening. However, financial development in rural China exhibits asymmetric effects on the efficiency of physical capital investment and land use, enhancing the former while decreasing the latter. These findings offer valuable insights for policymakers in China and other developing countries, underscoring the significance of land institutional arrangements in affecting the performance of rural financial development. By understanding the potential interaction between financial development and land institutional arrangements, policymakers can design effective strategies to foster sustainable rural development and economic growth.

Keywords: Rural Financial Reform, Agricultural Labor Productivity, Technology Progress, Capital Deepening, Land Consolidation

JEL Codes: G20, O40, Q14, Q15

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1 Introduction

Over the past four decades, China has made a great achievement in agricultural development, making significant contributions to ensuring national food security, increasing rural income, and reducing the incident of poverty. From 1978 to 2022, agricultural GDP in real term (at the 2010 constant price) has on average grown at a rate of 5.4% per year, far surpassing the average population growth rate of 1.0% per year for the same period. This success resulted in a substantial improvement in per capita food supply. Despite possessing only 5% of the world's freshwater resources and utilizing less than 9% of the world's arable land, China, with nearly 20% of the global population, not only resolved the food security issue but also significantly improved the nutritional structure of the entire population. The rapid development of agriculture also led to a substantial increase in rural income and a decrease in the incidence of rural poverty. By the end of 2020, China has successfully lifted all rural populations out of poverty according to existing standards, achieving the goals set by the United Nations for sustainable development (SDG) in 2030 a decade ahead of schedule. This accomplishment serves as a model for achieving zero hunger and zero poverty on a global scale.

While a significant success has been made in the past, China's agricultural development still faces numerous challenges. First, the labor-intensive farming system, predominated by small household farms, has restrained the growth of agricultural productivity, leading to a rapid decline in the international competitiveness of agricultural products. Second, agricultural output growth has often come at the expense of sacrificing natural and environmental resources. Pressures on agricultural production from constraints on land and water supply and environmental pollution are intensified over time. Third, the growth of farmers' income from engaging in agricultural production has slowed significantly, resulting in the widening income gap between urban and rural areas, becoming a major constraint to achieving common prosperity for the entire population. To address these challenges, the 20th National Congress of the Communist Party of China has set a new goal of transforming China from an agricultural powerhouse to an agricultural strong nation, through promoting the modernization of agricultural production and accelerating the rural revitalization process. However, to achieve this goal, the priority is to expedite the reform on the

rural land, labor and financial markets. By promoting the efficiency of capital and labor allocation, stimulating on-farm innovation, and enhancing agricultural productivity, this reform aims to drive the industrialization and commercialization of agricultural production.

There have been a large number of studies carried out to examine the role of institutional reforms on the land, labor and financial markets in facilitating agricultural development (Meng, 2000; Carter and Olinto, 2003; Ito, 2010). These studies generally attributed the rapid growth of agricultural labor productivity in rural China either to the land reform (i.e. Lin (1992) household responsibility system reform) in the late 1980s or the labor market reform in the early 2000s (i.e. relaxation of the Hukou system). However, little attention has been paid to rural financial development since the late 1990s and its impact on agricultural development. Theoretically, it is believed that establishing effective financial markets is the foundation of modern economic development (Levine and Zervos, 1998; Gatti and Love, 2008; Guirkinger and Boucher, 2008; Brown, Martinsson, and Petersen, 2012; Pardey and Alston, 2019). Yet, the impact of financial institution development on agriculture may differ from non-agricultural sectors, since agricultural production is more uncertain and heavily dependent on land as a fixed input (Sheng et al., 2024). On the one hand, it may relax financial constraints on farms, leading to increased adoption of new technologies. On the other hand, it may engage in risk mitigation for small, less productive farms, thereby slowing down industry consolidation. The conflicting effects may offset each other, making the overall impact of financial development on agricultural labor productivity an empirical question.

In this paper, we investigate financial development in rural China and its impact on agricultural development, with a particular focus on agricultural labor productivity. As the world's largest and fastest-growing developing country, China's rural financial development has undergone a complex reforming process since the mid-1990s. With the establishment of new branches and deregulation in the credit market, the rural financial system has gradually transformed from being dominated by the central-planned and state-owned banks to the market-based system with the diversified entities. By 2020, the average coverage rate of bank branches at the township level reached 97.13%, and more than 99.97% of administrative villages could get basic financial services. At

the same time, the total bank loans in agriculture reached 43.21 trillion yuan, with around 20.6% appropriated to small household farms. The rapid development of rural financial market in China has not only made significant contributions to the development and transformation of agriculture but has also accumulated a wealth of experience and lessons for other developing countries in different stages of agricultural development.

Drawing on a natural experiment of the Postal Saving Bank of China (PSBC) reform, we construct a generalized staggered difference-in-difference (GSDID) as the empirical strategy to quantify the impact of rural financial market reforms. A continuous measure of the PSBC reform is developed, which incorporates both the establishment of new branches across regions over time and the authorization of the self-operating branches to switch from collecting deposits to providing credit services. By using a balanced panel of 1,474 rural counties for the 1993- 2016 period, we then examine the impact of the PSBC reform on agricultural labor productivity through either promoting agricultural technology progress and on-farm innovation or facilitating capital deepening. To properly identify the causality, we adopt the generalized method of moment (GMM) approach, following Arellano and Bond (1991); Blundell and Bond (1998); Wooldridge (2001) to address the potential omitted variable and reverse causality problem, in addition to using the two-way-fixed effect (TWFE) model. We also address the recent econometric concerns, such as sample selection bias and the negative weight problems, on the TWFE model. Finally, we have also conducted a series of robustness checks to examine the PSBC, in terms of the establishment of new branches across regions over time and the authorization of the self-operating branches to switch from collecting deposits to providing credit services, respectively.

We show that rural financial development, in terms of the PSBC reform, has contributed to 8.4% increase in agricultural labor productivity for the 1993-2016 period, driven by an increase in agricultural productivity by 11.6% and a decrease of returns to total capital deepening by 3.4%. This result implies that rural financial development positively contributed to agricultural productivity growth through promoting technology progress, but negatively affect the contribution of total capital accumulation in agriculture through increasing the rural credit supply. While the overall effect on total capital accumulation is negative, rural financial development imposed

asymmetric effects on the efficiency of physical capital investment and land use, enhancing the former but decreasing the latter. Our finding implies that the rigid land institutional arrangement could restrict the development of rural financial market from facilitating the more efficient use of land within agriculture, and thus causing a decline in the returns to capital and hindering agricultural labor productivity growth.

Our paper contributes to the literature at least in three aspects. Firstly, we construct agricultural production account at the county level in China to reveal the impact of technological progress and capital investment on agricultural labor productivity, with a specific focus on the role of financial market reforms. Many studies have examined the impact of financial market reforms and their impact on productivity and economic growth in many countries (e.g, Levine and Zervos (1998); Andrews and Cingano (2014); Bravo-Biosca, Criscuolo, and Menon (2016)), but most of them focus only on the non-agricultural sectors or the whole economy (Brandt and Rawski, 2008; Brandt and Zhu, 2007; **?**; Chava et al., 2013; Moll, 2014) and did not attempt to examine the mechanism through which the rural financial market reform may impose its impact. Secondly, we construct a natural experiment based on the PSBC (one out of three largest rural financial institutions in rural China) reform and incorporate both the increased financial penetration ratio and banking deregulation: the number of years since the first PSBC branch was established and whether the PSBC branch in the county is allowed to provide the loan services. The previous literature usually uses only the dummy variables to measure financial reforms (Beck, Levine, and Levkov, 2010; Rice and Strahan, 2010), or the financial market intensity (Cetorelli, 2004; Krishnan, Nandy, and Puri, 2015) to analyze its economic impact. Yet, our measurement enable the cross-county comparison of the extent to which the PSBC reform is implemented in a continuous way. Thirdly, we distinguish between physical capital accumulation and land consolidation when looking at the role of rural financial market reform in affecting capital accumulation. In particular, we highlight the particular role of land reallocation within the industry, pointing out the possibility that the financial market reform could restrict land consolidation through increasing the survival rate of small farms. This contributes to enrich the literature on the relationship between financial development and rural economic transformation.

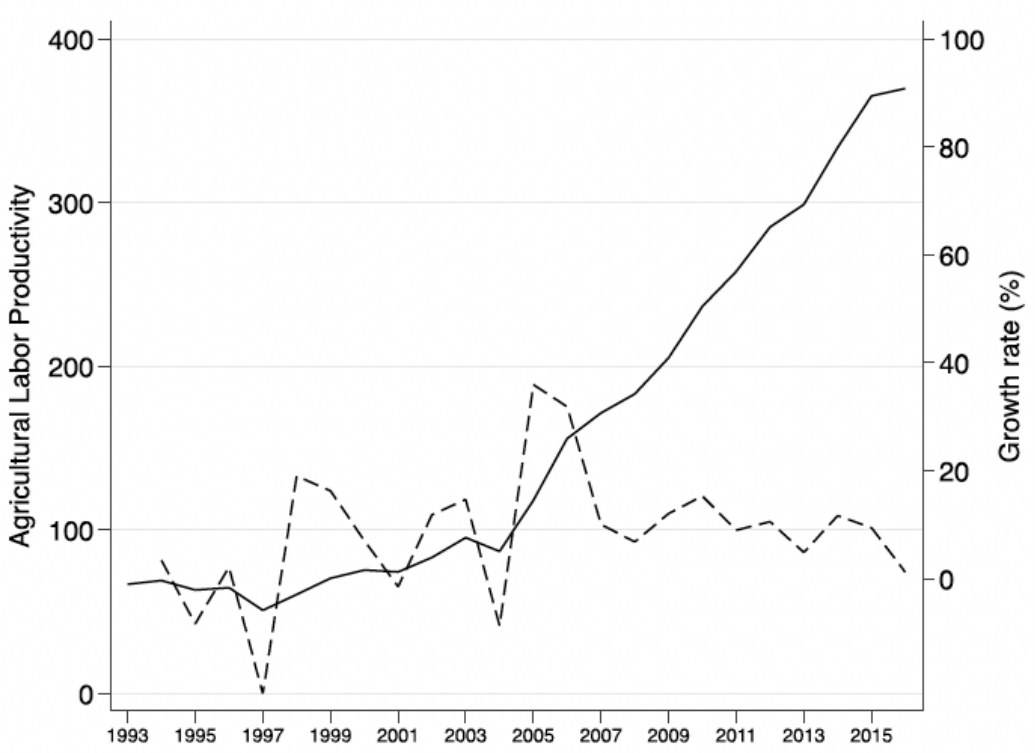
The rest of the paper is organized as below. Section 2 describes the development of financial market in rural China since the mid-1990s, with a particular focus on the deregulation reform of the PSBC. Section 3 develops a simple structural model to specify the mechanism through which financial development may affect agricultural labor productivity, followed by a discussion on the empirical strategy and the solution on the related econometric issues in Section 3. Section 4 presents the data source and the descriptive statistics on major variables. A continuous variable is constructed to measure the PSBC reform across regions over time. Section 5 analyze the estimation results, and Section 6 shows the robustness results. Section 7 concludes.

2 Rural Financial Development and the PSBC Reform

Over the past four decades, agricultural labor productivity has experienced a rapid growth, thereby increasing the income of farmers engaged in agricultural production and eliminating the urban-rural and industrial-agricultural income disparities. Between 1978 and 2022, agricultural labor productivity, measured as agricultural GDP per capita in real term (at the 2010 constant price) has grown at the rate of 4.4% per year, higher than that in non-agricultural sector (e.g. 4.0% per year) and in agriculture of many other developing countries in Asia and the Pacific region, e.g. 2.2% during 1980-2010 (Briones and Felipe, 2013). The rapid growth in agricultural labor productivity has substantially improved the effectiveness of labor in agricultural production helping to reduce the ratio of labor income between agriculture and non-agriculture from 1:4.8 to 1:3.7. Additionally, the increased agricultural labor productivity also agricultural development and economic structural transformation by moving more than 20 million rural labors from agriculture to non-agricultural sectors to feed the industrialization and urbanization process. Along with the proportion of agricultural GDP decreased from 25.82% in 1978 to 7.69% in 2022, the employment share in agriculture has decreased from 70.5% in 1978 to 24.1% in 2022 (NBSC, 2023). Consequently, labor productivity between agriculture and non-agricultural sectors as well as between rural and urban areas tend to gradually converge over time.

Underlying the rapid growth of agricultural labor productivity, agricultural technological progress and capital deepening are the most important drivers (Huang et al., 2022; Fan et al., 2021).

