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Farm expansion under credit constraint: evidence from commercial rice farmers in Guangxi, China

RESEARCH ARTICLE

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Abstract

Agricultural production decisions in China are usually financially constrained, and the lack of credit often can prevent profitable investment such as farm expansion that generates economies of scale. However, farm expansion is still increasingly observed in China, where more smallholders are expanding farms towards moderate-scale operation, especially in the rice sector. This study investigates this paradox by specifically assessing the impact of credit constraint on farm expansion decisions using a representative household survey of rice farmers in Guangxi Province, China. Farm expansion is empirically measured by both actual expansion in the past five years and the willingness to expand in the near future, which is predicted by a series of factors where the possible endogeneity of credit constraint is accounted for using instrumental variable techniques. It is found that credit constraint negatively and significantly affects farm expansion. Such impact is heterogeneous and is larger among moderate scale holders. Our findings highlight the importance and necessity of offering financial services to relatively small-scale commercial farms in developing countries to relax their credit constraints.

Keywords: credit constrains, farm size, farm expand, rice farmer, China
JEL code: Q12

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1. Introduction

Food security is among the most important agricultural issues in China, where feeding a population of 1.38 billion has been consistently prioritized in agricultural policy designs (Godfray *et al.*, 2010). While economies of scale usually stimulate agricultural productivity and thus increase farmer's income, for decades (Cao and Birchenall, 2013), the mismatch between a relatively large rural population and scarce arable land have allowed Chinese farm households (farmers hereafter) to operate on a landholding of only less than half hectare (Ostwald and Chen, 2006). On the one hand, farming at a too-small scale has inhibited the adoption of modern agricultural technology and the growth of farmers' income (Khataza *et al.*, 2019). On the other hand, rising off-farm employment opportunities with urbanization, as well as increasing labor cost of farming, have further discouraged agricultural cultivation, especially for smallholders. As a result, land abandonment widely exists, with the remaining land being increasingly switched from staple to cash crops (Zhang *et al.*, 2016), which lead great challenges to sustainable development of agriculture and potential enhancement of food security. In face to this change, the Chinese government has been promoting farm expansion through land transfer (of user rights)[1] to carry out moderate-scale grain cultivation (Huang *et al.*, 2017), which has gradually become a core component of China's agricultural policies in recent years (Chen, 2013). Encouragement from the government, along with the adoption of modern agricultural machinery, has stimulated moderate-scale grain cultivation in China (Huang and Ding, 2016). According to the decennial Agricultural Census of China[2], the acreage cultivated by moderate-scale farmers and business entities[3] account for 28.6% of the total cultivated area in China in 2016, and about 35% of the total farmland was transferred out, a huge increase from only 4.5% in 2006.

Realization of the economies of scale is subject to greater productive investment, especially in land and machinery (Wang *et al.*, 2016). However, farmers in developing countries are often constrained by low income and credit constraint due to long-term relatively small scale farming and incomplete rural financial markets (Conning and Udry, 2007). Given its importance, production decisions under credit constraint are intensively studied (Barham *et al.*, 1996; Boucher *et al.*, 2008, 2009; Diagne *et al.*, 2000; Jappelli, 1990). A growing empirical literature suggests that credit constraint has significant adverse effects on agricultural productivity (Guirkinger and Boucher, 2008; McIntosh *et al.*, 2013), income (Boucher *et al.*, 2008; Li and Xi, 2010; Tran *et al.*, 2016), technology adoption/investment (Berlinschi *et al.*, 2014; Kumar *et al.*, 2013; Okpukpara, 2010; Petrick, 2004; Porgo *et al.*, 2018; Rao *et al.*, 2014), and off-farm labor allocation (Porgo *et al.*, 2018; Uchida *et al.*, 2009). Researchers are commonly concerned about the reverse relationship between smallholders' farm size and productivity (Barrett, 1996; Fan and Chan-Kang, 2005; Feder, 1985; Helfand and Levine, 2004; Henderson, 2015), yet few have investigated the possible link between credit constraint and farm expansion. It is however important to quantify the impacts of credit constraint to assist future policy interventions that aim to strengthen the agricultural sector and help improve national food security through more profitable cultivation.

