

Financial Frictions and Agricultural Productivity Differences

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Abstract

This paper explores the role of financial frictions in accounting for agricultural productivity differences. A two-sector general equilibrium model with a subsistence consumption requirement and financial frictions is constructed to explain and quantify the importance of financial frictions in agricultural labor productivity differences. Severer financial frictions decrease the use of intermediate inputs while increase the use of labor inputs. Consequently, labor productivity in agricultural sector is lower and hence, due to a larger employment share in agricultural sector, aggregate labor productivity is also lower. The quantitative results show that a substantial part of observed agricultural employment share and labor productivity differences can be accounted for by financial frictions.

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1 Introduction

A growing literature documents that huge agricultural productivity differences account for a large fraction of the large aggregate productivity differences and hence the income differences across countries (see [Restuccia, Yang, and Zhu 2008](#); [Gollin, Lagakos, and Waugh 2012](#)). Since to understand the large income differences across countries is one of the most important issues in economics, theoretical and quantitative frameworks that account for huge agricultural productivity differences are needed. Recently, a growing literature tries to address the issue by proposing various frictions that force poor countries to produce agricultural goods inefficiently.

To gain more insight to this issue, this paper explores the role of financial frictions in accounting for the agricultural productivity differences. The main economic mechanism is as follows. Farmers in poor area do not have enough funds to finance the purchase of intermediate inputs such as fertilizers. They have to borrow from financial intermediaries to get enough funds to carry out agricultural production. Severer financial frictions lead to a decrease of the purchase of intermediate inputs for agricultural production. Farmers have to rely more on labor inputs when they do not have enough intermediate inputs. Therefore, severer financial frictions decrease the use of intermediate inputs while increase the use of labor inputs. Consequently, labor productivity in agricultural sector is lower and hence, due to a larger employment share in agricultural sector, aggregate labor productivity is also lower. The financial friction differences thus could account for the productivity differences in agricultural sector and the aggregate economy.

Instead of studying cross-country agricultural productivity differences, we focus on cross-province agricultural productivity differences in China. We first document that, in China, both aggregate and agricultural labor productivity difference between the richest and the poorest province is very large and agricultural labor productivity difference could account for a large fraction of aggregate difference. Moreover, we document two other facts regarding intermediate goods used for agricultural goods production and financial frictions in agricultural sector. On the one hand, a significant positive relationship between intermediate goods and agricultural output is identified from the data. On the other hand, a significant negative relationship between financial frictions in agricultural sector and agricultural labor productivity is also found. The survey data we rely on allow us to identify the reason for borrowing from financial intermediaries. The major reason to borrow from financial

intermediaries is to finance the purchase of intermediate inputs for agricultural goods production. Since poor farmers have to buy intermediate inputs through external finance, these two empirical facts suggest that financial frictions are potentially quite important to account for agricultural labor productivity differences.

A two-sector general equilibrium model with financial frictions is constructed to explain and quantify the importance of financial frictions in agricultural labor productivity differences. There are two main ingredients in the model. The first one is there is a subsistence consumption requirement of agricultural goods due to non-homothetic preferences. The second ingredient is financial frictions: people can not borrow as much as they need. The model is used to match all the differences in the use of agricultural intermediate input-output ratio and explain substantial fraction of agricultural and aggregate labor productivity gap.

The quantitative exercises show that our model can account for 78% and 83% of the cross-province relationship of the agricultural employment share and financial frictions and the agricultural labor productivity and financial frictions. Moreover, we compare the economies with and without financial frictions. The economy with financial frictions can account for 74% of the relationship between agricultural employment share and labor productivity, while the economy without financial frictions can only account for 50%. Although the model with financial frictions still leaves a fraction of 26% unexplained ratio, it accounts a lot more than the model without financial friction by 24%. Our simulation does not allow any differences in TFP or other factors. Therefore, in our model financial frictions have a salient power in explaining agricultural labor productivity and are not negligible in explaining aggregate labor productivity differences.

This paper contributes to the literature of accounting for agricultural and aggregate labor productivity differences across countries. The contribution of this paper is twofold. First, we document several important empirical facts across provinces in China: labor productivity differences, financial frictions differences, agricultural intermediate inputs usage differences. We focus on accounting for the large agricultural labor productivity differences across provinces in China. The differences could explain a large fraction of aggregate labor productivity differences. Other than reasons in the literature such as self-selection effect due to subsistence requirement of agricultural goods (Lagakos and Waugh, 2012), policy frictions on size distribution of farms (Adamopoulos and Restuccia, 2011), frictions on infrastructure (Gollin and Rogerson, 2010), incomplete market which hindering

risk-sharing (Donovan, 2012), this paper considers financial frictions as an important reason for low labor productivity in poor areas.

To the best of our knowledge, this paper is the first one which does the quantitative analysis of the effect of financial frictions on agricultural sector, although there is a large literature on the effect of financial frictions on manufacturing and service sectors (see for example Buera, Kaboski, and Shin 2011). The most related paper is Restuccia, Yang, and Zhu (2008) which attributes low agricultural labor productivity to low labor cost and high intermediate inputs cost in the agricultural sector. This paper differs from theirs by considering financial frictions due to limited commitment, instead of input price frictions, as the reason for low agricultural labor productivity.

The remainder of the paper is organized as follows. Section 2 provides our motivating empirical facts on financial frictions and intermediate inputs usage. A two-sector general equilibrium model is described and characterized in Section 3. Calibration and quantitative findings are presented in Section 4. Finally, Section 5 concludes and data descriptions and model discussions are included in the Appendix.

2 Empirical Evidence

In this section, We first show that agricultural labor productivity plays an important role in explaining the labor productivity difference across provinces in China, then we show the relationship between agricultural labor productivity and the use of agricultural intermediate input. We also show that rural financial frictions are the key to explain the differences of agricultural intermediate input shares and agricultural labor productivities.

2.1 Agricultural and Aggregate Labor Productivity Gap in China

Table 1 shows the aggregate, agricultural and non-agricultural GDP per worker (measured in Chinese currency) and agricultural employment share across provinces in China in 2005. GDP per worker in the richest 10% percentile province is more than 5 times that of the poorest 10% percentile province. The log-variance of GDP per worker for the whole sample is 0.32. By disaggregating the total GDP per worker, we find that the agricultural labor productivity gap is larger than that of non-agricultural sector. And agricultural employment share is more than 50% in the poor area

while the rich area only has less than 10% workers in agricultural sector.¹

	GDP/L	GDP_a/L_a	GDP_n/L_n	L_a/L
10% percentile	74822.50	17460.96	78979.85	0.07
90% percentile	14351.59	3998.39	28173.42	0.57
$\frac{10\% \text{ percentile}}{90\% \text{ percentile}}$	5.21	4.37	2.80	

Table 1: Labor Productivity Gap across Provinces in China

A simple counterfactual analysis would show the importance of labor productivity in agricultural sector. Suppose all the provinces only have the same highest agricultural productivity, then the 10%/90% percentile ratio of total GDP per worker would be 3.47 and log-variance would be 0.19. If further assuming all the provinces has the same smallest agricultural employment share, then the the 10%/90% percentile ratio would be driven down to 2.96 and log-variance would be 0.17.