Figure 1: Average Agricultural Labor Productivity Trend and Growth in China: 1993-2016



Note: Agricultural labor productivity (ALP) is defined as agricultural value-added in real term dividing by labor in use at the county level. The data used estimate the ALP come from the agricultural production account for 1,465 rural counties in China that we construct.

Throughout the past four decades, the ongoing institutional reforms on the land, labor and capital markets have been believed to play an important role in promoting agricultural technological progress and facilitating capital deepening in rural China, apart from public infrastructural investment and public supporting policies favorable to agriculture. In particular, the reform of rural financial market since the late 1990s, while later than the land and labor market reforms, is essential to improve agricultural productivity in rural China. Fundamentally, the rural financial reform transformed the rural banking system from being dominated by the big state-owned banks (e.g. China Agricultural Bank and Rural Cooperation) to the market-based system with a wide range of diversified entities involved in banking businesses, and thus providing more credit supply to agricultural production. Consequently, the reform is expected to not only intensify the competition at the financial market facilitating agricultural technology progress and on-farm innovation, but also improve the efficiency of capital reallocation within the industry improving the returns

to capital investment and accumulation.

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Since its establishment in 1986, PSBC's branches have spread across the country, with postal workers acting as savings agents. This not only provides convenient services to rural residents but also offers loan services. The extensive network and depositor advantages have solidified PSBC's position in socio-economic life. Throughout the 1990s and the early 2000s, the PSBC only had the function of absorbing rural deposits and storing the savings without providing the lending services. As a result, the PSBC had to transfer all the deposits collected from the rural areas to People's Bank of China (or the central bank) for higher interest rates, causing an increasing debt burden for the central bank (given the substantial gap between the PSBC's transfer rates and the central bank's re-lending rates). Additionally, the rural deposit absorbed by the PSBC were only transferred to the central bank, causing local deposit outflows without generating loans, resulting in a significant outflow of rural funds. To resolve the problem, the PSBC conducted a three-step reforms aiming at improving its transfer rate mechanism and established a mechanism for rural

fund inflow.

- In 2004, the China Banking Regulatory Commission (CBRC) issued the "Interim Measures for the Business Management of Postal Savings Institutions," which clearly stated that financial operations between postal savings and postal services should be separated and accounted for independently.

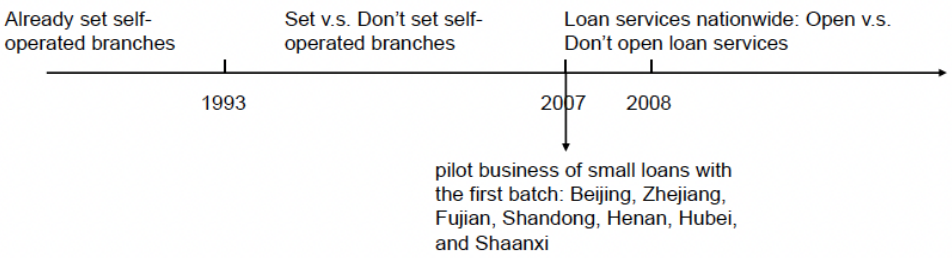
- In 2006, the China Banking Regulatory Commission (CBRC) issued the "Opinions on Strengthening the Pilot Management of Small Loans for Postal Savings Institutions," addressing the awkward situation of the PSBC (as a financial institution) "only storing without lending" by approving the initiation of syndicated loans. The PSBC has thus evolved to possess the rudiments of a commercial bank.

- In 2007, it was formally registered, positioning itself to serve agriculture, rural areas, urban and rural residents, and small and medium-sized enterprises. It established China's unique "self-operation + agency" operating model and completed its shareholding reform in 2012, officially listing on the Hong Kong Stock Exchange in 2016.

Throughout the 2000-2020 period, the PSBC reform has gradually become a dominating commercial finance institute targeting at financing agricultural production in rural China. While other commercial banks were reducing their branches at the end of the 20th century, the PSBC not only did not reduce its branches but also continued to establish new branches across rural areas, laying a solid ground for expanding financial services in rural China. By 2020, more than 80% of its branches have located in rural counties, engaging in personal savings deposits, settlement, and agency financial services. Particularly, all branches operate under a unified business management system with the decision for opening new branches across counties and changing the function only by the PSBC headquarters. This ensures that the PSBC reform is exogeneous to the county-level branch decision and performance (thus agricultural production), making the time-variant change in branch opening and banking loan businesses a natural experiment.

Compared to the reforms of Agricultural Bank of China and various rural commercial banks (the other two large financial institutions in rural China), the PSBC reform is more representative

Figure 2: The timeline for the PSBC reform



for the entire process of rural financial market reforms in China at the national wide. In particular, the Agricultural Bank of China, though is the largest bank operating in rural China, primarily serves the business and enterprises operating in urban areas of rural China rather than farmers and/or farming businesses, and continues to be state-owned in nature after the reform period. Conversely, various rural commercial banks rural commercial banks (which were initially originated from rural collective cooperation), though privatized earlier, are still undergoing reforms and operate independently by provinces or cities and thus not being able to properly reflect the nation-wide financial market reform. According to PBoC (2022), the number of the PSBC branches in rural China has accounted for more than 26% of the total number of financial institutions in rural China by 2020 (PBoC, 2022).

To date, many studies have been carried out to examine the role of rural financial development in affecting agricultural development in China. Historically, China's rural financial market was dominated by China Agricultural Bank, which was fully controlled by the central or local government and provide no direct financial services to farmers (García-Herrero, Gavilá, and Santabárbara, 2009; Song, Storesletten, and Zilibotti, 2011). Thus, it is believed that a transition of financial institutions from being dominated by the "single-state-owned bank" system to "coexistence of multiple financial institutions" help facilitate agricultural development (García-Herrero, Gavilá, and Santabárbara, 2009; Song, Storesletten, and Zilibotti, 2011). For example, Song, Li, and Liu (2023) indicates that establishing new rural financial institutions in rural China can increasing agricultural labor productivity by increasing returns to rural investment. Other studies by Ma, Qi, and Wu (2020) and Wang and He (2019) suggest that a competitive rural financial market will beneficial small farms if it provides more inclusive financial services. However, some

studies found that the expansion of rural financial institutions can lead to capital outflows from rural sectors (Tan et al., 2018). Overall, no consensus is reached on rural financial market may affect agricultural development, making the overall impact of financial institution development on agricultural labor productivity an empirical issue.

3 A Simple Production Model and Empirical Specification

3.1 A simple relationship between ALP and financial reform

To explore the impact of the PSBC reform on agricultural labor productivity, we start with assuming that the production of agricultural value-added (Y) takes a Cobb-Douglas technology, with capital (TK) and labor (L) as primary inputs. Since agriculture, unlike other sectors, has a unique characteristic of requiring land (Z) as a fixed input, we split land (Z) from physical capital (K). Thus, the baseline model can be written as

$$Y = AK^b Z^c L^\theta \tag{1}$$

where $\theta = 1 - b - c$ if there is a competitive agricultural output market ensuring agricultural production satisfies the constant return to scale condition. Dividing both sides of 1 by labor input (L) and taking logarithm, we have

$$lny = a + blnk + clnz \tag{2}$$

where $y = lnY$ refers to agricultural value-added output, a=lnA refers to technology progress, $k = K/L$ refers to capital-labor ratio or physical capital intensity and $z = Z/L$ refers to land-labor ratio or land intensity. Equ.2 shows that agricultural labor productivity can be decomposed into three components: technology progress (or agricultural total factor productivity, TFP or production efficiency), physical capital accumulation, and land consolidation (or land aggregation/reallocation) based on the simple value-added Solow model.

We then assume that agricultural production before and after the rural financial market reform

will take different technologies and use different ways of production (i.e. k and z). Using 0 and 1 to distinguish agricultural production between before and after the rural financial market reform, we have:

$$lny(0) = a(0) + b(0)lnk + c(0)lnz \tag{3}$$

For agricultural production before the rural financial market reform, and

$$lny(1) = a(1) + b(1)lnk + c(1)lnz \tag{4}$$

for agricultural production after the rural financial deregulation reform.

Let R represent the shocks caused by the PSBC reform, in terms of the proportion of regions that have made the reform. If $R = 1$, it indicates that all regions have made the reform; if $R = 0$, it indicates that all regions have not made the reform. Thus, the combined agricultural labor productivity for each time period over the PSBC reform process (lny) can be written as a weighted sum of $lny(0)$ and $lny(1)$, which can be written as:

$$\begin{aligned} lnTFP &= R * lnTFP(0) + (1 - R) * lnTFP(1) \\ &= a(0) + b(0)lnkl + c(0)lnz + \alpha R + \beta R \times lnkl + \gamma R \times lnz \end{aligned} \tag{5}$$

Here, $\alpha \equiv a(1) - a(0)$ measures the difference in agricultural productivity before and after the PSBC reform, $\beta \equiv b(1) - b(0)$ measures the difference in the returns to physical capital accumulation (or capital deepening) in agricultural production before and after the entry of financial institutions, and $\gamma \equiv c(1) - c(0)$ measures the difference in the returns to land consolidation (or land aggregation). All the estimators, including α, β and γ, are the focal points of this study. The above derivation has outlined three channels through which the PSBC reform may affect agricultural labor productivity, namely technology progress and efficiency improvement, physical capital deepening, and land consolidation (or land aggregation), in a simple and transparent way. This provides a theoretical foundation for the empirical study.

3.2 Empirical model specification and identification strategy

To put the above theoretical relationship into the empirical test, we propose to adopt the generalized staggered difference-in-difference approach. Thus, Equ. 5 can be converted into the following baseline model:

$$lny_{ct} = b_0 lnk_{ct} + c_0 lnz_{ct} + \alpha R_{ct} + \beta R_{ct} \times lnk_{ct} + \gamma R_{ct} \times lnz_{ct} + \epsilon_{ct} \tag{6}$$

where subscript ct represents the $c-th$ county in the $t-th$ year. u_c is the fixed effect for the county, ν_t is the fixed effect for time, and $\epsilon_c t$ is the error term.

The key dependent variable, R_{ct}, is a measure of the PSBC reform which can be either a continuous variable or a dummy variable used to indicate whether and/or to what extent the PSBC reform has been conducted in county c at time t. We measure the PSBC reform by constructing a continuous variable, which incorporates both the number of years since the first PSBC branch was established (a continuous variable, BY) and whether the PSBC branch in the county is allowed to providing the loan services (a dummy variable, LS). The two variables are multiplied, such that $R_c t = BY_{ct} \times LS_{ct}$. Additionally, we also construct the dummy variables, $Dummy_{LSct}$,allowed to issue the loan services for the first time to measure the PSBC reform from a particular perspective for the robustness checks.

To estimate Equ. 6, we first adopt a Two-way Fixed Effects Model (TWFE) model to quantify the average impact of the PSBC reform on the county-level agricultural labor productivity. The econometric model is as follows:

$$\Delta lny_{ct} = b_0 \Delta lnk_{ct} + c_0 \Delta lnz_{ct} + \alpha \Delta R_{ct} + \beta \Delta (R_{it} \times lnk_{it}) + \gamma \Delta (R_{ct} \times lnz_{ct}) + \Delta \epsilon_{it} \tag{7}$$

where $\Delta lny_{ct} = lny_{ct} - 1/T \sum_t TFP_{ct}$, $\Delta lnkl_{ct} = lnkl_{ct} - 1/T \sum_t kl_{ct}$, $\Delta R_{ct} = R_{ct} - 1/T \sum_t R_{ct}$, $\Delta(R_{ct} \times lnk_{ct}) = (R_{ct} \times lnkl_{ct}) - 1/T \sum_t (R_{ct} \times lnkl_{ct})$, $\Delta(R_{ct} \times lnz_{ct}) = (R_{ct} \times lnz_{ct}) - 1/T \sum_t (R_{ct} \times lnz_{ct})$, and $\nu_{ct} = \nu_{ct} - \bar{\nu}$ and $\Delta \epsilon_{ct} = \epsilon_{ct} - 1/T \sum_T \epsilon_{ct}$. We are interested in three estimators, including α, γ and γ, in addition to b_0 and c_0. Where α reflects the direct impact of the establishment of financial institutions on agricultural labor productivity, indicating the influence of financial

institution establishment on agricultural productivity. On the other hand, γ and γ reflect the average impact of the PSBC reform on agricultural labor productivity either through facilitating the accumulation of physical capital accumulation or the land consolidation and its induced resource reallocation. Equ. 7 could provide an accurate estimates on the impact of the PSBC reform on agricultural labor productivity only when the PSBC reform is properly identified from agricultural production at the county level.