In rural China, financial markets are generally incomplete, and credit constraint is common among smallholders (Feder *et al.*, 1990; Kumar *et al.*, 2013; Li and Xi, 2010). The contrast between the widespread credit constraint and the noticeable farm expansion in the past decade therefore becomes a paradox to be investigated in the current study. Specifically, this paper aims to rigorously analyze the link between credit constraint and farm expansion in rural China using recent rice farm household survey in Guangxi province, China. To provide a comprehensive picture, past farm expansion decision and future expansion intention are parallelly analyzed. The possible endogeneity of expansion decision is addressed with instrumental variable techniques to obtain consistent estimates. Findings of this study will assist China's food security policy, production scale management, and rural financial reform as well as provide policy lessons to other developing countries.

[1] Land transfer in China concerns user rights only and occurs almost exclusively through land rental, as most land is collectively owned, according to the Property Law of the People's Republic of China passed in 2007.
[2] Third National Agriculture Census of China 2017. Available at: http://www.stats.gov.cn/tjsj/tjgb/nypcgb/ (in Chinese)
[3] Moderate-scale farmer and business entity: the farmer or entity cultivate more than 100 Chinese mu for single cropping or more than 50 Chinese mu in double season per year, 1 mu=0.067 hectare (ha).

This article is organized as follows. Section two presents an analytical procedure. Section three describes data and summary statistics. Section four reports and discusses the empirical results. Section five finally concludes with policy implications.

2. Analytical procedure

To study the household farm expansion decision under credit constraint, it is necessary to first examine the existence of credit constraints among farmers. Following Diagne *et al.* (2000), Giné and Townsend (2004) and Boucher *et al.* (2008, 2009), the credit constraints is assessed using the direct elicitation approach. It carefully differentiates credit-constrained households from credit-unconstrained ones using self-reported credit demand in production activities. In the survey, farmers were asked about detailed loan needs, the reason(s) for either applying or not applying for loans, the amount of credit obtained and the reason(s) for not getting enough credit. To identify the existence of credit constraint, each farmer was asked whether he/she had a loan demand. Credit-unconstrained farmers are then identified as those who either had no credit demand or had such a demand but successfully secured the desired amount. In addition, farmers who listed the reasons for not applying credit such as high interest rate or repayment concerns are classified as an unconstrained as such demand was invalid (Boucher *et al.*, 2009; Reyes and Lensink, 2011). Following Boucher *et al.* (2008), credit-constrained farmers include three categories: (1) quantity-rationed (those who applied but could not secure the desired amount of loan; (2) transaction-cost rationed (those with credit needs but failed to apply due to complex procedures, limited bank access, lack of social relationships, or unfamiliarity with loan application); and (3) risk-rationed (those who failed to apply in fear of losing collateral).

With appropriate identification of credit constraint among farmers, the next step is to assess the impact of credit constraint on farm expansion decision making. Apparently, such a decision is jointly affected by the household production and consumption characteristics as well as socio-economic characteristics in addition to credit constraint. While simple multiple regression models can help establish the links, they may suffer from possible endogeneity as the existence of credit constraint may be associated with unobserved characteristics (such as skills, experiences, entrepreneurial talents, risk attitudes, and social networks). This is highly likely since the factors affecting credit status can also affect scale farm operation decisions (Evans and Jovanovic, 1989; Giné and Townsend, 2004; Jappelli, 1990; Porgo *et al.*, 2018), and such possible linkages can render regression estimation results biased and inconsistent. To correct for this, instrumental variable (IV) regressions are performed. At the farm household level, the conceptual model can be written as:

$$E = \alpha + \beta C + \gamma X + \delta M + \theta L + \varepsilon \quad (1)$$

In Equation 1, E is a binary measure of farm expansion, which takes the value of one if the farmer decides to expand and zero otherwise. We further test the impact of credit constraint on rice areas expanded in 2013-2017 as a robustness exercise, and report the auxiliary regression estimates in the supplementary material. In empirical estimation, E is measured in two alternative ways: whether the farmer has actually expanded farm size in the past five years, or whether he/she is willing to do so in the near future.

Among the independent variables, C is a binary measure of credit constraint, one for credit-constrained farmers and zero for credit-unconstrained farmers. X represents a set of demographic and socioeconomic characteristics that possibly affect farm expansion decision making. M is a vector of local market condition indicators, including the number of local rice processing enterprises and the distance to the nearest grain wholesale market (measuring crop marketing easiness). In addition, L is a landscape measure of the farm location (either in plain area or hilly and mountain area). $\alpha, \beta, \gamma, \delta$ and θ are coefficients representing the marginal effects of these factors on farm expansion decision to be estimated, and $\mathcal{E}$ is the random disturbance.