2.2 Agricultural Intermediate Input Shares across Provinces

One possible reason to explain the agricultural productivity gap is the differences in the use of intermediate input, such as fertilizer, pesticide, etc., which indicates the modernization level of agricultural production. [Restuccia, Yang, and Zhu \(2008\)](#) shows that there is a positive correlation between relative output per worker and intermediate input to output ratio in agricultural sector across countries. This is also true for provincial data in China.

Figure 1 shows the significant positive correlation.² For example, the poorest province, Guizhou, has a comparable arable land area and agricultural employment with one of the richest province, Jiangsu, but they differ largely in the use of intermediate input, as well as the agricultural output per worker.

2.3 Rural Financial Frictions and Agricultural Labor Productivity

Why do people in poor area use less intermediate input such as fertilizer? [Banerjee \(2008\)](#) list several possible reasons: “unwillingness to take risks, the unavailability of credit, the lack of the

¹See Appendix A.1 for the macro data source. For the year 2005, the 10% percentile (from the richest to the poorest) province is Beijing, and the 90% percentile province is Gansu.

²See A.1 for the intermediate input data. The largest agricultural output is normalized to be 1. Both axes are in log scale, with a correlation 0.65.

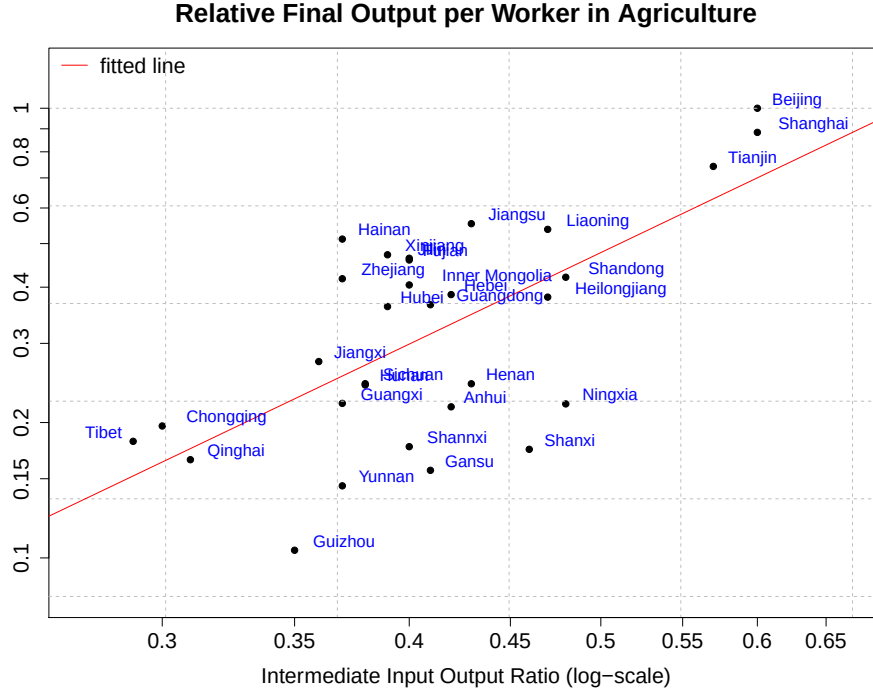


Figure 1: Intermediate Input Output Ratio vs Relative Agricultural Output per Worker

right internal or external incentives for long-range planning, distortions in the land market or a lack of understanding of the benefits of fertilizer.” Since fertilizer is widely used in China, and China has already corrected its land market distortions after 1978, the most possible explanation should be unavailability of credit.

We use several novel data sets to study the relationship between rural financial frictions and agricultural labor productivity. One is *Farmer’s Credit Situation Survey* which was conducted by People’s Bank of China in year 2006. The questionnaire has questions about the basic situation of each rural household, agricultural sales income, credit situation of agricultural production and so on. Based on this data, we follow [Lau, Lin, and Luo \(1990\)](#) to use binding ratio as an index of rural borrowing constraint. Binding ratio is defined as the number of farmers who need money to produce but cannot get enough credits divided by the total sample number.³ Figure 2 shows a significant negative correlation between agricultural sales income per worker with the binding ratio.

From Figure 2 we can see that farmers in the rich provinces, such as Jiangsu, is less likely to be

³See Appendix A.2.1 for the details.

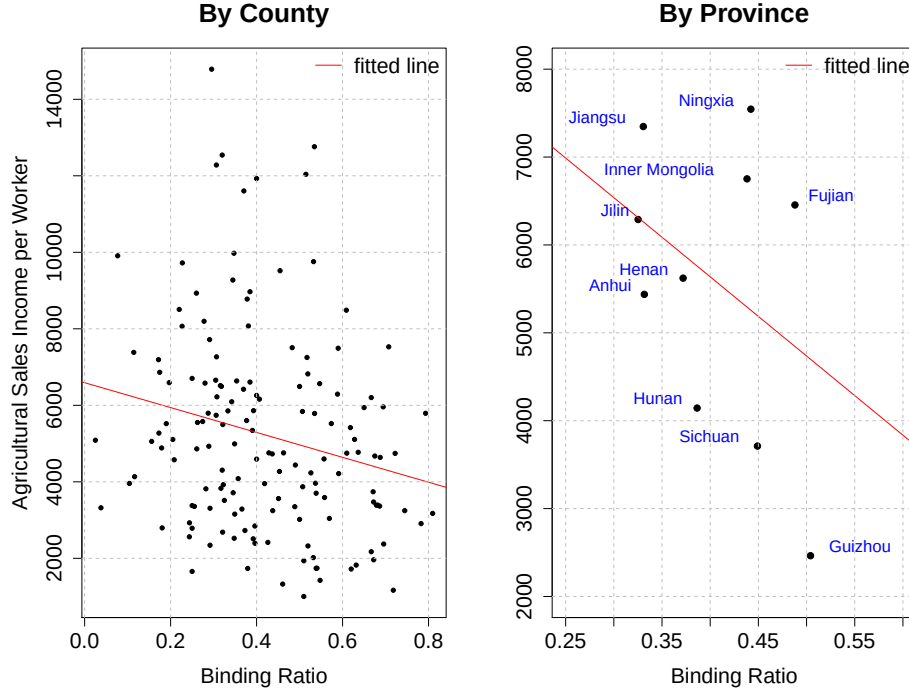


Figure 2: Binding Ratio vs Agricultural Sales Income per Worker

credit constrained, with a binding ratio of 0.33 while more than 50% farmers are credit constrained in the poorest province, Guizhou.

In sum, we argue that rural financial frictions have an important impact on the intermediate input use in agricultural sector, and therefore result in a difference in agricultural labor productivity.