On the one hand, if the PSBC reform is not randomly assigned across counties, the TWFE model will suffer from the potential sample selection bias. For instance, when Postal Savings Bank prepares to conduct related business in various counties, it might choose the timing of setting up branches based on specific local macroeconomic performance, such as economic growth and industrial structure. If the counties where the institution is set up earlier have higher agricultural labor productivity than those set up later, the comparison between these two groups may be subject to the interference of sample selection issues.

To cope with the sample selection bias problem, we employ the nearest neighbor matching method proposed by Imbens (2015) based on $Pr(R = 1|X) \in (0, 1)$ in logit form, where X represent the non-confoundness conditions. Three variables, including county-level industrial GDP, fiscal expenditure and fiscal revenue are used for the matching process, since they are key indicators for economic and financial development correlated with the PSBC reform but not directly related to agricultural production. Different from cross-sectional data or the traditional difference-in-differences method, this paper takes 2007 as the baseline and matches the counties with Postal Savings Bank branches after 2007 with those that already had branches but with no loan services in 2007. The matching process generates a subsample of 641 counties. The effectiveness of the matching is examined based on the parallel trend tests.

On the other hand, the estimation of Equ. 7 may also suffer from the latent endogeneity problem, caused by the omitted variable problem or the reverse causality. For instance, the PSBC reform, though is believed to be independent of agricultural production, could be affected by the time-variant omitted variables, such as macroeconomic policies, labor market reforms, openness to trade and among others, which in turn may affect agricultural labor problem. Also, if

agricultural labor productivity (or farms' income) grows more quickly in a county, it will be likely to cause the PSBC to establish new branches and extend its loan business. To cope with this problem, we use the general method of moment (GMM) estimation technique, following Arellano and Bond (1991); Blundell and Bond (1998); Wooldridge (2001), rather than the two-stage-least-square (2SLS) method. We make this choice because that Equ. (7) is in a structural function form, which contains five independent variables that could suffer from the potential endogeneity problem. It is a challenging task to identify so many exogenous instrumental variables for all the variables at the same time. Meanwhile, we also adopt the DW test to examine whether the GMM estimation approach has properly coped with the potential endogeneity problem.

3.3 Other econometric issues: negative weights and dynamic effects

Even if we can properly resolve the potential selection bias problem and the potential endogeneity problem, the estimated impact of the PSBC reform on agricultural labor productivity based on the TWFE model may suffer from two other econometric issues.

One econometric issues the so-called "negative weights," which is now the commonly discussed problems in the literature on the difference-in-differences method (Borusyak, Jaravel, and Spiess, 2021; De Chaisemartin and d'Haultfoeuille, 2020; Goodman-Bacon, 2021). For example, let's consider Counties A and B. They established postal savings bank branches at different times, with County A establishing them earlier than County B. Therefore, there would be some differences in the impact of financial institution establishment on agricultural labor productivity between the two counties. If a two-way fixed effects model is used to analyze the differences in these two counties, the estimated average effect would be a weighted average of these two effects. The treatment effect for County A is relatively accurate because it is compared with counties without postal savings bank branches. However, the treatment effect estimation for County B might be inaccurate because the two-way fixed effects model treats County A's "already treated group" as the "control group," introducing incorrect information for comparison (Roth et al., 2023). To address this issue, this study employs the latest robust estimators for the staggered difference-in-differences analysis to examine the impact of financial institution establishment on agricultural labor productivity

and to test the underlying mechanisms (Callaway and Sant'Anna, 2021; De Chaisemartin and d'Haultfoeuille, 2020; Gardner, 2022; Sun and Abraham, 2021). Specifically, assuming m and n represent two groups with different times of financial institution establishment, where m is the "Early-treated group," n is the "Late-treated group," and U represents the group that has never been subject to treatment effects, the average impact of financial institution establishment can be decomposed as follows:

$$\widehat{\alpha} = \sum_{m \neq U} s_{mU} \hat{\alpha}_{mU} + \sum_{m \neq U} \sum_{n > m} [s_{mn}^{m} \widehat{\alpha}_{mn}^{m} + s_{mn}^{n} \widehat{\alpha}_{mn}^{m}] \tag{8}$$

where $\widehat{\alpha}$ represents the average treatment effect of financial institution establishment and is expressed as:

$$\begin{aligned} \widehat{\alpha}_{jU}^{a\times 2} &= (lny_{j}^{Post(j)} - lny_{j}^{Pre(j)}) - (lny_{U}^{Post(j)} - lny_{U}^{Pre(j)}), j = m, n \\ \widehat{\alpha}_{mn}^{a\times 2,m} &= (lny_{m}^{Mid(m,n)} - lny_{n}^{Pre(m,n)}) - (lny_{n}^{Mid(m,n)} - lny_{n}^{Pre(m)}) \\ \widehat{\alpha}_{mn}^{a\times 2,n} &= (lny_{n}^{Post(n)} - lny_{n}^{Mid(m,n)}) - (lny_{n}^{Post(n)} - lny_{m}^{Mid(m,n)}) \end{aligned} \tag{9}$$

Equ. 9 represent the difference between the "Early-treated group" and the "Never-treated group", the difference between the "Early-treated group" and the "Late-treated group", and the difference between the "Late-treated group" and the "Never-treated group". The superscripts "Pre", "Mid", and "Post" represent the stages of financial institution establishment. The weights $s(\dot{})$ are proportional to the size of the treated group and the variance of each pair of treatment variables, $\sum_{m \neq U} s_{mu} + \sum_{m \neq U} \sum_{n > m} [s_{mn}^{m} + s_{mn}^{n}] = 1$. Similarly, the cross-term $\hat{\beta}$ is estimated in the same way, serving as a robust test for the variables of interest in this study.

Another econometric issue is the estimated average effect of the PSBC reform on agricultural labor productivity could be contaminated by its dynamics across regions and over time. Considering the effects across time and different counties, two potential issues may arise during estimation. The first concern is the cumulative impact over time. The influence of financial institution establishment on agricultural labor productivity might change after the initial implementation. If the

short-term effect is positive (or negative) but diminishes over time, the ultimate impact could be more substantial than the short-term effect. Average impact estimates might fail to reflect the actual impact of financial institution establishment on county-level agricultural labor productivity. The second problem is cross-lagged summation. This issue involves different counties establishing financial institutions at different times. In such cases, the impact of financial institution establishment on agricultural labor productivity may vary due to differing county characteristics. Average treatment effects may struggle to capture the complex interaction effects between time lags and heterogeneous groups, potentially lacking appropriate economic interpretability.

To address potential issues with average effect results, the study employs an event-study approach to investigate the dynamic impact of financial institution establishment on county-level agricultural labor productivity. The empirical research methodology involves introducing virtual variables for the years of financial institution establishment to explore the direct impact on agricultural labor productivity. Additionally, the study estimates the indirect impact of financial institution establishment on the marginal return of capital investment. Similar to the first step, the study uses a nearest-neighbor matching method to address sample selection bias. However, there is a slight difference in this step. Instead of matching counties based on the authorizing loan business year of 2007 as in the estimation of average effects, the study matches counties with established financial institutions to those without each year. This adjustment accounts for potential underestimation of the impact of yearly changes in the dynamic effects. The estimation model is as follows:

$$\begin{aligned} \Delta y_{ct} = & \sum_{j=-10, j\neq -1}^{9} \alpha_j \Delta 1\{t - t_R^0 = j\} \\ & + b\Delta lnk_{ct} + c\Delta lnz_{ct} + \beta\Delta(R_{ct} \times lnk_{ct}) + \gamma\Delta(R_{ct} \times lnz_{ct}) + \Delta\nu_t + \Delta\epsilon_{ct} \end{aligned} \tag{10}$$

$$\begin{aligned} \Delta y_{ct} = & \alpha\Delta R_{ct} + b\Delta lnk_{ct} + c\Delta lnz_{ct} \\ & \sum_{j=-10, j\neq -1}^{9} \beta_j \Delta 1\{t - t_R^0 = j\} lnk_{ct} + \sum_{j=-10, j\neq -1}^{9} \gamma_j \Delta 1\{t - t_R^0 = j\} lnz_{ct} + \Delta\nu_t + \Delta\epsilon_{ct} \end{aligned} \tag{11}$$

where t_R^0 represents the first year in which county c establishes a financial institution, and the dummy variablethe dummy variable $\{t - t_R^0 = j\}$ indicates the time interval relative to t_R^0 being k year. The estimated α_k, β_k capture the marginal returns of agricultural labor productivity and capital intensity over time after the establishment of financial institutions. Similarly, building on the standard event study approach, this paper uses the following model for estimation. Similarly, we use estimates of Callaway and Sant'Anna (2021); De Chaisemartin and d'Haultfoeuille (2020); Gardner (2022); Sun and Abraham (2021) to examine the effectiveness of financial institution establishment on agricultural labor productivity.

4 Data Source and Major Variables

In this paper, we use a balanced panel data of 1,465 rural counties (out of totally 2,760 counties) in China over the 1993-2016 period (as the primary dataset), which include the detailed information on agricultural production. The rural counties used in our sample are defined as the average proportion of agricultural output value in total output value being more than 50% between 1993 and 2016. We construct the production account for agriculture in these counties, following the procedure proposed by Sheng et al. (2020) for China agriculture at the aggregate level. The initial data are mainly sourced from China's County-level Statistics obtained from National Bureau of Statistics of China (NBSC) and the Costs and Benefits of Agricultural Products compiled by National Development and Reform Commission (NDRC). We choose 1993 as the starting year, since it is not until 1992 when the first batch of joint-stock commercial banks emerged indicating that a formal financial market was initiated in China.

Agricultural output is defined as total agricultural value-added, which is calculated by using agricultural gross output value (including both crop and livestock product value plus the value of non-separable agricultural services) to minus total costs of intermediate inputs, deflated by the agricultural producer price index. The agricultural producer price index is estimated by applying the Fisher-EKS index to aggregate the price of 11 major categories of agricultural products with their corresponding out value share as weights. Agricultural inputs consist of three primary inputs including depreciable capital, land and labor. Depreciable capital input refers to capital

services derived from capital stocks, which is calculated by aggregating the historical formation of agricultural fixed asset investment in non-residential building and structures, transportation vehicles and other machinery and equipment. Land input refers to land services, estimated by using the land rental in real term. A hedonic approach has been adopted to account for quality difference for the agricultural land used for different purpose. Labor input refers to hours worked, and quality adjustment has been made by using the wage of rural labors segregated by different sub-sectors and by hired and self-employed.

To measure the PSBC reform, we collect the detailed information on the development of all commercial banks and other agricultural institutes (including their branches) from the China Banking and Insurance Regulatory Commission (CBIRC). These data cover 342 urban regions and 2,814 rural counties throughout the whole country between 1948 and 2021. We use the information on bank names, establishment times of branches, and geographical locations of each financial institution and their branches to identify the PSBC branches. Following the coding rules for administrative regions set by the Ministry of Civil Affairs, we sort out the county-level administrative regions excluding urban districts and match them with the rural countries for agricultural production.