To account for the possible endogeneity of credit constraint, IV regression is performed, where the first-stage regression model is specified as:

$$C = a + bD + cN + dX + fM + gL + u \quad (2)$$

To estimate Equation 2, two IVs are employed: the distance to the nearest financial institution (*D*), and the number of local financial institutions within 30 kilometers from the respondent's residence (*N*). Other covariates are described above. *a, b, c, d, f, g* are coefficients to be estimated, and *u* is the disturbance. It can be intuitively justified that both IVs should be correlated with the existence of credit constraint but should not directly affect farm expansion decision other than through their impact on the farmer's credit status. Much of Guangxi is of a karst topography characterized by cone-like mountains and flat areas in between. Unlike some other regions in China, most of these mountains are too steep to construct rice terraces. Hence, rice cultivation is largely concentrated in flat areas, where township centers are usually located. In those flat areas, farmers' land plots are usually connected with similar land quality and agroecological conditions. Therefore, few townships are too remote to access financial services. On the other hand, the Chinese government has been endeavoring to provide credit access to every single township in hope of removing credit constraints among the neediest members in rural areas. Consequently, there are usually at least two or three financial institutions in every township center (mainly Agricultural Bank of China, Rural Credit Cooperatives, and Postal Savings Bank of China). There is also variation in the number of financial institutions according to population size and industrial developmental stage. But no township is too remote to access finance as a distance of 30 kilometers is large enough to allow such access (even from nearby townships). Therefore, concerns over the validity of the distance-based IVs for credit constraint should be minimized. Empirical tests further reveal that these IVs are appropriate in identifying the hypothesized relationship, as discussed in detail below.

3. Data and descriptive statistics

3.1 Data

Guangxi is one major region in China for double-season rice planting, which has a long history of rice cultivation and is the origin of human rice culture (Huang *et al.*, 2012). The current study is facilitated by a recent rural household survey conducted by the academic staff members and graduate students of Guangxi University from July 2016 to April 2017. The survey covered six regions: Nanning, Guilin, Liuzhou, Guigang, Yulin and Qinzhou, which jointly contribute about 70% rice production of the whole province. Stratified sampling approach was used in the survey. Within these six regions, 15 counties were first selected according to the aggregate rice cultivation area in the past four years (2013-2016). Three townships were then randomly selected in each county, and twelve rice farmers were randomly selected from each township. As the focus of the survey is rice farm size and scale operation, the surveyed households selected in these samples have met the following conditions: (1) rice is grown for commercial markets rather than mere self-sufficiency; and (2) rice cultivation is one of the main sources of household income. Farmers who planted rice on a moderately large scale were still few in rural Guangxi, especially those who planted more than 50 mu (3.33 ha) of land. Compared with developed countries, the farm size of the sampled farmers in this paper is relatively small, but compared with those subsistence farmers, farm sizes of sampled households are larger. A total of 540 rice households were randomly selected in 45 townships, of which 462 (85.6%) were at home at the time of survey and all of them participated. Among the 78 absentees, we contacted them later through telephone and accessed 48 of them. The observed characteristics, namely values of variables included in the following analysis, were very similar to those of face-to-face respondents (with no statistical significance at 5% level through pairwise t-tests). Concerns over sample selection is thus minimized.

3.2 Descriptive statistics

The distribution of credit constraint among surveyed farmers in Guangxi is presented in Table 1. 42.86% of the farmers were credit constrained while 57.14% were unconstrained, jointly manifesting a relatively large data variation. About half of the unconstrained farmers exhibit invalid demand for credit, while only less than one fifth of the farmers in need of credit have successfully secured the needed amount. Most credit-constrained farmers are quantity rationed, failing to obtain the desired amount.

Table 1. Credit constraint distribution among surveyed households (n=462).

Credit status	Frequency	Percentage
Unconstrained	264	57.14
No need for credit	116	25.11
Could obtain enough credit	31	6.71
No application due to high interest rate	60	12.99
No application due to repayment concerns	57	12.34
Constrained	198	42.86
Quantity rationed	121	26.19
Transaction-cost rationed	65	14.07
Risk rationed	12	2.60

Farm size changes in 2013-2017 are reported in Table 2. About 31.38% of the total households remained at the same size, while 61.04% households increased and 7.57% decreased their rice farm size over the five years. On the one hand, about half of the credit constrained households increased their farm size, whereas 69.69% of the credit unconstrained households increased. On the other hand, 15.15% of credit constrained households decreased their rice farm size while just 1.89% of credit unconstrained households decreased over the five years.