3 The Model

We model an economy with two sectors: agricultural sector and non-agricultural sector. The two sectors produce two final goods respectively: an agricultural good and a non-agricultural good. The output of the agricultural sector is used for consumption only and the output of the non-agricultural sector has to be used for agricultural good production in addition to consumption. The model economy is populated by a continuum of mass N homogeneous households. Each household is endowed with one unit of labor which is supplied inelastically. Assume that labor market in each sector is competitive but there are labor market distortions that in effect incur a cost of reallocating labor from agricultural sector to non-agricultural sector and among provinces. Labor distortions

reflect the facts such as human capital differences. Final goods markets are competitive. Different from labor, final goods are standard and are easy to be distributed. We assume that final goods are tradable among provinces so that final goods have the same price all over the country. There exists a representative financial intermediary which behaves competitively and has a deep pocket. The economy coincides with a province in China. Assume there are $J > 1$ economies/provinces.

3.1 Non-Agricultural Production

The non-agricultural good is produced by labor only:

$$Y_n = AL_n, \quad (1)$$

where Y_n and L_n are output of non-agricultural good and labor input, respectively. Parameter A is the economy-wide productivity.

Denote the wage rate in non-agricultural sector by w_n . Profit maximization of the representative firm in non-agricultural sector implies $w_n = A$. The non-agricultural good is used as numeraire.

3.2 Agricultural Production

The agricultural production uses both an intermediate input and labor. The production function is

$$Y_a = X^\alpha (Z^{1-\sigma} (\kappa AL_a)^\sigma)^{1-\alpha}, \quad 0 < \sigma < 1, 0 < \alpha < 1, \kappa > 0, \quad (2)$$

where Y_a and L_a are output of agricultural good and labor input, respectively. Z and X are land and intermediate input supplied by the non-agricultural sector. As [Restuccia et al. \(2008\)](#) argues, this intermediate inputs may consist of chemical fertilizers, pesticides, hybrid seeds, fuel, energy and other purchased factors. The economy-wide productivity A and agricultural specific productivity κ are both labor augmenting. Assume that land is a fixed factor in the production function so that labor and intermediate input both exhibit decreasing returns to scale.

Before production, farmers (producers of agricultural goods) have to buy intermediate goods in advance. However, farmers are assumed to be too poor to purchase any intermediate goods upfront. The only way to finance the purchase of intermediate goods is to borrow from the financial

intermediary through financial contracts. Farmers have limited commitment and they could default. In particular, after the production, farmers could renege on the financial contracts. In that case, only a fraction $1 - \lambda$ of the output net of wage payment could be kept by farmers. Denote the exogenous interest rate, wage rate in agricultural sector and the price of agricultural goods by r^* , w_a and p_a . For a given X , an incentive-compatible financial contract requires the following condition holds:

$$\max_{L_a} \{p_a Y_a - w_a L_a\} - (1 + r^*) X \geq (1 - \lambda) \max_{L_a} \{p_a Y_a - w_a L_a\}. \quad (3)$$

The above condition states that a farmer must end up with no less economic resources when he fulfills his credit (left-hand side) than when he defaults (right-hand side).

Optimization of the representative farmer means the following two conditions hold:⁴

$$\sigma (1 - \alpha) p_a \frac{Y_a}{L_a} = w_a, \quad (4)$$

$$X = \min \left\{ \frac{\lambda [1 - \sigma (1 - \alpha)] p_a Y_a}{1 + r^*}, \frac{\alpha p_a Y_a}{1 + r^*} \right\}. \quad (5)$$

We model the cost incurred by the distortion in labor markets as a percentage of the wage rate in the non-agricultural sector:

$$w_a = (1 - \theta) w_n, \quad 0 \leq \theta < 1. \quad (6)$$

The above inequality could be rewritten as

$$X \leq \min \{ \lambda [1 - \sigma (1 - \alpha)], \alpha \} Z \left(\frac{1}{1 + r^*} \right)^{\frac{1 - \sigma (1 - \alpha)}{(1 - \sigma)(1 - \alpha)}} \left(\frac{\sigma (1 - \alpha)}{1 - \theta} \right)^{\frac{\sigma}{1 - \sigma}} p_a^{\frac{1}{(1 - \sigma)(1 - \alpha)}} \kappa^{\frac{\sigma}{1 - \sigma}}. \quad (7)$$

Hence, it is easy to check the financial constraint is binding or not. In particular, we have the following result.

Proposition 1: Farmers are financially constrained if and only if

$$\lambda \leq \frac{\alpha}{[1 - \sigma (1 - \alpha)]}. \quad (8)$$

⁴An alternative specification of financial constraint is provided in the Appendix B.2. In that specification, the first-order condition with respect to labor has a wedge between the marginal labor productivity and the wage rate for agricultural labor. This wedge could potentially generate labor productivity differences even if there is no distortion in labor market (no wage differences).

3.3 Preferences

The representative household gains utility from consuming the agricultural good c_a and non-agricultural good c_n . Since labor endowment is supplied inelastically, the total labor supply (or aggregate employment) is equal to N . The preference of each household is represented by a Stone-Geary utility function, which implies the Engel's law:

$$U = a \log(c_a - \bar{a}) + (1 - a) \log c_n, \quad 0 \leq a < 1,$$

where $\bar{a}$ is subsistence level of consumption of agricultural good and a is a utility weight over the two goods. This utility function requires the representative household spends $p_a \bar{a}$ resources to $\bar{a}$ units of agricultural good in the first place and then allocates the rest of resources optimally according to the weight a . Specifically, the consumption choice rules are as follows:

$$c_a = \bar{a} + a p_a^{-1} (y - p_a \bar{a}), \quad (9)$$

$$c_n = (1 - a) (y - p_a \bar{a}), \quad (10)$$

where y is the income (total resources) of the representative household.

3.4 Competitive equilibrium

A competitive equilibrium is a set of allocations $\{L_a, L_n, c_a, c_n, X\}$, a set of prices $\{p_a, w_a, w_n\}$, and profits for firms in agricultural sector, such that: (i) given prices and profits, $\{c_a, c_n\}$ solve the utility optimization problem of the representative household; (ii) given prices, $\{L_a, L_n, X\}$ solve the profit optimization problem of the representative firms in each sector; (iii) condition (6) holds so that the representative household is indifferent between working in the two sectors; and (iv) labor market clears:

$$N = L_a + L_n; \quad (11)$$

(v) agricultural goods market clears:

$$Y_a = N c_a; \quad (12)$$

(vi) non-agricultural goods market clears:.

$$Y_n = Nc_n + X. \quad (13)$$

Note that the market clear conditions we are using market clear conditions for final goods in each economy, treating each economy as a fully closed economy. The reasons for taking this approach are twofold. First, solving for closed-economy solutions are much easier and closed-form solutions could be derived. More intuition could be derived from the closed-form solution and quantitative exercises are much easier to be done. Second, as showed in the Appendix (B.1), the closed-economy equilibrium is one of the open-economy equilibria. The only difference between the two economy is that the open economy final goods market clear conditions are

$$\sum_j Y_a^j = N \sum_j c_a^j, \quad (14)$$

$$\sum_j Y_n^j = N \sum_j c_n^j + \sum_j X^j, \quad (15)$$

where $j = 1, 2, \dots, J$ is the economy index. In this sense, the closed economy in the model is actually an open economy. The intuition is as follows. Since final goods are tradable and hence have the same price in each economy, the closed economy is an open economy with no trade of final goods and labor mobility among economies. Note that the production technology in non-agricultural sector is linear and hence the allocation of labor among economies does not matter for any open-economy equilibrium. Hence, open economy has multiple equilibria. One of the open-economy equilibrium picks the closed-economy equilibrium non-agricultural labor allocation as the equilibrium non-agricultural labor equilibrium. Since the closed economy has unique equilibrium (see the argument above), this particular open-economy equilibrium coincides with the closed-economy equilibrium.