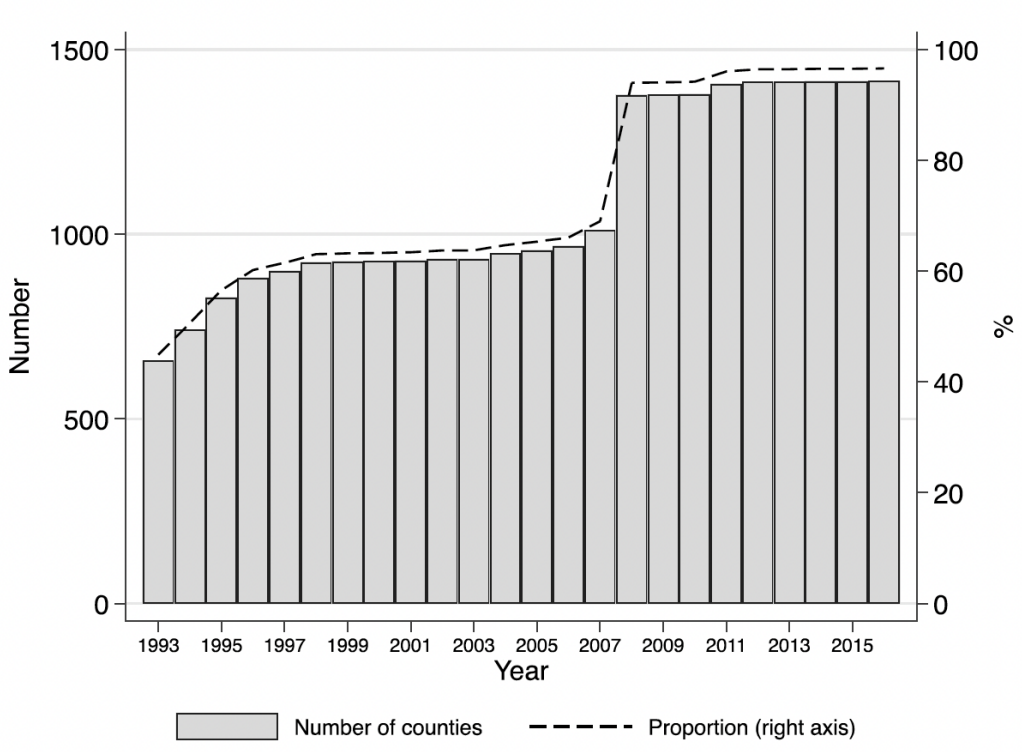
The Postal Savings Bank of China (PSBC) started its deposit collecting business at the county level since 1986. Before the start year of our sample (i.e. 1993), there were 774 rural counties having already had the PSBC branches. The remaining 680 counties gradually set up the PSBC branches for the period of 1993- 2016. The sample includes 11 counties that acquired PSBC branches after 2016, mainly concentrated in the Tibet Autonomous Region and Qinghai Province. Due to Beck, Levine, and Levkov (2010), we employ a virtual variable based on the time when Postal Savings Bank of China (PSBC) first establishes a branch in each county. This virtual variable is set to 1 for the year of the first establishment and subsequent years in each county, while it is set to 0 for other years. It is worth noting that before 2007, PSBC only engaged in savings-related businesses. In 2007, the State Council and regulatory authorities promoted the reform of postal savings, advancing the "self-operated + agency" model for PSBC. The self-operated branches provide comprehensive financial services to customers, including various types

of loans, deposits, and intermediary business products and services.

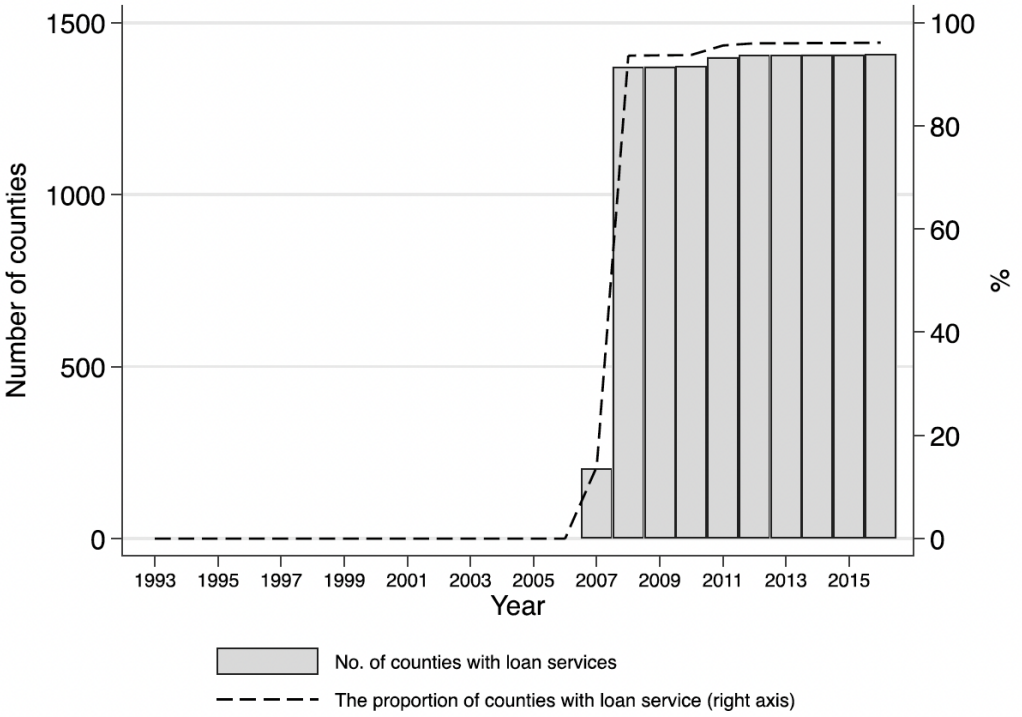
Figure 7 illustrates the distribution of the newly established PSBC branches at the county level for the 1993-2016 period. It can be observed that the early 1990s and the years around 2007-2008 were concentrated periods for PSBC to establish branches in counties. The PSBC has a coverage of around 70% of branches in counties and below, with service outlets covering 99% of counties in China.

While the PSBC has continued to establish new branches across rural counties, these newly established branches were not authorized to provide the bank load services until 2007. By May 2007, the China Banking Regulatory Commission, for the first time, authorized the PSBC and its self-operated branches to conduct the pilot small-scale loan businesses. The first batch of pilot regions included seven provinces: Beijing, Zhejiang, Fujian, Shandong, Henan, Hubei, and Shaanxi. In 2008, all self-operated branches were authorized to provide bank loan services in the rest regions. As the decision for this reform is made solely by the central government, this provides an exogenous natural design for our study. Consider that the longer the PSBC branches are established in a region the more wide- network they are likely to build with the local farmers, we also construct a continuous variable, namely the number of years since the first PSBC branch was established in a rural county, to measure the penetration level of the PSBC reform. Multiplying the two indicators, we can properly measure and compare the intensity of the PSBC reform across rural counties over time. Generally, the measure of the PSBC reform takes the value of zero before 2007 when the banking loan businesses were first authorized and thereafter a positive number after 2007 depending on the time length of the PSBC branches had established and when the banking loan business of self-operated branches is authorized. In a robustness check, we also use the two measures of the PSBC reform separately to re-do the exercise. The descriptive statistics on major variables used in this paper are shown in Table 1.

Figure 3: The distribution of Postal Savings Bank (PSBC) entrance: 1993-2016



(a) The number and proportion of PSBC branches across counties



(b) The number and proportion of PSBC branches providing loan service

Note: The right figure show the results of PSBC branches conducting loan business. 634 rural counties have already had the self-operated PSBC branches before 1993 while the remaining 774 counties gradually set up the PSBC branches between 1993-2016. The other 57 counties acquired PSBC branches after 2016, mainly concentrated in the Tibet Autonomous Region, Qinghai Province and Yunnan Province. In 2007, the self-operated branches in 204 counties in 5 province are authorized to open the loan business.

Table 1: Descriptive StatisticsBefore vs. After the PSBC reforms

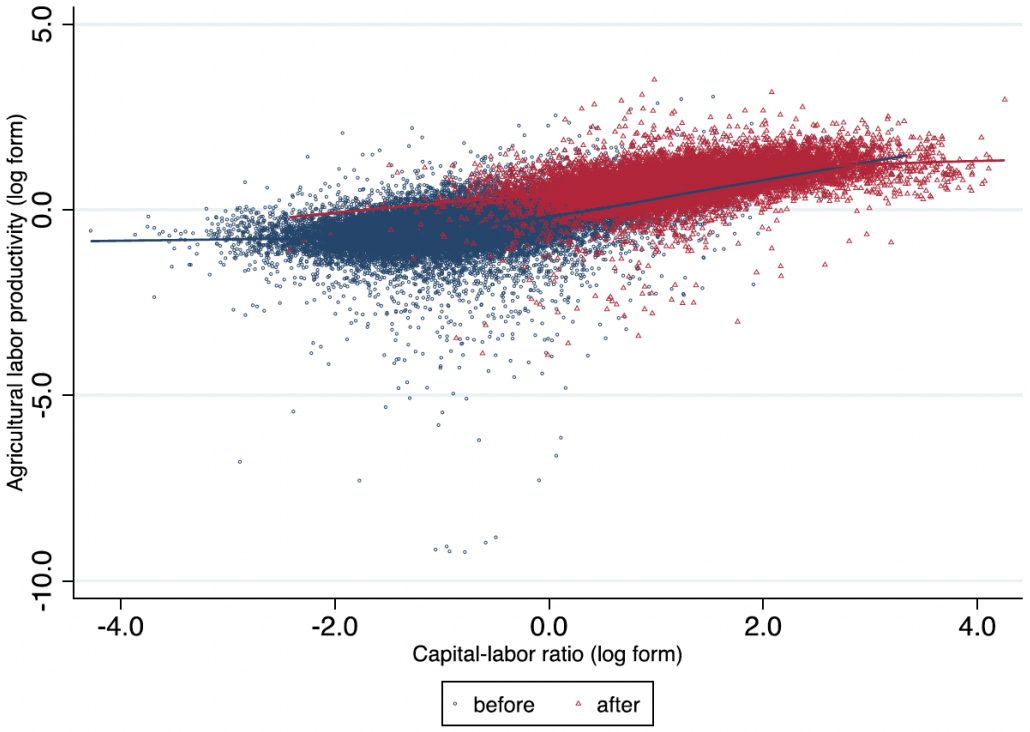
Variable	Definition	Mean/S.D.	All	Before	After
Agri. Labor Productivity	**Agricultural labor productivity, total agricultural output/ labor input (man-day)**	Mean	159.91	94.92	274.10
		S.D.	225.31	124.86	303.48
Capital-labor ratio	Capital-labor ratiocapital input/ labor input (man-day)	Mean	0.48	0.16	1.05
		S.D.	0.90	0.25	1.27
Land-labor ratio	Land-labor ratio, land input/labor input (man-day)	Mean	5.06	2.81	9.00
		S.D.	5.91	3.19	7.36
Years since set up	Years since the first PSBC branch set up in the county	Mean	10.16	6.43	16.72
		S.D.	9.14	6.75	9.10
GDP	Total GDP (10,000 RMB)	Mean	681963.61	295550.42	1360807.42
		S.D.	1398834.01	729704.37	1932848.56
Fiscal self sufficiency	Fiscal income/fiscal expenditure	Mean	38.80	43.24	30.99
		S.D.	26.49	27.64	22.31
First GDP	First industry GDP (10,000 RMB)	Mean	113258.76	64703.57	198559.67
		S.D.	128938.11	65082.86	164235.68
Fiscal expenditure	Fiscal expenditure (10,000 RMB)	Mean	86474.63	22351.84	199124.42
		S.D.	132973.18	32060.32	164398.13
Fiscal income	Fiscal income (10,000 RMB)	Mean	34838.66	9712.01	78980.71
		S.D.	97603.90	23098.98	149226.56
Rainfall	Total rainfall in one year (mm)	Mean	973.90	948.78	1018.02
		S.D.	548.60	534.19	570.39
No. of observations			35160	22406	12754

5 Financial Development in Rural China and Agricultural Labor Productivity

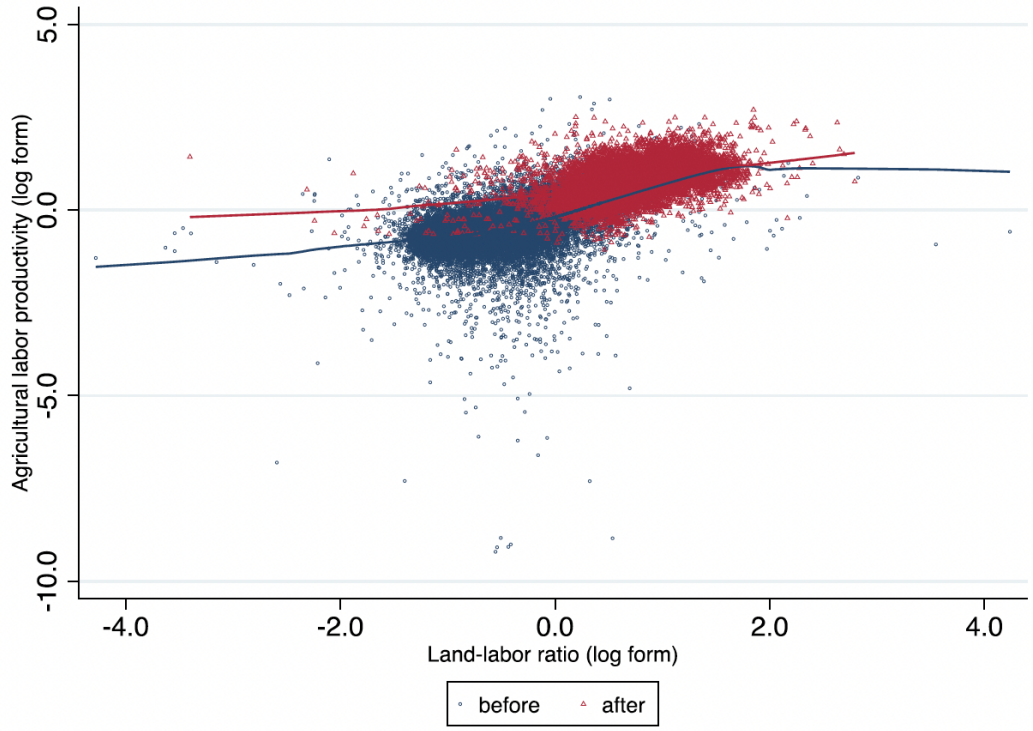
5.1 Three preliminary hypothesis tests for GSDID

Using the agricultural production account data at the county level, we start with describing the growth patterns of agricultural labor productivity in China and its underlying determinants (i.e. physical capital intensity and land intensity) segregated by the PSBC reform. As is shown in Figure 3(a), average agricultural labor productivity at the county level continued to grow throughout the entire 1993-2016 period. However, the growth rate of average agricultural labor productivity at the county level is much stronger and volatile for the sub-period of 1997-2007, coinciding with the PSBC reform period. Moreover, we compare the relationships between agricultural labor productivity and physical capital-labor ratio, as well as those between agricultural labor productivity and land-labor ratio, before and after the PSBC reform. As is shown in Figure 4 (b) and (c), the relationship between agricultural labor productivity and land-labor ratio becomes more flattened over the post-PSBC reform period while the relationship between agricultural labor productivity and physical capital-labor ratio does not change (compared to the pre-PSBC reform period). This implies that the marginal returns to land aggregation in rural China at the county level tend to decline for the post-PSBC reform period.

