Measuring the farm level impact of rural credit:
A two-stage approach

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MEASURING THE FARM LEVEL IMPACT OF RURAL CREDIT: A TWO-STAGE APPROACH

ABSTRACT

The purpose of this study is to investigate the impact of credit on the agricultural production value of non-family farmers in Brazil. The study compares non-family farmers' production value considering the obtainment of credit, and the characteristics of the producers and their farms. The data set consists of the 2006 Agricultural Census on 796,422 farmers. To take into account the bicausal relationship between credit and agricultural production, the empirical analysis is carried out using a two-stage method. Results suggest the following determinants of credit access: production value, farm size, intensity of labor force participation, establishment location, and producers' socioeconomic characteristics. It is also verified that credit access had a positive and significant impact on the value of agricultural production. In addition, the influence of credit access varied according to the source of financing obtained and across Brazilian regions.

Keywords: agricultural credit; agricultural production; non-familiar farmers; two-stage approach.

1. INTRODUCTION

The relationship between the development of the financial system and economic growth has been a focus of interest in the economic literature since the seminal studies conducted by Schumpeter (1911) and Robinson (1952), with further analysis carried out by Gurley and Shaw (1955), Goldsmith (1969), and Shaw (1973). One of the perspectives of this investigation is based on the idea of supply-leading, in which financial institutions, in making credit available to economic agents, encourage innovation, which in turn drives economic dynamics. In other words, the transfer of resources from lenders to borrowers improves the allocation of resources and, thus, leads to increased marginal productivity of capital (Rajan and Zingales, 1998; Levine, 1997; King and Levine, 1993).

When including the rural sector in this analysis, it can be noted that financial markets have a positive impact on agricultural activity by: i) supplying risk management products; ii) generating liquidity in order to guarantee better business planning and execution - which includes credit for costing, investment (to adopt new technologies, for example) and commercialization of the activity; iii) stimulating research and development aimed at technological innovation; iv) collaborating in the generation of income and lowering inequality in the rural area; v) providing benefits to the producer that are not directly related to production, such as regulating farmers' personal consumption.

Agricultural financing, however, comes up against challenges related to specific characteristics of the sector, which increase the risks for lenders. Yaron et al. (1997) highlight that it is more difficult for the financial system to access rural areas due to factors such as rural income, which tends to be lower and more volatile when compared to urban income. In addition, financial operations in rural areas are generally characterized as small scale and with no collateral. Finally, the markets are fragmented and isolated, which amplifies the problem of asymmetric information between lenders and borrowers. To minimize asymmetric information, the financial system employs selection and monitoring mechanisms. Consequently, contracts are designed with high requirements in terms of guarantees, which increase the transaction costs (Stiglitz and Weiss, 1981). These factors have a significant impact on credit decisions and risk evaluation, increasing the costs related to small loans, primarily those required by small rural producers. Because of these characteristics, financing of the rural sector in Brazil derives largely from government banks, who operate with fiscal resources and lower interest rates than those practiced on the market, despite the growth in the participation of private institutions.

A number of empirical studies have evaluated the impacts of microcredit in different regions around the world (e.g. Li et al., 2011; Rooyen et al., 2012; Tu et al., 2015). In Brazil, much of this research has focused on the analysis of Pronaf - National Program for Strengthening Family Farming (Anjos et al., 2004; Magalhães et al., 2006; Guanziroli, 2007; Damasceno et al., 2011). However, little attention has been paid to the differentiated effects of credit on small and large-scale establishments. In addition, no study has explored this issue in Brazil using microdata and focusing on non-family farming.

This study analyzes the impact of credit access on the economic performance of non-family farms in Brazil. The analysis is based on microdata from the 2006 Agricultural Census from the Brazilian Institute of Geography and Statistics (IBGE), which covers 796,422 non-family farmers. Family farmers were not included in the research given that they are largely dedicated to self-sufficiency[1], and thus the study aimed to fill a gap in the literature on credit by focusing the analysis on non-family farms. Despite non-family farmers represented 16% of establishments in Brazil in 2006, they hold around 70% of the total area and make up 68% of the total value of agricultural production in the country. It is hypothesized that credit has a positive effect on agricultural production, and thus stimulates the generation of income in rural areas.