Since our focus is to account for the cross-province agricultural labor productivity differences, a few variables in the competitive equilibrium are key to the analysis: the intermediate input ratio X/Y_a , the share of employment in agricultural L_a/N , labor productivity in agricultural sector Y_a/L_a , and aggregate labor productivity Y/N . Production function of the agricultural sector sug-

gests the following equality:

$$\frac{Y_a}{L_a} = (\kappa A)^\sigma \left(\frac{Z}{N} \right)^{1-\sigma} \left(\frac{X}{Y_a} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{L_a}{N} \right)^{\sigma-1}. \quad (16)$$

According to this equality, the labor productivity in agricultural sector depends positively on the intermediate input ratio X/Y_a and negatively on the employment share in agricultural sector L_a/N . Assuming the borrowing constraint of the representative farmer is binding in the equilibrium. Then from optimality condition (4), the binding version of the borrowing constraint (5), and the decomposed version of agricultural production function (16), by eliminating the price of agricultural goods, we have the following two equilibrium conditions:

$$\frac{X}{Y_a} = \left[\frac{\lambda(1-\sigma(1-\alpha))(1-\theta)}{\sigma(1-\alpha)(1+r^*)} \frac{A^{1-\sigma}}{\kappa^\sigma (Z/N)^{1-\sigma}} \right]^{1-\alpha} \left(\frac{L_a}{N} \right)^{(1-\alpha)(1-\sigma)}, \quad (17)$$

$$\frac{Y_a}{L_a} = A^{\sigma+\alpha(1-\sigma)} \kappa^{\sigma(1-\alpha)} \left[\frac{\lambda(1-\sigma(1-\alpha))(1-\theta)}{\sigma(1-\alpha)(1+r^*)} \right]^\alpha \left[\frac{(Z/N)}{(L_a/N)} \right]^{(1-\alpha)(1-\sigma)}. \quad (18)$$

Market clearing conditions and optimality conditions of the utility maximization problem of the representative household give the following equilibrium condition:

$$\frac{Y_a}{N} = \bar{a} + \frac{a}{(1-a)p_a} \left[A \left(1 - \frac{L_a}{N} \right) - \frac{X}{N} \right].$$

Rewriting the above equation and using optimality condition (4) and binding version of (5), we obtain

$$\frac{Y_a}{L_a} \frac{L_a}{N} = \bar{a} + \frac{aA}{(1-a)} \left[\frac{\lambda(1-\sigma(1-\alpha))}{1+r^*} \right] \left(\frac{X}{Y_a} \right)^{-1} \left[1 - \left(1 + \frac{\lambda(1-\sigma(1-\alpha))(1-\theta)}{\sigma(1-\alpha)(1+r^*)} \right) \frac{L_a}{N} \right]. \quad (19)$$

Equation (19) could be further simplified as follows:

$$\left[a + \left(1 - a + \frac{a\lambda(1-\sigma(1-\alpha))}{(1+r^*)} \right) \frac{1-\theta}{\sigma(1-\alpha)} \right] \left(\frac{L_a}{N} \right) = \frac{(1-\theta)(1-a)}{\sigma(1-\alpha)} \frac{\bar{a}}{(Y_a/L_a)} + a. \quad (20)$$

Equilibrium conditions (17), (18) and (20) could be solved for three key variables we are interested in: Y_a/L_a , L_a/N , and X/Y_a . The last variable we are interested in is the aggregate GDP per worker

which could be obtained as follows:

$$\begin{aligned}\frac{Y}{N} &= \frac{\text{GDP}_a + \text{GDP}_n}{N} = \frac{p_a Y_a - X + A(N - L_a)}{N} \\ &= \frac{Y_a}{L_a} \frac{L_a}{N} \left(p_a - \frac{X}{Y_a} \right) + A \left(1 - \frac{L_a}{N} \right).\end{aligned}\quad (21)$$

Our quantitative analysis is based on equilibrium conditions (17), (18), (20) and (21).

3.5 An Analytical Example

Before switching to the quantitative exercise, in this subsection, we consider a special case which gives explicit expressions to our key variables. In particular, assume $a = 0$. In this case, since the utility weight is zero so that only the subsistence agricultural goods consumption is needed, i.e. $c_a = \bar{a}$. Market clearing condition means

$$Y_a = N\bar{a}.$$

Rewriting the condition obtains

$$\frac{Y_a}{L_a} = \bar{a} \left(\frac{L_a}{N} \right)^{-1}. \quad (22)$$

The production function and the above condition means

$$\frac{L_a}{N} = \frac{1}{\kappa A} \left(\frac{\bar{a}}{(Z/N)^{1-\sigma} (X/Y_a)^{\alpha/(1-\alpha)}} \right)^{1/\sigma}, \quad (23)$$

$$\frac{Y_a}{L_a} = \kappa A \left(\frac{(Z/N)^{1-\sigma} (X/Y_a)^{\alpha/(1-\alpha)}}{\bar{a}^{1-\sigma}} \right)^{1/\sigma}, \quad (24)$$

$$\frac{X}{Y_a} = \bar{a} \left[\frac{\lambda(1-\sigma)(1-\alpha)(1-\theta)}{\sigma(1-\alpha)(1+r^*)\kappa} \right]^{\frac{\sigma}{1-\sigma}} \left(\frac{1}{Z/N} \right)^{\sigma+1/(1-\sigma)}. \quad (25)$$

Equation (25) implies several potential reasons for limited use of intermediate inputs in developing countries: severe financial friction (small λ); 2) high labor market distortion (large θ). Moreover, equation (23) and (24) state the negative relationship between agricultural employment share and intermediate inputs ratio and the positive relationship between agricultural labor productivity and

the intermediate inputs ratio. This confirms our intuition that severer financial frictions lead to less use of intermediate inputs and consequently more use of labor (larger agricultural employment share) and smaller agricultural labor productivity.

4 Quantitative Analysis

The section quantitatively analyzes the role of financial friction (λ) in generating labor productivity gap. Since there is no counterpart in the data to let us calibrate λ , we follow Buera, Kaboski, and Shin (2011) to simulate the results with different $0 < \lambda \leq 1$ and compare the span of simulation with the data. The model can span to match all the differences in the use of agricultural intermediate input-output ratio and explain substantial fraction of agricultural and aggregate labor productivity gap.