Figure 4: The distribution of Postal Savings Bank (PSBC) entrance: 1993-2016



(a) The ALP-KL ratio relationships segregated by the PSBC reform



(b) The ALP-ZL ratio relationships segregated by the PSBC reform

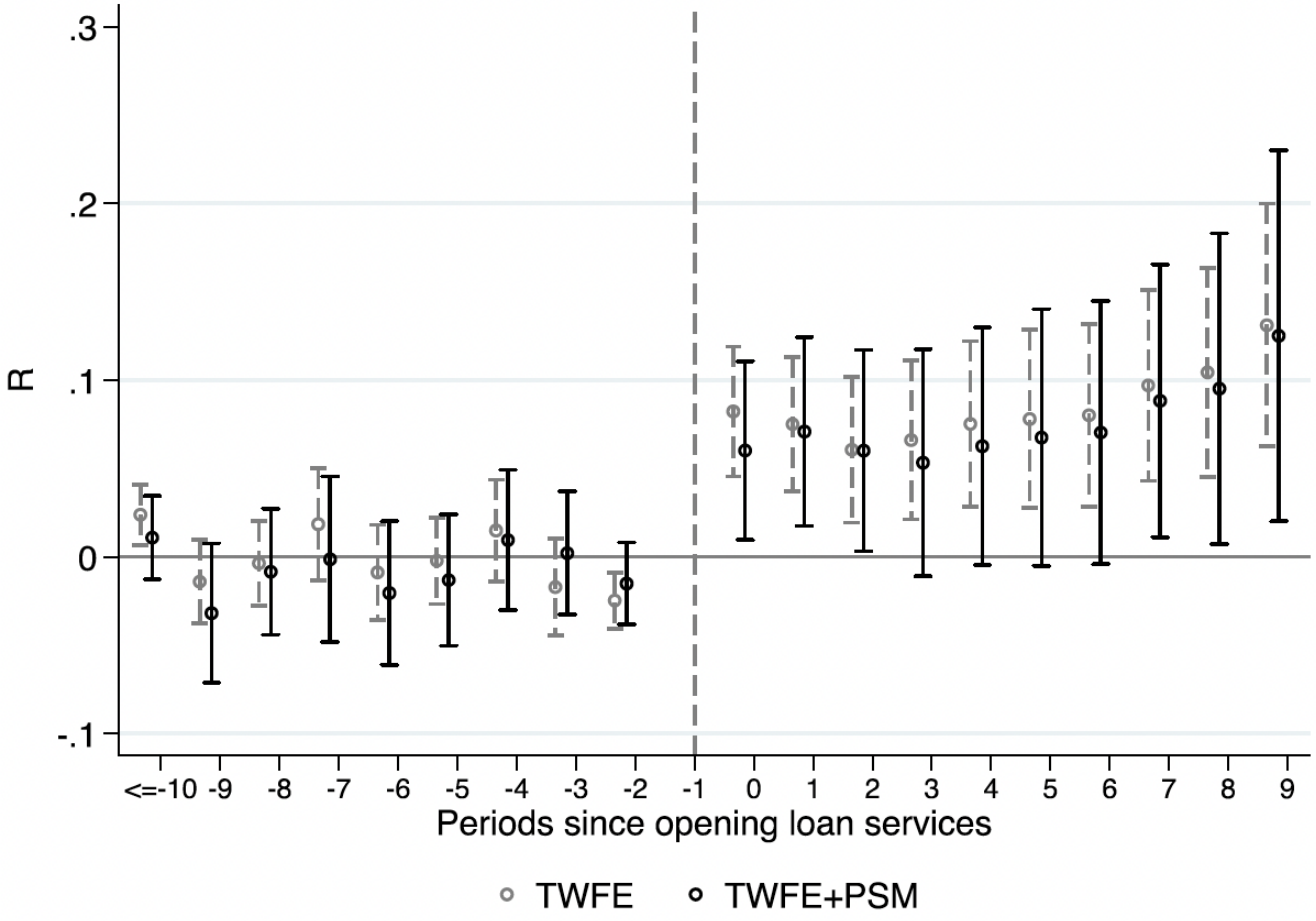
Note: The right figure show the results of PSBC branches conducting loan business. 634 rural counties have already had the self-operated PSBC branches before 1993 while the remaining 774 counties gradually set up the PSBC branches between 1993-2016. The other 57 counties acquired PSBC branches after 2016, mainly concentrated in the Tibet Autonomous Region, Qinghai Province and Yunnan Province. In 2007, the self-operated branches in 204 counties in 5 province are authorized to open the loan business.

Next, we conduct the parallel trend tests by interacting the dummy for the PSBC reform with the leading years to examine whether the growth pattern of agricultural labor productivity between reformed and non-reformed countries over the pre-reform period were sharing the same growing pattern. Figure 5 compares the test results obtained from using the full sample with those obtained from using the neighborhood matching technique. While the parallel trend test is not passed for the full sample at the conventional statistical level (i.e. 95%), it does for the sample using the neighborhood matching technique. This result implies that the adoption of the neighborhood matching technique has helped to correct the potential selection bias problem. A similar result is also obtained when the interaction terms between the measure of the PSBC reform and physical capital-labor ratio (and land-labor ratio) are well controlled in the parallel trend tests.

Apart from the parallel trend tests, the TWFE model could also suffer from the "negative weight" problem given the nature that the PSBC reforms were implemented in different regions at different times. To avoid the potential bias in this estimation, we conduct the Bacon decomposition as well as the "negative weight" tests following **?**De Chaisemartin and d'Haultfoeuille (2020), and report the Bacon decomposition results in Figure 6. Overall, there are totally 12,333 average treatment effects among which 5,320 receive negative weights accounting for 43.0%. This result implies that: the average treatment effects are still dominated by the positive weights but one may need to be careful about the interpretation of the TWFE estimation. As a compensation (or a robustness check), we also conduct the staggered difference-in-difference analysis by using the method proposed by Gardner (2022) to identify the impact of the "negative weight". The results obtained from using the Gardner (2022) approach is compared with the TWFE estimation.

Finally, it is to be noted that we use the system generalized method of moment (system-GMM) approach to resolve the potential endogeneity problem. This is because that we need to cope with five endogeneous variables (including the PSBC reform, capital-labor ratio, land-labor ratio and their interaction terms) in the estimation of the proposed structural model. Without sorting out enough valid instrumental variables, the traditional two-stage-least-square (2SLS) estimation may not be useful. In order to justify the validity of using the system-GMM approach to cope with

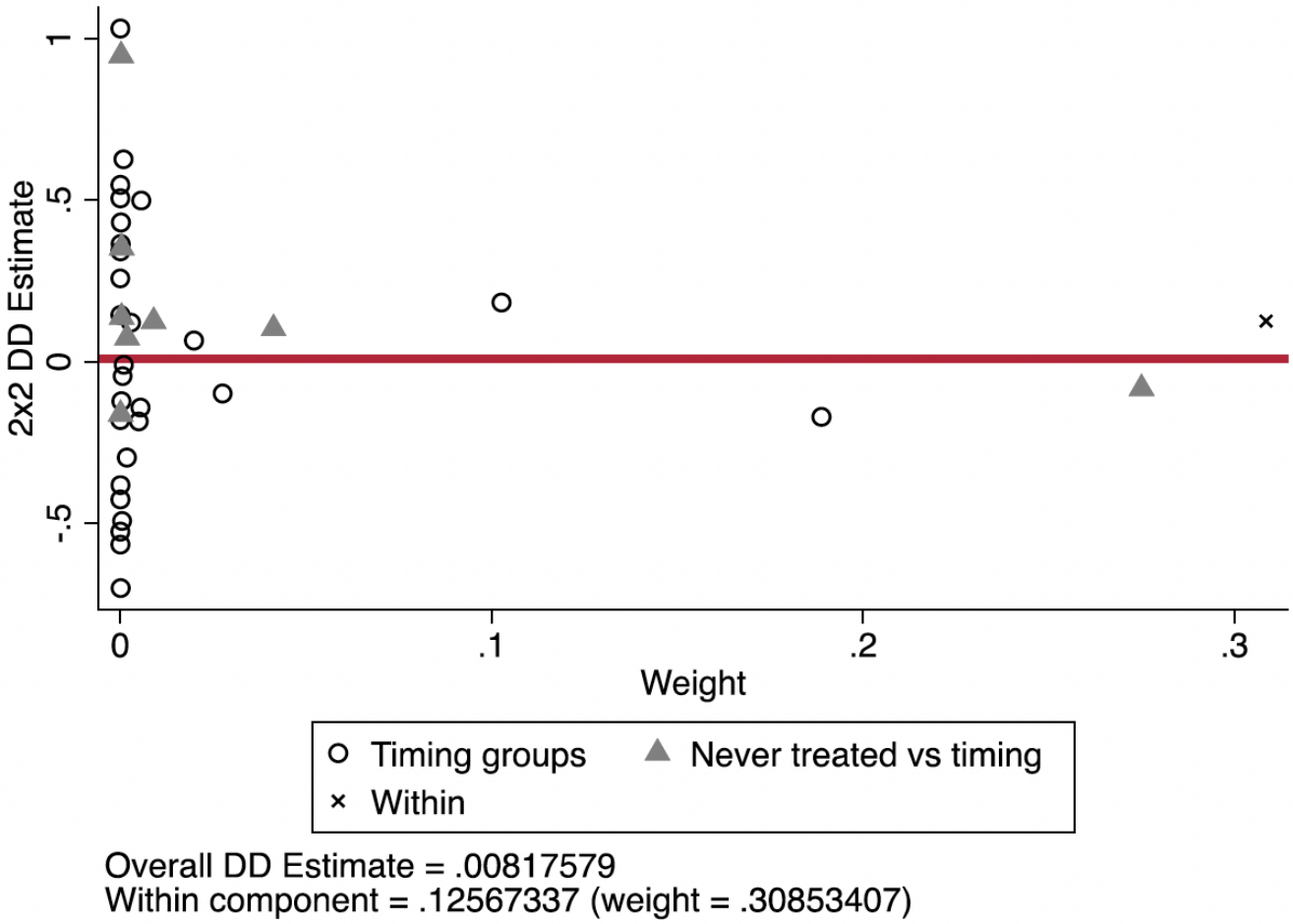
Figure 5: The parallel trend test: Full-sample vs. PS-matched sample



Note: We use 9 periods lags and 10 periods leads in this parallel trend test. The estimators can be obtained from the following regression:
$\Delta y_{ct} = \sum_{j=-10, j\neq -1}^{9} \alpha_j \Delta 1\{t - t_R^0 = j\} + b\Delta lnk_{ct} + c\Delta lnz_{ct} + \beta\Delta(R_{ct} \times lnk_{ct}) + \gamma\Delta(R_{ct} \times lnz_{ct}) + \Delta\nu_t + \Delta\epsilon_{ct}$

the potential endogeneity problem caused by the omitted variable/reverse causality problem, we also conduct the Arellano and Bond (1991) test. The results for the AR (1) test are less than 0.1, and those for the AR (2) test are higher than 0.1, indicating that first order autocorrelation exists but no second-order autocorrelation. Additionally, the Hansen test for the selected instrumental variables (namely, 282 lags) being exogenous is not rejected at the 1% level. The details can be found in Table 4.