Table 3 describes the outcome variables and covariates. About 61% households expanded their farm in the past five years and half of the farmers were willing to expand their rice farm size in the near future. Other observations include the low education rate (7.67 years on average) and the importance of on-farm income generation (82% of family income). In addition, 39% of the surveyed farmers had obtained credit from informal sources (e.g. friends, relatives, inputs suppliers).

4. Results and discussions

The empirical analysis proceeds as follows. With two alternative measures of farm expansion, the impact of credit constraint on expansion decisions in the past five years is first estimated, and then is the impact on the willingness of farm expansion in the near future. The possibly impacts on relatively larger (≥3.33 ha) and smaller holders (<3.33 ha) are further differentiated and compared.

Given the binary nature of the outcome variable, a probit model is first estimated. To address possible endogeneity of the credit constraint, an IV-probit model is also estimated. The same regression model is further estimated using two-stage least squares (2SLS). 2SLS is suitable as it is robust against first-stage misspecifications and it usually provides very close marginal effect estimates as compared to discrete choice models (Angrist, 2001; Angrist and Pischke, 2008). It thus serves as a reliable robustness check exercise. The first-stage results of 2SLS estimation as shown in Supplementary Table S1 rules out instrument weakness. Moreover, farmers who are farther away from the financial institutions and who have access to fewer financial institutions are more likely to have credit constraint, yet these two variables have negligible effect on the farm size. These findings consistently suggest the appropriateness of the IVs. In estimation, standard errors are clustered at township level.

Table 2. Farm size changes in 2013-2017: number of farmers (% of total).

	Full sample (n=462)	Credit-constrained (n=198)	Credit-unconstrained (n=264)
Increasing (expanded)	282 (61.04%)	98 (49.49%)	184 (69.69%)
Constant	145 (31.38%)	70 (35.35%)	75 (28.41%)
Decreasing	35 (7.57%)	30 (15.15%)	5 (1.89%)

Table 3. Descriptive statistics of variables.[a]

Variables	Full sample (n=462)	Credit-constrained (n=198)	Credit-unconstrained (n=264)
Farm expanded past five years (yes=1; no=0)	0.61 (0.48)	0.49*** (0.50)	0.69 (0.46)
Willing to expand in the future (yes=1; no=0)	0.47 (0.49)	0.26*** (0.44)	0.64 (0.48)
Rice cultivation area in 2013 (ha)	3.94 (8.06)	5.02*** (9.98)	3.14 (6.14)
Rice cultivation area in 2017 (ha)	6.12 (11.83)	7.04* (15.32)	5.43 (8.27)
Credit constrained (yes=1; no=0)	0.43 (0.49)	1.00 (0.00)	0.00 (0.00)
Head age (years)	49.03 (8.73)	49.31 (9.19)	48.82 (8.37)
Head gender (male=1; female=0)	0.92 (0.27)	0.93 (0.25)	0.91 (0.28)
Head education (years)	7.67 (2.59)	7.46* (2.54)	7.81 (2.63)
Family income[b] (4-year average, logarithmic)	3.78 (0.97)	3.73 (1.04)	3.82 (0.92)
Off-farm income share (4-year average)	0.18 (0.25)	0.15** (0.22)	0.20 (0.26)
Number of family laborers	2.27 (1.15)	2.25 (1.16)	2.28 (1.13)
Number of dependents in household	1.42 (1.32)	1.47 (1.36)	1.37 (1.29)
Farmer cooperative member (yes=1; no=0)	0.34 (0.48)	0.57*** (0.49)	0.17 (0.37)
Times of mechanical service from others (never=0, once=1, twice=2)	1.19 (0.72)	1.62*** (0.61)	0.87 (0.62)
Informal source of credit[c] (yes=1; no=0)	0.39 (0.48)	0.67*** (0.47)	0.18 (0.38)
Number of processing enterprises	1.53 (1.28)	2.27*** (1.27)	0.97 (0.96)
Distance to wholesale market (km)	38.21 (20.18)	39.04 (20.24)	37.58 (20.14)
Flat area (yes=1; no=0)	0.69 (0.46)	0.66* (0.47)	0.72 (0.45)

[a] Standard deviations are reported in parentheses. *, ** and *** indicate the variable mean differs from that of credit unconstraint household at 10, 5 and 1% levels, respectively.