4.1 Calibration

We assume Shanghai, which has the highest GDP per worker in China, as our undistorted ($\lambda = 1$) economy and calibrate all the model parameters to match its key aspects in 2005. We need to determine the following parameters: Z/N , A , κ , σ , α , a , $\bar{a}$, r^* , θ . Note that both input and output data of agricultural and non-agricultural goods are measured with nominal value (the same currency) in all provinces, therefore we can normalize the relative price of agricultural goods to 1 and it fits the open economy analysis in Appendix B.1. We then adjust θ based on equation (4). The intuition is, since labor cannot move freely, they can only take the wage (determined by labor productivity) as given. For Shanghai's case, $\theta = 0.88$. $r^* = 0.0558$ is the one year nominal interest rate in 2005. $\alpha = 0.6378$, which is the intermediate input output ratio multiplied by $1 + r^*$, is selected to match X/Y_a of Shanghai in China's National Bureau of Statistics (NBS) data. Z/N , the land-to-employment ratio, is directly chosen from NBS data. In 2005, the arable land per worker (in hectares) is 0.03 in Shanghai. $A = 114018$, as the economy-wide TFP parameter, is the non-agricultural GDP per worker of Shanghai.

Given the functional form of production function and α , A , we choose (κ, σ) to match the agricultural output per worker of Shanghai, and we get $\kappa = 0.9139$, $\sigma = 1$. Therefore $1 - \sigma$, which controls the land elasticity of output, is 0. And this fact is consistent with most of the agricultural

Parameter	Value	Target
Z/N	0.03	Land-to-employment ratio of Shanghai
A	114018	Non-agricultural labor productivity of Shanghai
κ	0.9139	Agricultural employment share and output per worker of Shanghai
σ	1	Agricultural employment share and output per worker of Shanghai
α	0.6378	Intermediate input share of Shanghai
a	0.0017	Long-run share of agricultural employment
$\bar{a}$	2554.9	Agricultural employment share of Shanghai
r^*	0.0558	One year nominal interest rate

Table 2: Calibration of Parameter Values to Shanghai

production studies based on cross-province data. We regressed the agricultural production function using cross-province input-output data, which results in an insignificant coefficient for land elasticity. To calibrate a and $\bar{a}$, we follow Restuccia et al. (2008) to set the target of long-run agricultural employment share to be 0.5%. Based on equation (20) the implied value is $a = 0.0017$. Then $\bar{a} = 2554.9$ is calculated to match the agricultural employment share of Shanghai in 2005. See Table 2 for all the calibrated parameters.

4.2 Results

The Agricultural input-output ratio is positively correlated with financial friction parameter λ and does not depend on economy-wide TFP A . We vary $0 < \lambda \leq 1$ and compare X/Y_a with the data. Given $0.29 < \frac{X}{Y_a} < 0.60$, the range of λ is $0.48 < \lambda \leq 1$. Then we generate the model implied values such as agricultural employment share, agricultural output per worker, and aggregate labor productivity per worker. Figure 3-5 show the comparison.

4.2.1 Agricultural employment share and output per labor

Figure 3-4 show the correlation between the intermediate input-output ratio and agricultural employment share and agricultural output per labor. Under log scale, our model predict linear elasticity between them. From these figures we can see our model can capture the significant fraction of this relation. In Figure 3, the model simulation gives a elasticity of -1.74. Comparing to the data which has a elasticity of -2.24, it is a fraction of 0.78 in prediction. L_a/N is also determined by A while X/Y_a is not. So the differences in magnitude between data and simulation can be explained by

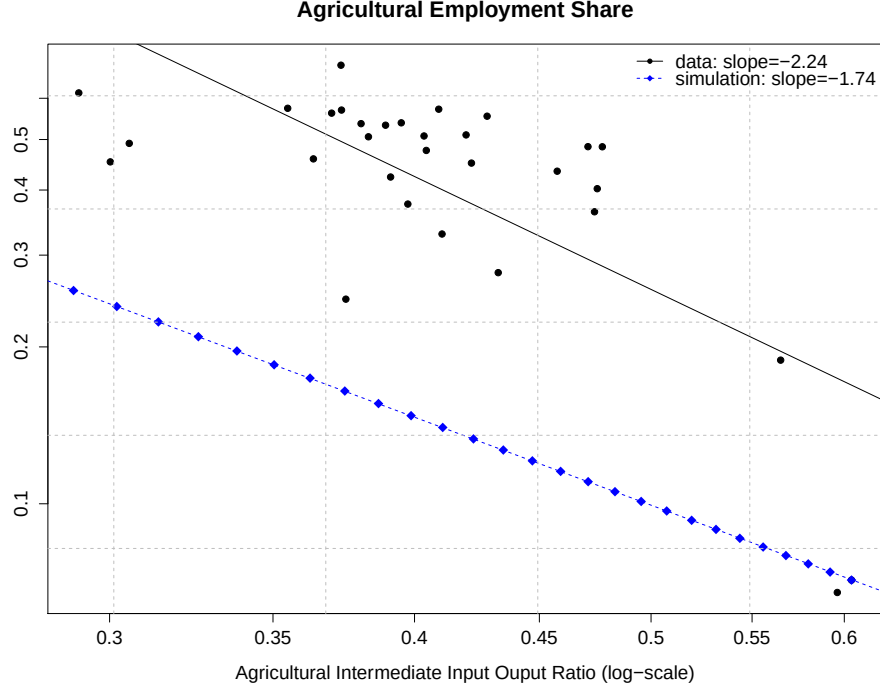


Figure 3: Impact of Financial Frictions: Employment Share

economy-wide TFP.

In Figure 4, the slope of simulation is 1.76 (input-output ratio elasticity of output per worker) and that of data is 2.13. Therefore this slope ratio between our simulation and the data is 0.83. Our simulation does not allow any differences in TFP or other factors. Similar as in Figure 3, the differences in magnitude between data and simulation can be explained by economy-wide TFP. Therefore in this model financial frictions have a salient power in explaining agricultural employment and labor productivity.