Figure 6: Goodman-Bacon Test for "Negative Weights"



5.2 Impact of rural financial reform on agricultural labor productivity

After conducting the three groups of tests, we estimate the impact of the PSBC reform[1] on agricultural labor productivity by using three models: namely, the TWFE model, the TWFE model with the neighborhood matching data, and the system GMM model. In all the three models, we take into account of both county-specific and time-specific effects, in addition to adjusting for the cluster-robust standard errors at the county level. The results are shown in Table 4, where Columns (1) and (2) provides the TWFE estimation with and without the additional control values (i.e. fiscal expenditure, GDP per capita and rainfall) by using the full sample, while Columns (3) and (4) provide the TWFE estimation and the system-GMM estimation by using the neighborhood

[1]We also use a dummy variable to measure the PSBC reform and the results are shown in Appendix Appendix B.

matching sample.

Based on the baseline model (or the TWFE model using the full sample), the estimated coefficient (or α) in front of the PSBC reform is 0.071 and significant at the 1% level. The estimator is consistently positive and significant at the conventional statistical level, when additional control variables are included and the TWFE model and system GMM model using the neighborhood matching sample are employed to resolve the potential selection bias and the endogeneity problems. By using the system GMM model with the neighborhood matching sample, the estimated coefficient in front of the PSBC reform becomes 0.116 and significant at the 5% level. This implies that a 1% increase of the PSBC reform is likely to generate 11.6% increase of agricultural labor productivity through promoting agricultural productivity, although the positive impact is not stable.

In addition to improving agricultural productivity, the PSBC reform has also increased agricultural labor productivity by increasing the returns to physical capital accumulation. Based on the system GMM model using the neighborhood matching sample, the estimated coefficients in front of physical capital-labor ratio (b) is 0.064 and significant at the 5% level. This implies that increasing physical capital-labor ratio will positively contribute to increasing agricultural labor productivity. Moreover, the estimated coefficient in front of the interaction term between the PSBC reform and physical capital-labor ratio (β) is 0.045 and significant at the 1% level. This implies that the PSBC reform tends to significantly improve the returns to physical capital accumulation and thus contributes to increasing agricultural labor productivity.

Conversely, the PSBC reform is likely to negatively affect the returns to land consolidation. Based on the system-GMM model using the neighborhood matching sample, the estimated coefficients in front of land-labor ratio (c) is 0.330 and significant at the 5% level. This result is consistent with the estimate for physical capital-labor ratio, implying that increasing land consolidation will contribute to improving agricultural labor productivity. However, the estimated coefficient in front of the interaction term between the PSBC reform and land-labor ratio (γ) is -0.079 and significant at the 5% level. This implies that the PSBC reform tends to decrease the marginal returns to land consolidation and thus reduce agricultural labor productivity.

Table 2: The impact of PSBC reforms on the agricultural labor productivity

	TWFE	TWFE	TWFE+PSM	SYS-GMM-PSM
	(1)	(2)	(3)	(4)
R	0.071***	0.071***	0.080***	0.116**
	(0.019)	(0.019)	(0.028)	(0.052)
Capital-labor ratio(log)	0.047***	0.048***	0.044**	0.064**
	(0.012)	(0.012)	(0.019)	(0.037)
Land-labor ratio(log)	0.333***	0.331***	0.320***	0.330**
	(0.028)	(0.029)	(0.041)	(0.079)
R × capital-labor (log)	0.031***	0.031***	0.022**	0.045***
	(0.008)	(0.008)	(0.011)	(0.019)
R × land-labor (log)	-0.042***	-0.042***	-0.043***	-0.079**
	(0.007)	(0.007)	(0.010)	(0.022)
Self-fiscal (log)		-0.016	0.002	0.135**
		(0.017)	(0.028)	(0.052)
GDP (log)		0.057	-0.048	0.105***
		(0.074)	(0.123)	(0.045)
Rainfall (log)		-0.009	-0.008	-0.034
		(0.015)	(0.025)	(0.045)
Constant	4.285***	3.698***	4.914***	3.588***
	(0.042)	(0.862)	(1.435)	(0.712)
County fixed effect	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
R-squared	0.78	0.78	0.77	
Difference-in-Hansen test				0.000
Number of instruments				282
Observations	35160	35160	15384	14102

Note: TWFE refers to the traditional fixed effect model. TWFE+PSM refers to applying the fixed effect model to the common support sample based on the one-to-one propensity score matching. SYS-GMM+PSM refers to the two-step system generalized moment estimation method on the matching samples. We incorporate the first-order and second-order lag forms of the dependent variable, adjusting the coefficients and standard errors accordingly. All the variables are taken in log form. We control the GDP, fiscal situation, and rainfall index in the regression. We also include county fixed effect, and year fixed effect. Robust standard errors clustered at the county level are reported in parentheses. ***, ** and * represent significance at the 1%, 5% and 10% levels.

The above estimation results are based on a valid Solow model estimation. As is shown in Table 4, the estimated coefficients in front of capital-labor ration and land-labor ratio (or b_0 and c_0) are added up together to be around 0.36-0.39. Under the assumption of constant return to scale, this implies that the ratio of capital to labor in agricultural production at the country level in China is around 4:6. This is consistent with the economic growth literature (Fan et al., 2021; Sheng et al., 2020), such that agricultural production relies on the labor-intensive technology.

Table 3: Estimated impact of the PSBC reform for "negative weights": TWFE vs. Gardner

Panel A.	R	**Std.err**	**t/z**	**95% confidence interval**		**Num of Obs.**
TWFE	0.071	0.019	3.81	0.035	0.108	35160
G2021	-0.002	0.031	-0.06	-0.062	0.059	35160
Panel B.	R × capital-labor	**Std.err**	**t/z**	**95% confidence interval**		**Num of Obs.**
TWFE	0.031	0.008	4.17	0.017	0.046	35160
G2021	0.017	0.008	2.22	0.002	0.033	35160
Panel C.	R × land-labor	**Std.err**	**t/z**	**95% confidence interval**		**Num of Obs.**
TWFE	-0.042	0.007	-5.95	-0.055	-0.028	35160
G2021	-0.026	0.013	-1.95	-0.052	0.000	35160

Note:TWFE refers to the traditional two-way fixed effect approach. G2021 estimator is developed by Gardner (2022). Both control the factors that may affect agricultural TFP.

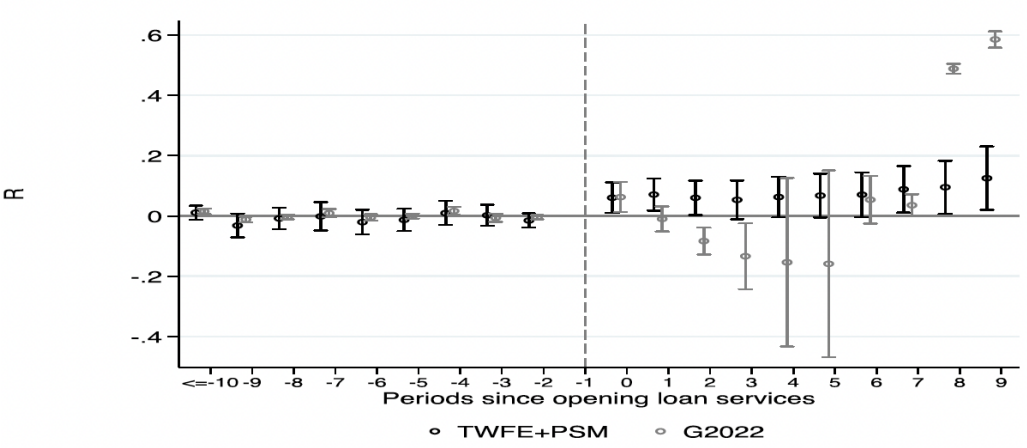
Our estimation results are generally consistent with the estimates obtained from using the Gardner model to account for the "negative weight" problem. Based on the Gardner model, the estimators in front of the interaction terms between the PSBC reform and physical capital-labor ratio (β) and that between the PSBC reform and land-labor ratio (γ) are 0.017 and -0.026 which are significant at the 5% level and at the 10% level respectively (shown in Table 3). While these estimators become less significant than those obtained from the TWFE model, the sign of those estimators are still consistent. This implies that: the adjustment for "negative weight" does not affect our finding that the PSBC reform tends to reduce the marginal returns to land consolidation and thus decreases agricultural labor productivity.

In literature, average estimates on the impact of the PSBC reform could be contaminated by heterogeneous effects of the reform across counties and over time. To cope with this problem, we conduct the event analyses by using both the TWFE model and the Gardner model to examine the

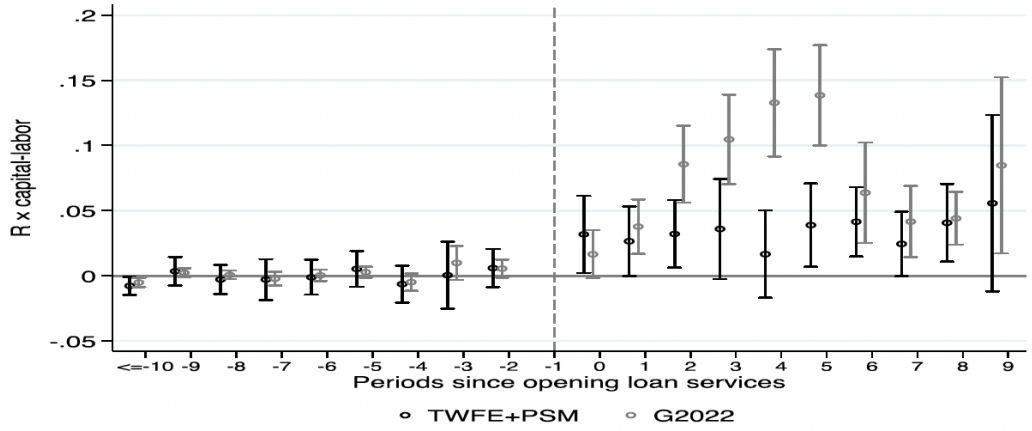
dynamic effects of the PSBC reforms on agricultural labor productivity and its underlying channels. Figure 7 shows the dynamics of the estimated effects (α, β and γ) on agricultural productivity, marginal returns to physical capital deepening and land consolidation respectively. Based on all the model specifications, the dynamic impacts of the PSBC reform on agricultural productivity continues to be positive but they are marginally significant at the conventional statistical levels, in particular when the potential selection bias and the negative weight problem are properly accounted for. However, the dynamic impacts of the PSBC reform on the marginal returns to physical capital deepening and land consolidation persist to be positive and negative. Both the estimated average effects are statistically significant at the 5% level. This suggests that the PSBC reform tends to positively affect marginal returns to physical capital deepening and negatively affect marginal returns to land consolidation even if the difference in cross-county and trans-temporal effects are considered.

Overall, our results show that the PSBC reform is likely to improve agricultural labor productivity through lifting up agricultural productivity but the magnitude of the positive productivity effect is not large in particular when the dynamic effects are properly considered. Moreover, when we consider the channel of factor deepening, the PSBC reform may generate asymmetric impact on physical capital deepening and land consolidation. In particular, compared to the pre-reform period, the marginal returns to physical capital deepening in the post-reform period will increase while that to land consolidation will decrease. This suggests that the PSBC reform is likely to impose negative impact on land consolidation thus reducing agricultural labor productivity. A possible explanation is that: agricultural production is more uncertain due to changing weather condition and it is heavily dependent on land as a fixed input, which makes the small household farms relatively more vulnerable compared to larger counter parts. As such, an increase in the credit supply is more likely to reduce the possibility for small household farms exiting from agricultural production and thus reduce the land consolidation.