Given the diversity, heterogeneity, and importance of Brazilian agriculture, evaluation of responses to credit access could shed more light on this topic. To our knowledge, there are no other studies in the literature that explore the credit impact on non-family farming with microdata, thus highlighting the contribution of this research.

2. LITERATURE REVIEW

The analysis of the impact of rural credit on agricultural activity is largely concentrated on developing countries, where this sector has significant economic importance. Several studies have explored the effects of credit policies on rural growth, agricultural activity, and farm households.

Binswanger and Khandker (1995) evaluated the impact of expansion of rural credit in 85 districts in India between 1972 and 1981. Using a simultaneous equation model, the authors verified that the expansion in financing had a greater influence on non-agricultural production. In the agricultural sector, credit access increased the use of fertilizers and machines, in addition to having a positive impact on rural salaries. Sidhu et al. (2008) also investigated the effect of credit in India, specifically in the state of Punjab. Based on data on 160 farmers and agricultural censuses, the estimation results from a simultaneous equation model indicated that credit had a positive influence on the

[1] Establishments considered as family farms are those that are managed by a family member and have a total area less than a regional threshold, a workforce made up predominantly of family members and income generated from the farm itself.

agricultural sector, since the access to capital enabled the adoption of more modern factors of production and private investments in mechanization and irrigation, for example. Furthermore, Narayanan (2016) analyzed the relationship between credit and the agricultural Gross Domestic Product (GDP) in India. Using panel data from 1995 to 2012, results indicated that credit had a relevant impact on the purchase of inputs (fertilizers and pesticides) and on mechanization. However, given the context of low productivity and technical inefficiency of the activity, the effect of credit on agricultural production was small.

Research carried out in other countries also provides relevant information regarding the influence of credit on the rural area. Using a frontier production function model and a sample of 152 Pakistani farmers, Akram et al. (2013) found that the technical efficiency of the famers with access to credit was higher than the other producers. Khandker and Faruqee (2003) also contributed to this debate, examining the impact of credit in Pakistan. Using data from the Agricultural Development Bank of Pakistan (ADBP), results from a two-stage estimation method suggested that credit positively influenced the prosperity of the farmers, particularly regarding the group of small properties. Focusing on Chinese rural families, Zhu and Li (2007) verified that credit had a heterogeneous impact on farmer income. Using the quantile regression model and data from 3000 rural families, results indicated that the influence of credit, both formal and informal, was positive for middle and low-income farmers and had no effect on the poorest and richest farmers. In addition, Xin and Li (2011) evaluated the effect of credit on the economic development of agriculture in the Heilongjiang province of China. Based on data from 1995-2008, and by applying time series techniques, the authors observed a positive and statistically significant relationship between the variables. Finally, Moura (2016) studied the causality between rural credit and growth in agricultural activity in Brazil. Using data from 1969-2014, the author verified the presence of unidirectional causality between credit and the growth of agricultural products, with no reverse relationship.

An additional group of studies explored the effects of credit restriction on the agricultural sector in different countries. Based on the Chinese market, Dong et al. (2012) analyzed the impact of such restriction on the productivity and income of 511 rural families living in the Heilongjiang province. Using an endogenous switching regression model, findings suggested that the agricultural productivity of these families rose by 31.6% and income by 23.2%, when restrictions to financing were eliminated. Results also suggested that farmers under credit constraints suffered lower productivity and income than the other rural producers. Li et al. (2013) also explored this issue, using data from 1000 rural families in China during 2003-2009 period. The estimation of a bivariate probit model revealed that 61.5% of Chinese families in rural areas experienced credit restrictions, which resulted in a loss of 15.7% of net earnings and a fall of 18.2% in consumption. Kumar et al. (2013) also explored this topic comparing the effect of credit constraint in India and China. The authors showed that for 74% of 741 Chinese families (and 400 Indian families) credit restriction resulted in a fall in inputs utilized in production, leading to a fall in productivity. Around 90% of Chinese and Indian families claimed that credit restrictions encouraged them to look for employment off the farm. In addition, Duong and Izumida (2002) conducted a similar analysis using data from three Vietnamese provinces with a sample of 300 rural families. Findings indicated that 30% of these families faced credit rationing. Moreover, results from a weighted least squares model showed high elasticity of supply in agriculture in relation to credit.