According to (4) and (6), the lower the λ (more financial frictions), the larger wage gap (smaller $1 - \theta$ or larger θ). We calculate the absolute wage gap across provinces from data using the following equation:

$$\tilde{\theta}_i = \frac{\sigma(1 - \alpha) \frac{Y_{ai}}{L_{ai}}}{A},$$

where A is the average labor productivity (also wage) for the non-agricultural sector in our benchmark economy (Shanghai), Y_{ai}/L_{ai} is the average agricultural labor productivity in province i . Therefore $\sigma(1 - \alpha) Y_{ai}/L_{ai}$ is the marginal product of labor (wage) in agricultural sector. We can see this absolute wage gap $\tilde{\theta}_i$ is linear in Y_{ai}/L_{ai} , therefore Figure 4 also shows the wage gap

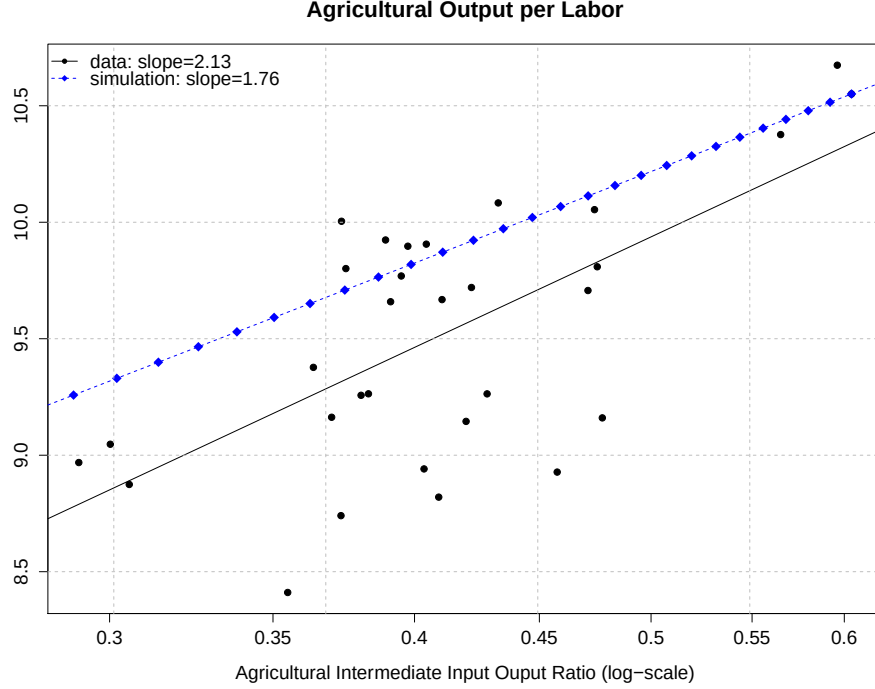


Figure 4: Impact of Financial Frictions: Agricultural Output per Labor

comparison. We can see financial frictions amplifies the nominal wage gap.

4.2.2 Aggregate labor productivity

Financial frictions are not negligible also in explaining aggregate labor productivity differences. Figure 5 reports the simulation result (not in log-scale). Our model can generate 19% in terms of range and narrow down from the gap (highest/lowest) from 12 to 10 in terms of factor comparing to the original data.

We should notice that the lower the economy-wide TFP A , the larger gap that our model can generate. The intuition is straightforward. When A is lower, due to the subsistent level $\bar{a}$, more workers have to be trapped in the agricultural sector. Then severe financial frictions can generate a lower agricultural labor productivity and a much lower aggregate labor productivity.

4.3 Robustness

In this section we change the calibrated values of long-run agricultural employment share target, nominal interest rate r^* , and the income share of labor in agriculture σ to see their impacts to our

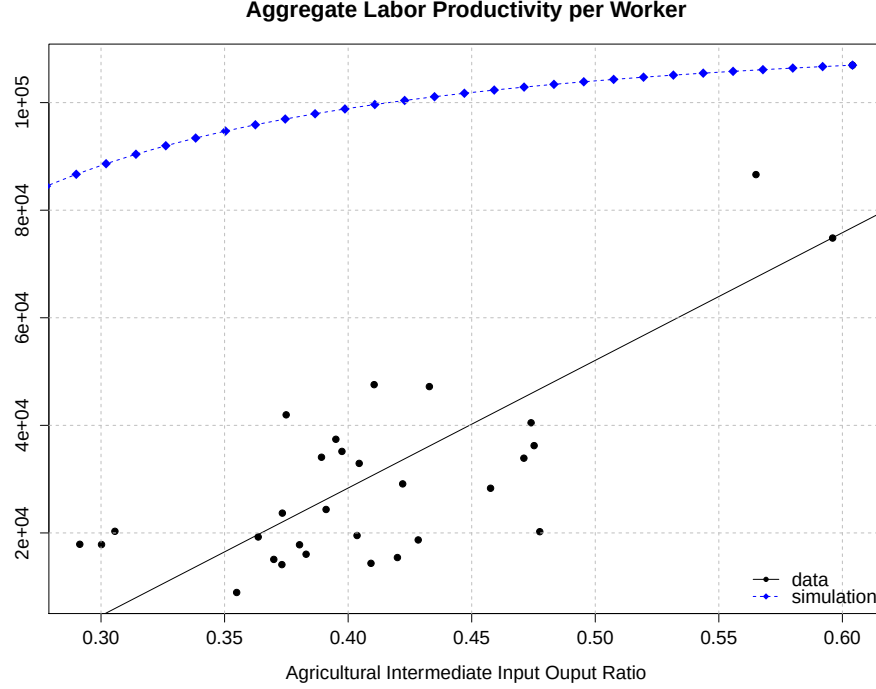


Figure 5: Impact of Financial Frictions: GDP per Worker

model.

4.3.1 Long-run agricultural employment share target

In Section 4.1 we set its value to be 0.5% to be consistent with Restuccia et al. (2008) and other literature. Although cross-country evidence shows that agricultural employment share does decline over time, this value is chosen arbitrarily. Now we gradually decrease it to 0 to see whether it affects the results. Note that when this target changes, both a and $\bar{a}$ will change.

	Data	Target of long-run L_a/N				
		0.004	0.003	0.002	0.001	0.000
X/Y_a elasticity of L_a/N	-2.24	-1.75	-1.75	-1.75	-1.76	-1.76
X/Y_a elasticity of Y_a/L_a	2.13	1.76	1.76	1.76	1.76	1.76

Table 3: Robustness Check for a

Table 3 shows the sensitivity test of long-run agricultural employment share target. We still compare X/Y_a elasticity of L_a/N and Y_a/L_a . We can see when we decrease this employment share target, the results are getting better, but in a very small magnitude. So Given the results in the table,

the 0.5% target gives the lower bound.

4.3.2 Nominal interest rate

	Data	r^*					
		0.05	0.04	0.03	0.02	0.01	0.00
X/Y_a elasticity of L_a/N	-2.24	-1.72	-1.67	-1.63	-1.59	-1.55	-1.51
X/Y_a elasticity of Y_a/L_a	2.13	1.73	1.69	1.65	1.61	1.57	1.53

Table 4: Robustness Check for r^*

The nominal interest rate r^* is picked from the data. Changing r^* does not affect other calibrated values except α . From Table 4 we can see when we decreases it, the results are getting worse with a modest magnitude. Since the input and output data are measured in nominal values, nominal interest rate is important to affect financial friction consequences.

4.3.3 Income share of labor in agriculture

In Section 4.1 we use $\sigma = 1$ which might be too unrealistic. It means the income share of land in agriculture is 0. Now we decrease σ (this will also change calibrated values for $a, \bar{a}, \kappa$), the results improves significantly. So If we underestimate the role of land ($1 - \sigma$), then the results generated by our model are also being underestimated. Given $\sigma = 1$, the results reported in Section 4.2 give the lower bound prediction. Table 5 summarizes the comparison.