[b] Originally measured in Chinese Yuan (CNY). Daily average exchange rate in 2016 is 1 USD=6.64 CNY.

[c] Informal source means that the household obtained credit from friends, relatives or inputs suppliers.

4.1 Effects of credit constraint on famers' farm expansion in the past five years

Table 4 represents the estimation results where farm expansion is measured in such decision made in the past five years. Computed marginal effects from the IV-probit and coefficient estimates from the 2SLS procedures are reassuringly similar, lending credence to the impact estimates. In all models, credit constraint is found to be negatively associated with farm expansion decision, such impact being highly significant. Specifically, the existence of credit constraint decreases the probability of rice farm size expansion by 37.3-40.4 percentage points. It is therefore implied that farm expansion would be encouraged once the credit constraint is removed, and economies of scale can be better realized among these rice farmers. On the other hand, the initial rice cultivation area in the past five years (as that of 2013) is also found to play a negative role in farm expansion: larger farms are less likely to expand. While such impact is relatively small, it does imply that there may be some systematic linkage between farm size and expansion decision.

Although credit constraint discourages farm expansion, the general pattern observed in China is that farm sizes are still growing. Thus, there is a need to interpret the possible roles that other factors play to understand the paradox. Among the covariates, farm expansion is more likely among richer farmers, having more dependents and located in flat areas. In production practices, farm expansion is associated with utilization of specialized mechanical service and informal credit. These individual impacts, however, are smaller in magnitude as compared to that of credit constraint.

Supplemetary Table S2 further reports regression results using actual farm expansion in 2013-2017 as the outcome variable. These estimates appear to be very similar to our main results above, with impact magnitudes of credit constraint being larger. The above findings are therefore well supported.

Table 4. Marginal effects on household's farm size expansion in 2013-2017.[a]

Covariate	Probit	IV Probit	2SLS
Credit constraint	-0.404*** (0.042)	-0.440*** (0.049)	-0.373*** (0.053)
Rice cultivation area (2013)	-0.011*** (0.004)	-0.010*** (0.004)	-0.012*** (0.004)
Head age	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)
Head gender	-0.071 (0.056)	-0.070 (0.055)	-0.079 (0.064)
Head education	0.019** (0.008)	0.017** (0.008)	0.019** (0.009)
Family income (in logarithm)	0.126*** (0.026)	0.122*** (0.027)	0.118*** (0.029)
% off-farm income	-0.089 (0.078)	-0.094 (0.077)	-0.077 (0.087)
Number of family laborers	0.014 (0.018)	0.014 (0.017)	0.018 (0.018)
Number of dependents	0.055*** (0.015)	0.053*** (0.015)	0.054*** (0.015)
Cooperative membership	0.075 (0.047)	0.082 (0.049)	0.087 (0.052)
Mechanical service	0.101*** (0.035)	0.107*** (0.035)	0.083** (0.033)
Informal credit	0.195*** (0.060)	0.202*** (0.059)	0.180*** (0.062)
Number of enterprises	0.010 (0.025)	0.014 (0.024)	0.003 (0.024)
Distance to wholesale market	-0.001 (0.001)	-0.001 (0.001)	-0.000 (0.001)
Flat area	0.086** (0.038)	0.081** (0.039)	0.111** (0.049)
Observations	462	462	462
Wald chi^2 (15)	232.7*** (0.000)	237.2*** (0.000)	
F-statistic for IV significance			222.61*** (0.000)
F-statistic (2^{nd} stage)			50.52*** (0.000)

[a] Standard errors are clustered at township level and reported in parentheses. ***, **, * indicate 1, 5 and 10% significance, respectively. Marginal effects reported in Probit and IV-Probit model, while coefficient estimates reported in 2SLS model.

4.2 Impact of credit constraint on farmers' willingness of farm expansion

The impact of credit constraint on farmers' willingness of farm expansion is further estimated (Table 5). Impact estimates from IV-probit and 2SLS are also reasonably similar in magnitude as well as 1% significance. Specifically, credit constraint negatively affects farm expansion willingness. The impact is 56.7-65.9 percentage points, which is larger than that on observed farm expansion in the past five years. Current rice cultivation area is again negatively affecting farm expansion willingness.