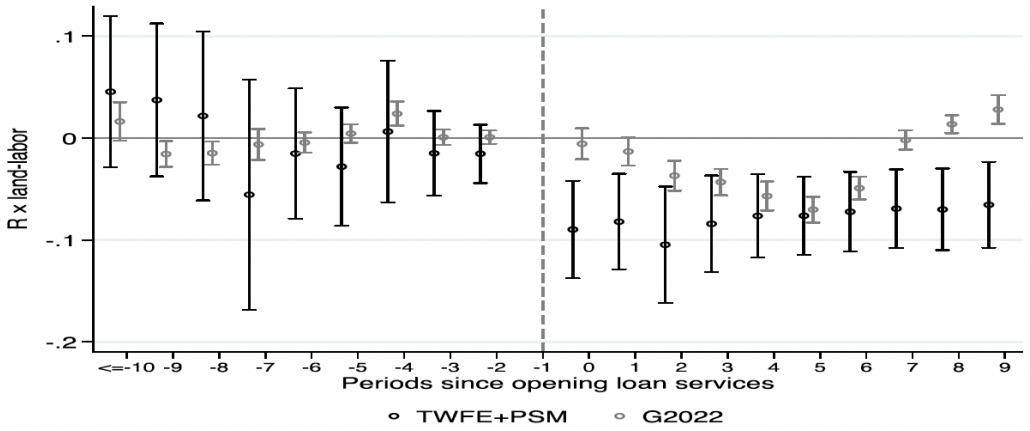
Figure 7: Event Analyses Results: TWFE vs. Gardner



(a) Impact of the PSBC reform on APL



(b) Impact of the PSBC reform on capital-labor ratio



(c) Impact of the PSBC reform on land-labor ratio

Note: TWFE refers to the traditional two-way fixed effect model. TWFE+PSM refers to applying the two-way fixed effect model to the common support sample based on the one-to-one propensity score matching. G2021 estimator is developed by Gardner (2022). The dashed lines represent 95%.

5.3 Exploring the mechanism through which the PSBC reform affecting capital accumulation

Although the above estimation results provide useful insights on that the PSBC reform may affect agricultural labor productivity by asymmetrically change the returns to physical capital deepening and land consolidation. In particular, we show that the PSBC reform will improve the returns to capital deepening while reducing the returns to land consolidation. However, both the GSDID model and the system-GMM model could not be used to inform how the asymmetric productivity impact of the PSBC reform is imposed. To better understand the underlying mechanism through which the PSBC reform affect agricultural labor productivity in rural China, we further adopt the regression forestry-tree approach to estimate the marginal impact of the PSBC reform when the capital-labor ratio and the land-labor ratio are gradually changed.

In order to explore why the PSBC reform may generate asymmetric impact on on the two types of capital accumulations, we employ the Generalized Random Forest (GRF) method proposed by Athey, Tibshirani, and Wager (2019) to analyze and compare the marginal impact of the reform on physical capital deepening and land consolidation by quantiles. Random Forest (RF) is a statistical learning method used to estimate conditional expectations (Breiman, 2001). The name of this method stems from the fact that it is achieved by randomly establishing a forest composed of multiple decision trees. When each new sample is input, each decision tree in the forest will perform classification judgements. Athey et al. (2019) proposed the generalized random forest method based on RF, providing a non-parametric estimation aimed at assessing the heterogeneity of treatment effects. footnote GRF has similarities with the idea of local maximum likelihood estimation, but it is different in that similarity weight between points does not depend on the minimization of the average distance between all dimensions of covariates, but rather on the frequency at which they appear in the same leaf node (leaf) in the random forest recursive grouping.

In our case, we take the segmentation into two groups (sub-nodes) along with physical capital-labor ratio and land-labor ratio respectively, and thus the objective of the tree structure of the

grouping set can be written as:

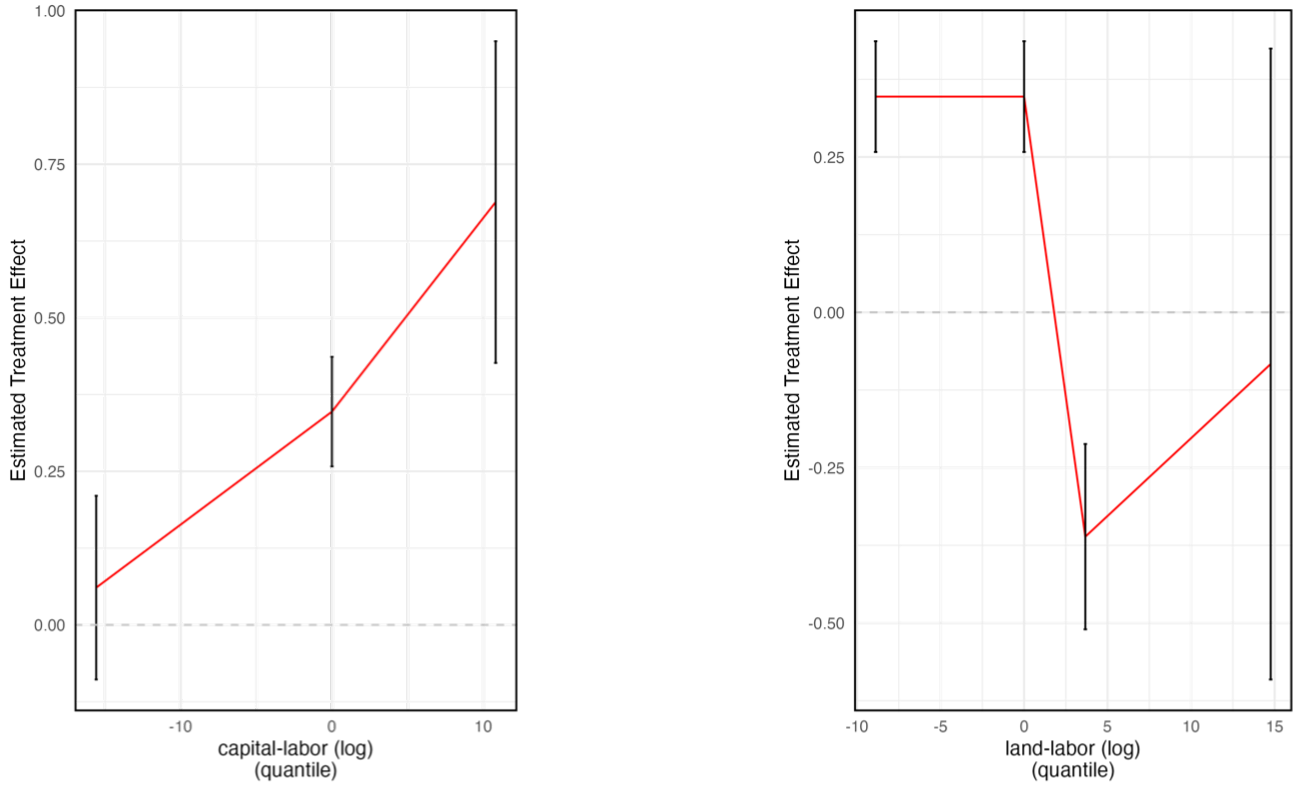
$$max\Delta(C_1, C_2) : n_{C_1}, n_{C_2}/n_p^2(\widehat{\theta}_{c_1}(J) - \widehat{\theta}_{c_2}(J)) \tag{12}$$

where $\widehat{\theta}_{c_i}(J)$ is the estimated value of the treatment effect of the sub-node, $n_(C_i)$ is the number of sample points C_i in the sub-node, and n_p is the number of samples in the upper layer parent node of this group of sub-nodes. Due to the huge amount of computation, we solve it using the Gradient Tree Algorithm. Through using the GRF method, we can obtain the distribution of the treatment effect among different characteristics groups, and sort the influence size of the covariates in the GRF grouping on the heterogeneity of the treatment effects. With other variables unchanged, by predicting how the conditional average treatment effect changes with the change of capital-labor ratio and land-labor ratio, we can quantify the influence patterns of different dimensional heterogeneities.

The estimation results are shown in Figure 8, where the sample are categorized in five quantiles based on the capital-labor ratio and the land-labor ratio. Panel (a) provides the estimated results on changing marginal productivity impacts of the PSBC reform along with the change in capital-labor ratio, while panel (b) provides the estimated results along with the change in land-labor ratio.

A possible explanation on the negative impact of the PSBC reform on the marginal returns to land consolidation in the regions with relatively higher land-labor ratio is that the asymmetric impact of the increased credit supply only matters for land consolidation when there are willingness for farmers to increase their operational scale and enjoy the benefits from land consolidation. This finding is different from what is documented in the previous literature, where a positive relationship between financial development and enterprise-level TFP based on the manufacturing industries (Demyanyk, Ostergaard, and Sørensen, 2007; Bai, Carvalho, and Phillips, 2018), which reflect the particular features of land input as a fixed input in agricultural production.

Figure 8: Generalized Random Forest Results: KL ratio vs. ZL ratio



(a) Capital-labor ratio

(b) Land-labor ratio

Note: Figure 7 apply GRF methods by Athey et al. (2019) to detect how the capital-labor ratio and land-labor ratio shape the effect of PSBC reforms on the agricultural labor productivity. The black line show the 95% confidence interval and the red point represents the estimated treatment effect. For the figure (a), the black lines represent the effect holding the capital-land labor at 0%, 25% (50%, 75%), and 100% quantile respectively. For the figure (b), the black line represent the effect holding the land-labor ratio at 0%, 25% (50%), 75% and 100% quantile respectively.

6 Robustness Checks

In this section, we carried out a series of robustness checks to examine the sensitivity of our estimation results to alternative measures of the PSBC reform, various model specifications and estimation methods. The results are summarized in Table **??**.

First, our measure of the PSBC reform helps to simplify the structural estimation procedure, but it is a combined variate containing two components, including the openness of new branches and authorization of loan business, that may affect agricultural labor productivity and its underlying determinants differently. To better understand how each of these components affect agricultural labor productivity, we separate the two measures and use each of them independently as a measure of the PSBC reform (R_{ct}) for the exercise. The results are shown in Table 5, where columns (1) and (2) provide the estimation results using the measure of opening new branches and columns (3) and (4) provide the estimation results using the measure of authorizing the loan business. Overall, the estimated coefficients in front of the measure of authorizing the loan business and its interaction term with capital-labor ratio and land-labor ratio are consistent with our main results. This implies that the impact of the PSBC reform on agricultural labor productivity mainly comes from transforming the business to lending the bank loans.

Second, it is believed that physical capital-labor ratio and land-labor ratio are highly positively correlated, which may cause the multicollinearity problem affecting the accuracy of estimators β and γ. In our dataset, the coefficient of correlation between physical capital-labor ratio and land-labor ratio is 0.67. To avoid the problem, we construct the ratio between land and physical capital to replace the land-labor ratio to eliminate the potential impact of multicollinearity. For a detailed derivation of this model specification, please refer to the Appendix C. The results are shown in Columns (5) and (6). Using the estimated coefficients in front of the physical capital-labor ratio and those in front of the physical capital-land ratio, we can calculate the marginal impact of the PSBC reform on the marginal return to land consolidation, which is -0.043 and significant at the 1% level. This implies that our results about the PSBC reform reduces the return to land consolidation is not because of the potential multicollinearity.

Thirdly, at the very end, we also restrict the sample to only include the bread-ban counties

(or the main grain producing counties) and the counties categorized into the poverty counties and re-do the exercise. The results are shown in Columns (7) and (8), As expected, the estimation results for those sub samples focusing on the grain production those low-rural income countries are generally consistent with the main results as well.

Table 4: Robustness Checks

Poverty county	Open a new branch		Authorize loan business		Loan business with continuous measure			
	Bread-ban county							
	TWFE	TWFE+PSM	TWFE	TWFE+PSM	TWFE	TWFE+PSM	TWFE+PSM	TWFE-PSM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R	-0.082	-0.089	0.201***	0.182**	0.071***	0.080***	0.072*	0.062*
	(0.074)	(0.075)	(0.053)	(0.090)	(0.019)	(0.028)	(0.039)	(0.035)
Capital-labor ratio(log)	0.089***	0.092***	0.045***	0.044**	0.048***	0.044**	0.047*	0.046**
	(0.017)	(0.017)	(0.012)	(0.019)	(0.012)	(0.019)	(0.027)	(0.022)
Land-labor ratio(log)	0.234***	0.234***	0.329***	0.325***	0.331***	0.320***	0.322***	0.296***
	(0.038)	(0.038)	(0.028)	(0.040)	(0.029)	(0.041)	(0.057)	(0.050)
R × capital-labor (log)	-0.044**	-0.046**	0.095***	0.058*	0.032***	0.023*	0.013	0.012
	(0.018)	(0.018)	(0.022)	(0.033)	(0.009)	(0.013)	(0.013)	(0.017)
R × land-labor (log)	0.024	0.027	-0.109***	-0.115***	-0.042***	-0.043***	-0.045***	-0.035***
	(0.037)	(0.037)	(0.019)	(0.030)	(0.007)	(0.010)	(0.016)	(0.012)
Constant	2.326***	2.345***	3.703***	4.919***	3.698***	4.914***	4.097***	2.756***
Controls	Y	Y	Y	Y	Y	Y	Y	Y
County fixed effect	Y	Y	Y	Y	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y	Y	Y	Y	Y
R-squared	0.64	0.64	0.78	0.77	0.78	0.77	0.76	0.82
Observations	20510	20216	35160	15384	35160	15384	6480	5520

Note: TWFE refers to the traditional fixed effect model. TWFE+PSM refers to applying the fixed effect model to the common support sample based on the one-to-one propensity score matching. Column (1) and (2) show the results when change R into a dummy measuring whether the county open a new branch. Column(3) and (4) show the results when change R into a dummy variables measuring whether the county authorize the loan business. The definition of R in column (5) – (8) are the same with that in table 2. We re-calculate the coefficients and standard error before land-capital in column (5) and (6) , and apply them to the capital-labor ratio, land-labor ratio, the two interaction terms respectively. Column (7) run the basic regression on the subsample of poverty counties and column (8) run the basic regression on the subsample of bread-ban counties. All the variables are taken in log form. We control the GDP, fiscal situation, and rainfall index in the regression. We also include county fixed effect, and year fixed effect. Robust standard errors clustered at the county level are reported in parentheses. ***, ** and * represent significance at the 1%, 5% and 10% levels.