	Data	σ			
		0.95	0.90	0.85	0.80
X/Y_a elasticity of L_a/N	-2.24	-1.83	-1.93	-2.04	-2.16
X/Y_a elasticity of Y_a/L_a	2.13	1.85	1.95	2.07	2.19

Table 5: Robustness Check for σ

4.4 Model Without Financial Frictions

Now we suppose there are no financial frictions. The use of agricultural intermediate inputs are not binding and resources are optimally allocated.⁵ To compare with the original model with financial

⁵See Appendix B.3 for the equilibrium equations of the financially unconstrained economy.

frictions, we use the same simulated wage gap to generate different L_a/N and Y_a/L_a . All other calibrated values are the same as in Section 4.1. To compare with data, the agricultural labor productivity is measured in terms of non-agricultural goods, i.e., $P_a Y_a/L_a$.

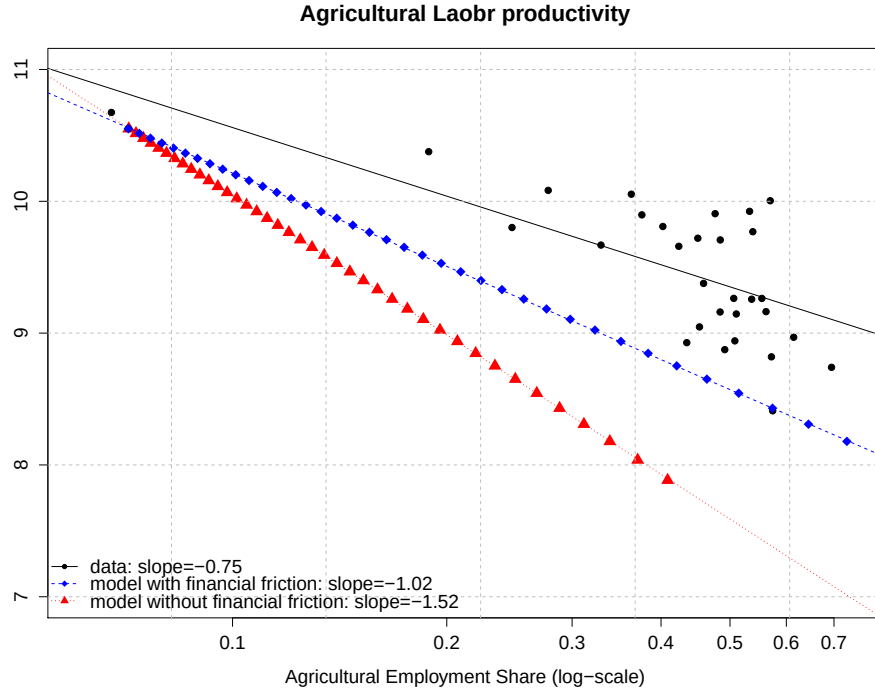


Figure 6: Compare with No Financial Friction Model: Agricultural Labor Productivity

Figure 6 shows that given the same labor productivity, the model with financial frictions (blue diamonds) has more power in predicting the agricultural employment share than that without financial frictions (red triangles). According to (20), L_a/N is determined by Y_a/L_a , therefore the Y_a/L_a elasticity of L_a/N is the reciprocal of the slope in Figure 6. This elasticity showed by data is -1.33 , the model with financial friction gives -0.98 , and the model without financial friction gives 0.66 . So the financial friction setup can predict 0.74 of elasticity ratio, while the other one can only get 0.50 . Although the model with financial friction still leaves an unexplained ratio of 0.26 , it surpass the model without financial friction by 0.24 in terms of this measure of success.

Given the same agricultural labor productivity, Figure 7 shows the differences in aggregate labor productivity. Our model with financial frictions can generate better results than that without financial frictions. The intuition is because of the subsistence level. With more frictions, workers are trapped in the agricultural sector and therefore hinder the rise of aggregate labor productivity.

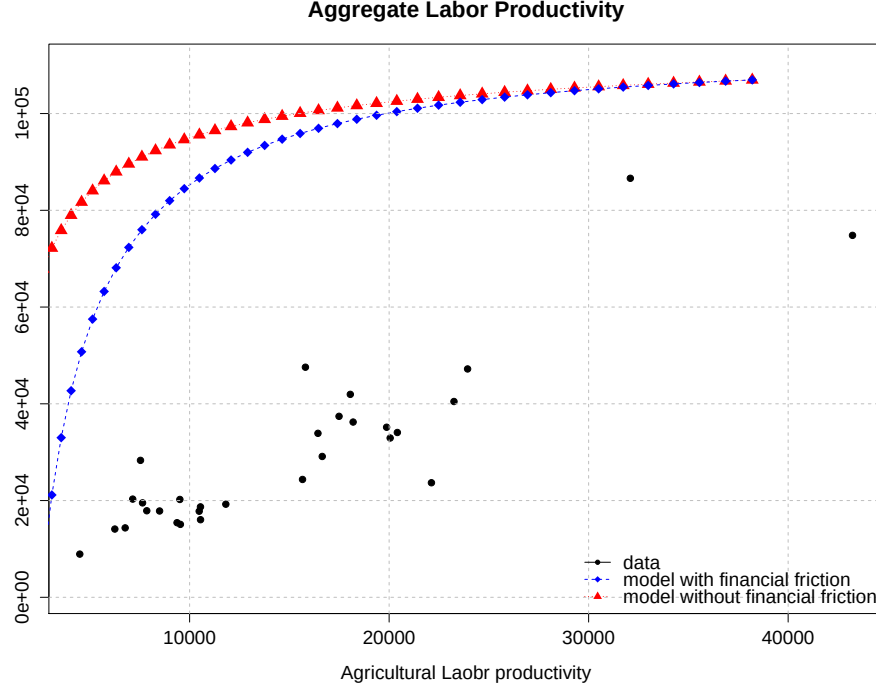


Figure 7: Compare with No Financial Friction Model: Aggregate Labor Productivity

5 Conclusion

This paper explores the role of financial frictions in accounting for agricultural productivity differences. A two-sector general equilibrium model with financial frictions is constructed to explain and quantify the importance of financial frictions in agricultural labor productivity differences. Severer financial frictions lead to a decrease of the purchase of intermediate inputs for agricultural production. Farmers have to rely more on labor inputs when they do not have enough intermediate inputs. Therefore, severer financial frictions decrease the use of intermediate inputs while increase the use of labor inputs. Consequently, labor productivity in agricultural sector is lower and hence, due to a larger employment share in agricultural sector, aggregate labor productivity is also lower. The financial friction differences thus could account for the productivity differences in agricultural sector and the aggregate economy.

This paper contributes to the literature by quantifying the role of financial frictions in accounting for agricultural productivity differences. Our quantitative results show that a substantial fraction of agricultural employment share and labor productivity differences can be accounted for by financial frictions. This paper provides a new insight that financial frictions play an important role in agri-

cultural productivity differences. One challenge our model faces is that financial frictions could be potentially overcome by self-financing (Moll, 2012). Our model is static and can not deal with this issue. Therefore, one promising future research direction is to construct a dynamic model in which farmers could save and hence accumulate funds.