Credit rationing and the consequences in rural areas of Africa were also investigated. Ali et al. (2014), for example, explored this subject in Ruanda, using a sample of 3600 families for the year 2011. The authors verified generalized credit rationing in the country, which had a significant impact on the efficiency of agricultural production. Access to information, higher educational attainment and adhesion to agricultural cooperatives had a positive impact on reducing credit constraints. In addition, using a regression model with endogenous variables, findings indicated that the elimination of credit rationing increased agricultural production by approximately 17%. Foltz (2014) studied the impact of credit restrictions in 142 rural families in Tunisia. Using the same techniques as the previous study, the author showed that such rationing had a significant impact on the profitability of these rural properties, which resulted in suboptimal production and allocation of factors of production, such as land, labor and other inputs.

Research focusing on European countries and the United States was also conducted. Petrick (2004), using data from 464 rural families in Poland, showed that the borrower's reputation and demographic characteristics of the location where the family lived had a significant impact on credit rationing. Also, for families under credit restrictions, access to subsidized financing had a significant impact on investments carried out by these agents. Ciaian et al. (2012), in analyzing panel data with information on central European and Asian countries, confirmed that the rural properties came up against credit restrictions in both the short and long term. These constraints took place with greater frequency in the case of financing variable inputs and capital. In terms of land and labor, the study found no evidence regarding credit restriction. The authors also verified that the growth in credit had a positive effect on the use of inputs and investment in capital - an increase in 1,000 euro in credit resulted in an estimated 1.9% rise in the total productivity of the factors. In addition, Briggeman et al. (2009) carried out a study based on a sample of North American farmers and properties. The propensity score-matching method was employed and results indicated that the value of agricultural production fell when credit was restricted.

The impact of rural credit constraints on the Brazilian market was also evaluated in a number of studies. Assunção and Chein (2007) analyzed how rural credit rationing impacted the Brazilian population. Data from the 1991 and 2000 demographic censuses confirmed that credit rationing took place in all regions in the country. The authors, however, questioned the ability of credit policies to solve this problem, given that the results of empirical tests showed that the areas with a greater increase in bank credit were precisely those that faced greater rationing in the period. The creation of policies and official programs focused on the development of the sector was one solution given in order to minimize the effects of credit restriction on farms. Finally, Lopes et al. (2011) analyzed a sample of 1720 establishments in Brazil. Using a weighted least squares method and instrumental variables, findings showed that the producers that had better access to the financial market would be better off, since the main restriction to the growth of Brazilian agricultural production was capital.

Overall, previous studies have found evidence that access to credit impacts rural areas. In addition, findings have shown that rural families under credit constraints present lower productivity and income. However, no research has specifically evaluated the influence of financing on the group of non-family farmers. In the following sections, we will discuss how the present study explores this topic.

3. DATA

3.1. Farmer and farm characteristics

The analyses of the effect of access to financing on the total value of production were based on microdata taken from the 2006 Brazilian Agricultural Census. Small family farmers were excluded of our analyses, since they have a special source of credit in Brazil and their production are largely targeted to self-subsistence. Family farms and non-family farmers were defined according to the Federal Law 11326 of 07/24/2006, which is officially used for targeted policies in Brazil. Two groups of farmers were defined: the first one, “Group 1”, was based on the establishments that had no access to financing in 2006, and the second, “Group 2”, was formed by those that had access to credit - from banks or other sources, such as suppliers, family members, cooperatives and credit unions, financiers and non-financial companies. Based on this typology, we compared the characteristics of the farms and farmers, such as education, work experience, land use management and characteristics of the production systems.

The main variable of interest (dependent variable) was the total value of production (*VOP*). Table 1 shows the average values of this variable, in addition to the socioeconomic characteristics of 796,422 non-family farmers that accessed, or not, financing in 2006[2]. The largest concentration of farmers with access to financing was found in the Southern region (Group 2), with 49,067 farmers, followed by the Southeastern region with 37,171 farmers. Except for Southern region, where 31.7% of establishments accessed credit in 2006, the percentage of access was low: 9.8% in the North, 11.8% in the Northeast, 16.8% in the Southeast and 15.6% in the Central-West. In the Northern region (Northeast), for example, the number of farms without financing was approximately nine (eight) times larger than the number of farms with access to credit. These data highlight the existence of credit constraints in the country.