Among the covariate coefficients, age and gender become statistically significant, which contrast the above findings with actual farm expansion measure. Intuitively, older and female farmers are less willing to expand farm, though such patterns are inexistent among the farmers who have actually expanded farms in the past five years. In addition, larger off-farm income contribution also discourages farm expansion, while membership of farmer cooperative encourages it possibly due to better access to production and/or risk-mitigating resources, and/or marketing opportunities (Liu *et al.*, 2019). The impacts of education and family size (number of dependents) are again confirmed. While the role of informal credit is not well supported (as the coefficient is statistically insignificant in 2SLS estimation), this is possible as farmers with only willingness to expand farms might not utilize these resources and so such impact has not been noticeable. A further discrepancy exists regarding mechanical service utilization, the impact of which becomes insignificant on farmers' willingness of farm expansion. This can be possibly explained by the fact that third-party mechanical service could become unaffordable with farm size expansion for a significant portion of farmers.

Table 5. Marginal effects on household's willingness to farm expand in the future.[a]

Variable	Probit	IV Probit	2SLS
Credit constraint	-0.589*** (0.054)	-0.659*** (0.063)	-0.567*** (0.049)
Rice cultivation area (2017)	-0.008*** (0.002)	-0.007*** (0.003)	-0.006*** (0.002)
Head age	-0.012*** (0.002)	-0.012*** (0.002)	-0.014*** (0.002)
Head gender	0.132*** (0.049)	0.128*** (0.048)	0.145** (0.057)
Head education	0.039*** (0.008)	0.035*** (0.009)	0.045*** (0.009)
Family income (in logarithm)	0.019 (0.032)	0.013 (0.031)	0.006 (0.032)
% off-farm income	-0.147** (0.061)	-0.158*** (0.061)	-0.197*** (0.075)
Family laborers	0.016 (0.013)	0.015 (0.013)	0.014 (0.016)
Number of dependents	0.037*** (0.012)	0.033** (0.013)	0.031** (0.013)
Cooperative membership	0.152*** (0.052)	0.166*** (0.052)	0.104*** (0.035)
Mechanical service	0.032 (0.031)	0.043 (0.031)	0.034 (0.029)
Informal credit	0.105** (0.050)	0.124** (0.052)	0.072 (0.045)
Number of enterprises	0.048*** (0.018)	0.056*** (0.018)	0.036* (0.020)
Distance to wholesale market	0.001 (0.001)	0.000 (0.001)	0.000 (0.001)
Flat area	0.052 (0.043)	0.044 (0.044)	0.052 (0.047)
Observations	462	462	462
Wald chi^2 (15)	269.6*** (0.000)	296.4*** (0.000)	
F-statistic for IV significance			224.54*** (0.000)
F-statistic (2^{nd} stage)			75.69*** (0.000)

[a] Standard errors are clustered at township level and reported in parentheses. ***, **, * indicate 1, 5 and 10% significance, respectively. Marginal effects reported in Probit and IV-Probit model, while coefficient estimates reported in 2SLS model.

4.3 Robust checks

In the above analysis, family income and utilization of mechanical service could be an outcome of farmers' farm expansion decision, which may introduce a reverse causality problem. Also, rice cultivated area may have non-linear effects. To explicitly address these concerns, we implement robustness checks by adding or removing the explanatory variables. Results are reported in Table 6.

As shown in Table 6, the first column is the regression result after removing the family income variable in the model. The second column is the regression result after removing the mechanical service variable. And the third column is the regression result after adding the square of the rice cultivation area. Computed marginal effects from the IV-probit and coefficient estimates from the 2SLS procedures show that there are no noticeable differences in the estimated marginal effects of credit constraint on the actual farm expansion decision and willingness of farm expansion in the future. The changes of control variables in the estimates have little impact on the estimated results, and the credit constraint is negative and very significant in all the models. For the focus of the impact of credit constraints, these estimates are robust and lend credence to our main results.