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A Data Description

A.1 Macro Data

The aggregate and disaggregate level of data, including GDP, total output, employment come from the series of *China Statistical Yearbook* which are published by China's National Bureau of Statistics. All goods and services are measured in nominal values. Intermediate input is defined as total output minus value added.

The sample consists of 31 provinces, autonomous regions, and municipalities of the mainland China. They are Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shannxi, Gansu, Qinghai, Ningxia, and Xinjiang.

The agricultural sector consists of agriculture, forestry, animal husbandry, fishery and agricultural services. Detailed sectoral level data comes from *China Agricultural Statistical Yearbook*.

A.2 Micro Data

A.2.1 2006 Farmer's Credit Situation Survey

Farmer's Credit Situation Survey was conducted by The People's Bank of China in year 2006. It covers 10 provinces, 263 counties, 20040 households. The 10 provinces are Inner Mongolia, Jilin, Sichuan, Ningxia, Anhui, Jiangsu, Henan, Hubei, Fujian, Guizhou.

We focus on the households who mainly engaged in agricultural production in year 2006 and eliminate those who do not have the habit of borrowing money. Borrowing households were asked whether they can get credits from the bank and whether they can get enough credits. The household who is binding is defined as who needs to borrow for agricultural production and the loan is less than demand. The household who is not binding is defined as who does not need to borrow or loan is larger than demand. The binding ratio is defined as the number of farmers who are binding divided by the total sample number. The number of worker of each household is defined as the number of labor over the age of 16 minus the number of migrant workers.

For the county level data, we exclude the counties which contain less than 38 households to

improve the accuracy of binding ratio. From Figure 8 we can see that the significance of negative correlation does increase as we raise the criteria level (below which we need to exclude). As we increase the cutoff sample size, the significance start to drop because of the severe reduction of total sample size.

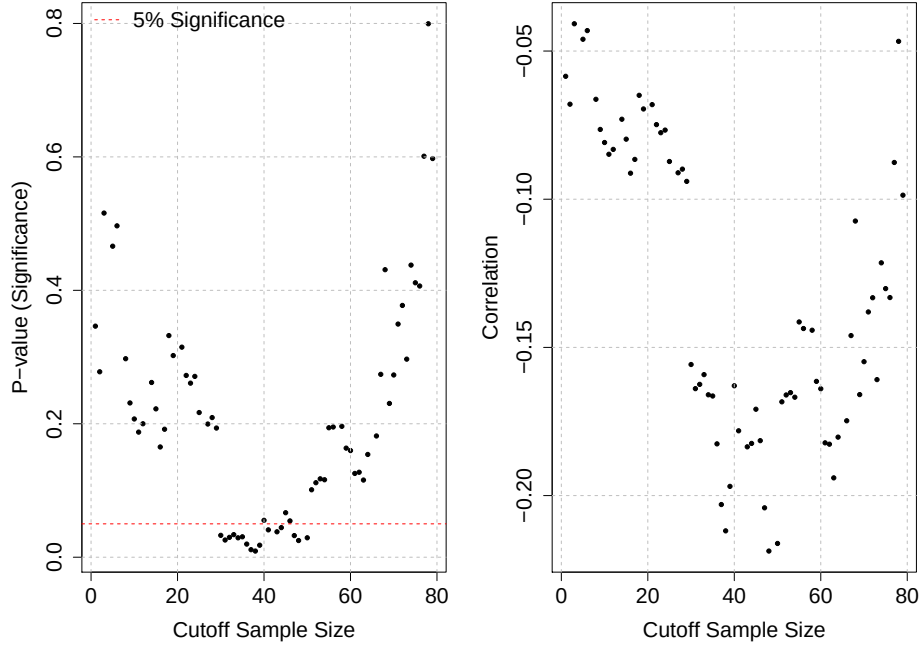


Figure 8: Significance and Correlation of Different Cutoff Sample Size

B Model Discussion

B.1 Proof of the equivalence of the closed economy and open economy

Lemma: The closed-economy equilibrium is an open-economy equilibrium.

Proof: The closed-economy equilibrium is determined by equation (1)-(2), (4)-(5) and (6)-(13) for each economy $j = 1, 2, \dots, J$. It is straightforward to show that the solution to the system (1)-(2), (4)-(5) and (6)-(13) is the solution to the system (1)-(2), (4)-(5), (6)-(11) and (14)-(15), since (14) and (15) are summations of (12) and (13), respectively. The system (1)-(2), (4)-(5), (6)-(11) and (14)-(15) is actually the system determines open-economy equilibria. Hence, the closed-economy equilibrium is one of the open-economy equilibria.

B.2 An alternative specification of the financial constraint

Assume that a fraction ϕ of wage bill has to be paid upfront. Under this assumption, farmers have to borrow more than X to finance the wage bill which has to be paid in advance. The incentive-compatible constraint for the representative farmer is

$$\max_{L_a} \{p_a Y_a - (1 + r^*) \phi w_a L_a - (1 - \phi) w_a L_a\} - (1 + r^*) X \geq (1 - \lambda) \max_{L_a} \{p_a Y_a - (1 - \phi) w_a L_a\}.$$

The first-order condition for the problem on the equilibrium path (left-handed side) is

$$\sigma (1 - \alpha) p_a \frac{Y_a}{L_a} = (1 + r^*) \phi w_a.$$

Obviously from the above optimality condition, variations of ϕ could generate variations of labor productivity even if wage has no variation.

B.3 The equilibrium of the financially unconstrained economy

If in an economy the financial constraint is not binding (for large value of λ), the equilibrium is determined by the following equations.

$$\begin{aligned} \frac{X}{Y_a} &= \left[\frac{\alpha (1 - \theta)}{\sigma (1 - \alpha) (1 + r^*)} \frac{A^{1-\sigma}}{\kappa^\sigma (Z/N)^{1-\sigma}} \right]^{1-\alpha} \left(\frac{L_a}{N} \right)^{(1-\alpha)(1-\sigma)}, \\ \frac{Y_a}{L_a} &= A^{\sigma+\alpha(1-\sigma)} \kappa^{\sigma(1-\alpha)} \left[\frac{\alpha (1 - \theta)}{\sigma (1 - \alpha) (1 + r^*)} \right]^\alpha \left[\frac{(Z/N)}{(L_a/N)} \right]^{(1-\alpha)(1-\sigma)}, \\ \left[a + \left(1 - a \left(1 - \frac{\alpha}{(1 + r^*)} \right) \right) \frac{1 - \theta}{\sigma (1 - \alpha)} \right] \left(\frac{L_a}{N} \right) &= \frac{(1 - \theta) (1 - a)}{\sigma (1 - \alpha)} \frac{\bar{a}}{(Y_a/L_a)} + a. \end{aligned}$$