7 Conclusion

We investigate the impact of rural financial deregulation, in terms of the PSBC reform, on agricultural labor productivity and its underlying mechanism, using the county-level data in China. By employing the difference in different-time for the PSBC to open new branches and authorize them to provide loan services across counties, we construct a natural experiment to identify the causal relationship between the PSBC reform and agricultural productivity growth, and decompose the overall productivity impact into technology progress effects, physical capital deepening effects and land consolidation effects.

We show that the PSBC reform has generated a positive direct impact on agricultural labor productivity through improving agricultural technology progress. Based on our estimation, a 1% increase in the PSBC reform is likely to generate around 3% increase in agricultural productivity. However, the positive direct productivity effect is not stable, in particular when we properly consider the cross-region and trans-temporal heterogeneity. The statistical significance of the measured direct productivity effect is at the 10% level.

Compared to improving technology progress, the PSBC reform is more likely to improve agricultural labor productivity through affecting the marginal returns to capital deepening. Yet, we show that the PSBC reform is likely to increase agricultural labor productivity by strengthening the role of physical capital deepening but not through intensifying land consolidation. While the estimated marginal impact of the PSBC reform on physical capital-labor ratio is positive, the estimated marginal impact of the PSBC reform on land-labor ratio is negative and significant at the 1% level.

Our estimated effects of the PSBC reform is more likely from the PSBC authorizing more branches to provide loan services other than opening more new branches. This productivity effect in rural China becomes more pronounced over time. The finding aligns with previous literature suggesting that the establishment of financial institutions stimulates local investment and economic development by enhancing local loan supply. In contrast to the situation in the 1990s when most financial institutions mainly attracted deposits without extending loans, the current scenario, where financial institutions engage in lending activities, contributes to a 11.6% increase in agricultural labor productivity through technological progress and a 2.7% increase through capital input. The results remain robust even after addressing issues of "sample selection bias" and "negative weights."

In sum, our findings underscore the positive role of financial institutions, particularly the impact of their loan services, in fostering agricultural labor productivity through the promotion of local investments.

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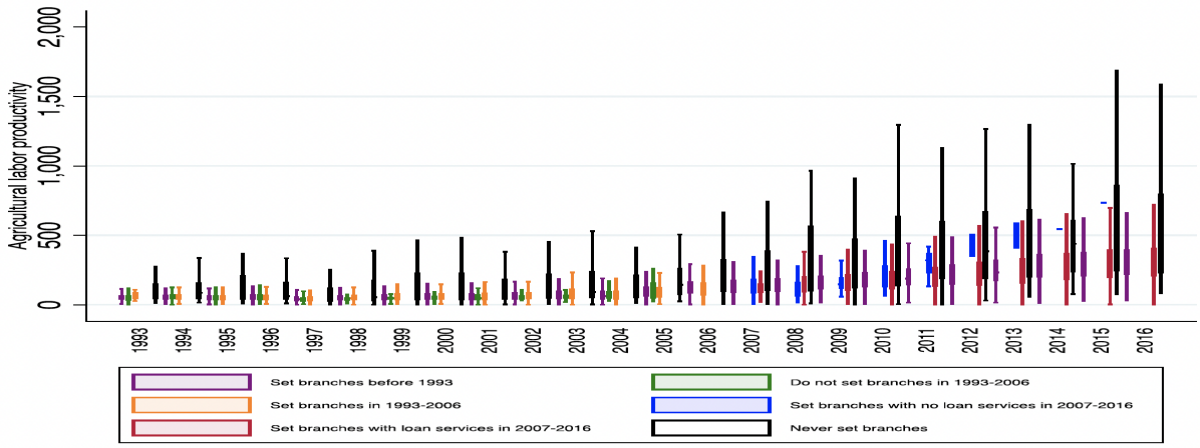
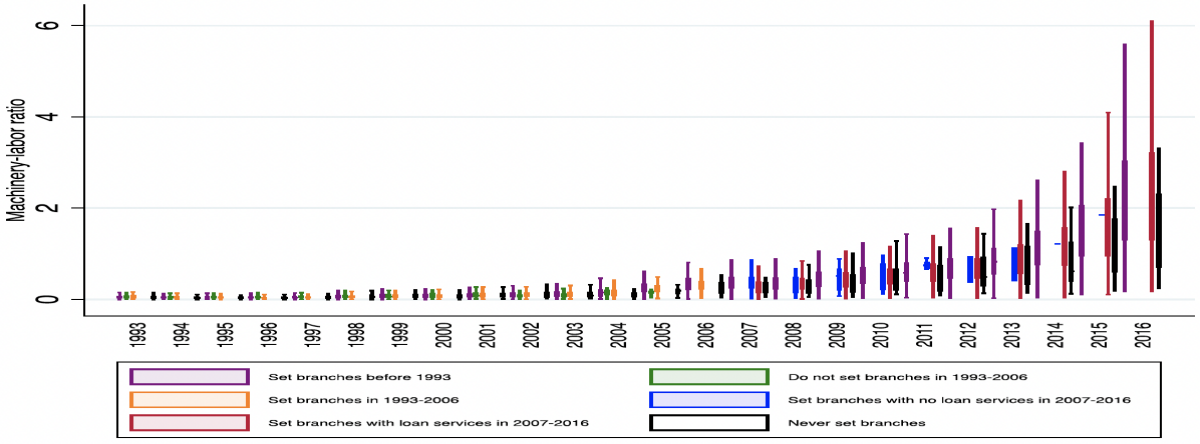
Appendix A Boxplots of main variables

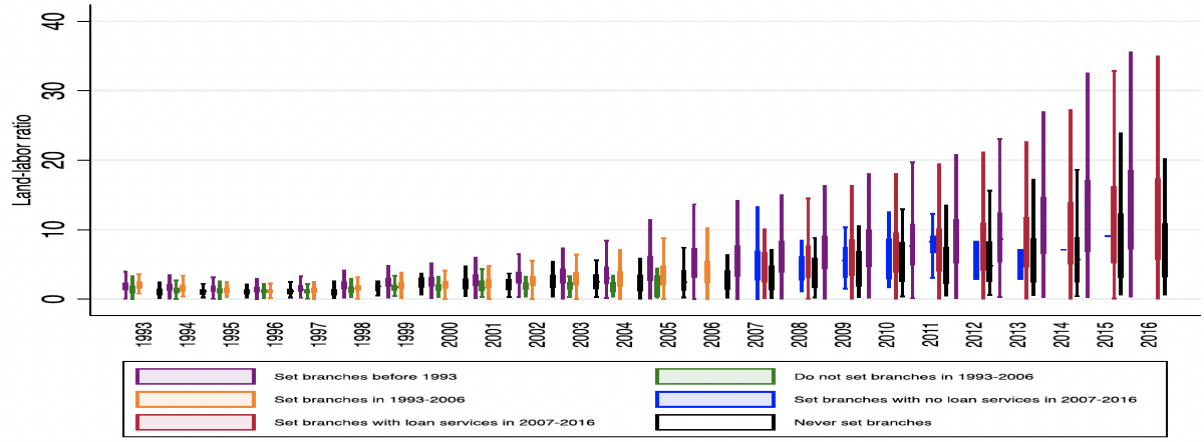
Figure A1: Boxplot of ALP



(a) Boxplot of ALP



(b) Boxplot of capital-labor ratio



(c) Boxplot of land-labor ratio

Appendix B Robustness

Table B1: The impact of PSBC reforms on the agricultural labor productivity

	TWFE	TWFE	TWFE+PSM	SYS-GMM-PSM
	(1)	(2)	(3)	(4)
R	0.201***	0.201***	0.182**	-0.06
	(0.053)	(0.053)	(0.090)	(0.173)
Capital-labor ratio(log)	0.044***	0.045***	0.044**	0.093*
	(0.012)	(0.012)	(0.019)	(0.047)
Land-labor ratio(log)	0.332***	0.329***	0.325***	0.240***
	(0.027)	(0.028)	(0.040)	(0.087)
R × capital-labor (log)	0.093***	0.095***	0.058*	0.320**
	(0.022)	(0.022)	(0.033)	(0.080)
R × land-labor (log)	-0.110***	-0.109***	-0.115***	-0.193**
	(0.019)	(0.019)	(0.030)	(0.073)
Self-fiscal (log)		-0.015	0.006	0.060
		(0.017)	(0.028)	(0.073)
GDP (log)		0.058	-0.048	0.120
		(0.074)	(0.124)	(0.047)
Rainfall (log)		-0.013	-0.010	-0.033
		(0.015)	(0.025)	(0.067)
Constant	4.279***	3.703***	4.919***	4.787***
	(0.042)	(0.861)	(1.441)	(0.893)
County fixed effect	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
R-squared	0.78	0.78	0.77	
Difference-in-Hansen test				0.000
Number of instruments				272
Observations	35160	35160	15384	13970

Note: TWFE refers to the traditional fixed effect model. TWFE+PSM refers to applying the fixed effect model to the common support sample based on the one-to-one propensity score matching. SYS-GMM+PSM refers to the two-step system generalized moment estimation method on the matching samples. We incorporate the first-order and second-order lag forms of the dependent variable, adjusting the coefficients and standard errors accordingly. All the variables are taken in log form. We control the GDP, fiscal situation, and rainfall index in the regression. We also include county fixed effect, and year fixed effect. Robust standard errors clustered at the county level are reported in parentheses. ***, ** and * represent significance at the 1%, 5% and 10% levels.

Table B2: The impact of PSBC reforms on the agricultural labor productivity: dummy variable

	TWFE	TWFE	TWFE+PSM	SYS-GMM-PSM
	(1)	(2)	(3)	(4)
R	0.071***	0.071***	0.080***	0.324***
	(0.019)	(0.019)	(0.028)	(0.078)
Capital-labor ratio(log)	0.381***	0.379***	0.364***	0.381***
	(0.031)	(0.030)	(0.042)	(0.089)
Land-labor ratio(log)	0.333***	0.331***	0.320***	0.304***
	(0.028)	(0.029)	(0.041)	(0.082)
R × capital-labor (log)	-0.011	-0.010	-0.020	-0.272
	(0.009)	(0.009)	(0.013)	(0.027)
R × land-labor (log)	-0.042***	-0.042***	-0.043***	-0.078***
	(0.007)	(0.007)	(0.010)	(0.023)
Self-fiscal (log)		-0.016	0.002	0.132
		(0.017)	(0.028)	(0.054)
GDP (log)		0.057	-0.048	0.121***
		(0.074)	(0.123)	(0.047)
Rainfall (log)		-0.009	-0.008	-0.035
		(0.015)	(0.025)	(0.047)
Constant	4.285***	3.698***	4.914***	3.490***
	(0.042)	(0.862)	(1.435)	(0.802)
County fixed effect	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
R-squared	0.78	0.78	0.77	
Difference-in-Hansen test				0.000
Number of instruments				240
Observations	35160	35160	15384	14102

Note: TWFE refers to the traditional fixed effect model. TWFE+PSM refers to applying the fixed effect model to the common support sample based on the one-to-one propensity score matching. SYS-GMM+PSM refers to the two-step system generalized moment estimation method on the matching samples. We incorporate the first-order and second-order lag forms of the dependent variable, adjusting the coefficients and standard errors accordingly. All the variables are taken in log form. We control the GDP, fiscal situation, and rainfall index in the regression. We also include county fixed effect, and year fixed effect. Robust standard errors clustered at the county level are reported in parentheses. ***, ** and * represent significance at the 1%, 5% and 10% levels.