4.4 Impacts of credit constraint on relatively smaller and larger farmers' expansion

Results from both measures (actual decision and willingness of farm expansion) suggest that farm size can play a role, and that the impact of credit constraint may differ between relatively smaller (<3.33 ha) and larger (≥3.33 ha) commercial farmers. It is therefore straightforward to implement two subsample analyses to break down the possible heterogeneity. This is meaningful to policymakers regarding the necessity to differentiate interventions by landholding to maximize the desired effect. Results are reported in Table 7.

Table 6. Robust checking estimates with alternative covariate sets.[a]

Covariate change	Excluding family income		Excluding mechanical service		Adding square term of rice cultivation area	
	IV Probit	**2SLS**	**IV Probit**	**2SLS**	**IV Probit**	**2SLS**
Farm size expanded						
Coef. of credit constraint	-1.798***	-0.403***	-1.524***	-0.342***	-1.691***	-0.351***
	(0.234)	(0.052)	(0.250)	(0.054)	(0.264)	(0.051)
Marginal effects	-0.402***		-0.327***		-0.334***	
	(0.053)		(0.056)		(0.053)	
Wald chi^2	186.8***		227.1***		206.7***	
	(0.000)		(0.000)		(0.000)	
F-value (1st stage)		214.5***		264.3***		218.7***
		(0.000)		(0.000)		(0.000)
Willingness to expand						
Coef. of credit constraint	-3.102***	-0.567***	-2.991***	-0.554***	-3.146***	-0.570***
	(0.303)	(0.049)	(0.285)	(0.046)	(0.310)	(0.049)
Marginal effects	-0.511***		-0.490***		-0.513***	
	(0.062)		(0.057)		(0.064)	
Wald chi^2	266.3***		278.6***		312.9***	
	(0.000)		(0.000)		(0.000)	
F-value (1st stage)		217.2***		268.0***		226.2***
		(0.000)		(0.000)		(0.000)

[a] Standard errors are clustered at township level and reported in parentheses. ***, **, * indicate 1, 5 and 10% significance, respectively.

Table 7. Subsample impact estimates by farm size.[a,b]

Variable	Larger holders		Smaller holders	
	IV Probit	**2SLS**	**IV Probit**	**2SLS**
Farm size expanded[c]	n=113		n=349	
Coef. of credit constraint	-3.084*** (1.031)	-0.471*** (0.084)	-1.586*** (0.365)	-0.296*** (0.079)
Marginal effects	-0.593*** (0.151)		-0.381*** (0.092)	
Wald chi^2	47.83*** (0.000)		98.90*** (0.000)	
F-value (1st stage)		98.70*** (0.000)		94.11*** (0.000)
Willingness to expand[d]	n=207		n=255	
Coef. of credit constraint	-3.482*** (0.695)	-0.617*** (0.067)	-2.648*** (0.467)	-0.444*** (0.078)
Marginal effects	-0.654*** (0.105)		-0.487*** (0.082)	
Wald chi^2	56.05*** (0.000)		71.68*** (0.000)	
F-value (1st stage)		77.51*** (0.000)		129.1*** (0.000)

[a] Standard errors are clustered at township level and reported in parentheses. ***, **, * indicate 0.1, 1 and 5% significance, respectively.

[b] Farm size is classified by rice cultivation area: larger holders ≥3.33 ha, smaller holders <3.33 ha.

[c] A larger holder has a farm size ≥3.33 ha; while a smaller holder has a farm size <3.33 ha in 2013.

[d] A larger holder has a farm size ≥3.33 ha; while a smaller holder has a farm size <3.33 ha in 2017.

As reported in Table 7, there are noticeable differences in the estimated marginal effects of credit constraint on the actual farm expansion decision and willingness of farm expansion in the future. Specifically, the marginal effects in IV-probit models and the coefficient estimates in 2SLS models appear to be bigger for large holders (i.e. the impact is bigger for large holders). Therefore, when the smaller holders grow into moderate farmers with a size of 50 mu (3.33 ha) or more, householders will be more vulnerable to credit constraints,

and it will be even more difficult to expand farm size/scale. Hence, moderate farmers may deserve specific attention in policy designs that aim to optimize the production scale and improve the credit market conditions.

The above findings generally suggest that credit constraints impede farm expansion. The negative impacts, however, might have been totally offset by positive contributions of other covariates, and thus farm expansion is still commonly observed. This helps explain the paradox where credit constraints and farm expansion are both widely observed and suggests that removal of credit constraints can further facilitate farm expansion.

5. Conclusions and policy implications

Using a recent survey of commercial rice farmers in Guangxi Province, China, this study empirically assesses the impact of credit constraint on farm expansion to investigate the paradox where credit constraints and farm expansions coexist. As hypothesized, credit constraint significantly discourages farm expansion decision, as measured by both actual expansion decision and the willingness. Moreover, subsample analysis further suggests that, while the impacts of credit constraint on farm expansion are similar between relatively small and moderate scale holders, moderate farmers are more susceptible to credit constraint both in actual expansion decision and such willingness in future. This finding contributes to the literature on the multifaceted disadvantages of smaller holders in farm expansion and their consequences (Collier and Dercon, 2014; Huang and Ding, 2016; Ostwald and Chen, 2006), and points to a need for tailored policy considerations (Huber *et al.*, 2015). While the negative impacts of credit constraint on farm expansion are offset by resources available otherwise (e.g. informal credit, third-party mechanical service, and cooperative membership), further farm expansion and better realization of the economies of scale still rely on credit constraint removal.

Given the immediate impact estimated above, it should be among the government's policy considerations to further develop the credit market with a focus on the provision of microfinance to householders. First, the role of informal credit access clearly points to the importance of having a variety of available credit options to meet different credit needs. Hence, encouraging the development of micro financial institutions and informal agricultural financial institutions will be beneficial in relaxing credit constraints on farmers. Second, as smaller holders generally lack collateral, credit constraint cannot be completely removed in the short term. On the one hand, interventions may alternatively focus on the stabilization of rural household income, through the mitigation of possible production and/or marketing risks, to facilitate continuous income growth and increases in capital investment. On the other hand, the ongoing gradual reform of the rural land system can also increase the liquidity of farmers' land and thus facilitate land mortgage with the rural financial institution. Third, provision of mechanical and related agricultural services can also lower the investment of farmers and stimulate scale operation.

Policy implications can be then drawn for the credit supply side, namely agricultural credit institutions. With the expansion of agricultural operation scale, the fact that nearly half of the (42.86%) surveyed farmers were credit constrained suggests that the rural financial market huge potential given the substantial demand. Therefore, credit institutions should pay attention to services and financial instrument innovations to meet farmers' needs. In addition, policies seeking the development of rural financial business, rural financial institutions could rigorously study the feasibility of issuing micro-credit to more smaller farmers and provide more financial services to large farmers with the help of modern information technology more efficiently assessing farmers' credit ratings and collateral values. Last but not the least, rural financial institutions may invest more marketing efforts, and make it easier for farmers to grow their knowledge of available financial products as transaction cost rationed is an important reason for farmers' credit constraint.

There are also policy implications for the credit demand side respect to farm and agribusiness management. First, farms should carry out necessary risk management strategies (such as purchasing agricultural insurance and diversifying product portfolio) to smooth farm income maintains good credit history, which can help minimize financial providers' concerns over repayment risk. Second, farms should seek to participate in relevant financial trainings or market activities many times carried out as parts of extension packages and

keep communication with financial institutions so as to reduce information asymmetry. Third, smaller-scale farms can cooperate with each other and support each other in terms of credit through farm cooperatives or associations, especially in mutual borrowing. While validating the merits of these policies is beyond the scope of this analysis, they are worth policy considerations, which is especially important in enhancing food security in countries like China.

For individual farms, the potential use of credit also needs improvement. It should be noted that farm management practices in China may differ from those in developed countries. Chinese farmers still emphasize the production process while largely overlook value chain development and marketing. In smaller scale farming, farmers will purchase third-party services in some production links to ease the financial constraints (such as mechanical services). With available credit, farmers may use the credit to invest machinery and equipment, but usually fail to investment in value chain cooperation, talent development and marketing. This perceptual myopia may arise from the tradition of subsistence agriculture and need to be corrected for sustainable farm management. This is especially important to China, which is transitioning from smallholder rural economy to commercialized agriculture.

The current study observes limitations. For one thing, the cross-sectional nature of data cannot fully capture farmland dynamics over time. For another, the specific geographical focus (one major rice-cultivating region) may not represent situations observed in other parts of China or different countries. These limitations jointly call for further investigations and research to help establish the external validity of our findings.

Supplementary material

Supplementary material can be found online at https://doi.org/10.22434/IFAMR2019.0118

Table S1. First stage regression estimation of 2SLS model.
Table S2. Regression results of farm size changes in 2013-2017.

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