Despite the low number of farms that accessed credit in 2006, their average value of production was greater in relation to the others, in all regions. The Central-West region showed the higher average value of production, with around R$630 million for the farms with access to credit (Group 2), while the non-family farmers with no access to financing (Group 1) had an average value of around R$187 million. With respect to average productivity per hectare (*PPH*), the superiority of the producers with access to financing is more evident, across all regions. Again, the Central-West stands out, where the average productivity of the farms with access to credit was almost three times higher when compared to the group with no access to credit.

The participation in cooperatives (*COOP*) was higher among the producers with access to credit, in all regions, mainly in the South and Southeast of the country, where the participation reached 57.7% and 45.8% of the farms, respectively. The data on education (*EL*) show that the Central-West and Southeast regions presented a higher percentage of farmers with secondary or university education. The percentage of farmers that completed elementary education, or higher levels, was higher in the group who had access to loans, across all regions, except for the Northeast.

In addition, for all the regions, the percentage of crops (*CAP*) was higher in the farms with access to credit. The only exception is the North region, where the percentage of pastures (*PAP*) was higher among the farms that accessed credit.

[2] Appendix A shows the variables relative to the characteristics of the farmers and the farm used in the study.

Table 1. Average values of farmers and farms characteristics.

Description	Northern (NO)		North-eastern (NE)		South-eastern (SE)		Southern (SU)		Center-West (CW)	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Number of farmers – *n*	55,978	6,113	229,148	29,367	183,692	37,171	105,714	49,067	84,570	15,602
Value of agricultural production (BRL) – *VOP*	60,637.07	108,034.06	52,091.48	129,451.25	155,558.64	336,227.68	117,579.20	211,036.11	187,368.58	629,979.46
Area of the establishments (in hectares, ha) – *AE*	627.8	618.8	183.3	195.9	187.9	205.8	180.0	197.6	937.7	1070.3
Productivity per hectare (R$/ha) – *PPH*	96.59	174.59	284.19	660.80	827.88	1633.75	653.22	1067.99	199.82	588.60
Gender (%) – *GEN* (a)	6.0	5.9	8.0	8.5	6.5	5.4	7.8	4.1	5.8	4.4
Age – *AGE*	44.8	48	47.1	47.2	50.5	51.7	49.9	49.1	48.5	49.9
Cooperative membership (%) – *COOP*	4.5	9.7	4.0	5.9	25.5	45.8	26.2	57.7	13.3	32.2
Association membership (%) – *ASSOC*	27.1	46.3	28.6	47.7	21.3	32.7	27.7	45.5	18.2	32.3
Education level 1 (%) – *EL*1 (b)	7.2	7.8	11.0	11.0	4.6	3.6	2.9	2.0	4.1	2.6
Education level 2 (%) – *EL*2 (b)	7.5	5.9	4.4	3.8	3.6	2.3	2.5	1.5	5.0	2.9
Education level 3 (%) – *EL*3 (b)	46.3	43.2	32.3	34.2	39.7	35.7	47.4	49.2	40.9	31.8
Education level 4 (%) – *EL*4 (b)	11.2	12.5	7.9	8.1	14.0	14.4	14.3	15.6	14.2	15.8
Education level 5 (%) – *EL*5 (b)	11.6	16.1	11.1	10.7	18.0	21.7	17.0	18.9	18.4	25.5
Education level 6 (%) – *EL*6 (b)	4.2	5.9	5.4	4.2	15.3	19.5	12.6	11.5	12.9	19.6
Crop area percentage (%) – *CAP*	13.9	14.4	40.6	43.9	29.0	42.2	33.5	56.5	10.7	30.9
Pasture area percentage (%) – *PAP*	47.0	49.6	35.2	32.0	50.4	40.7	38.4	23.3	63.8	47.4

Source: 2006 Agricultural Census, IBGE.

(a) Percentage of women that manage the farm; (b) Maximum education level of the farmer (in percentage): (1) ability to only read and write (*EL*1), (2) adult literacy (*EL*2), incomplete elementary school (*EL*3), completed elementary school (*EL*4), completed high school (*EL*5), completed undergraduate course (*EL*6).

3.2. Production system characteristics

Table 2 presents the average values of the characteristics of non-family farmers' production system[3]. Information on the use of traction (*TR*) provides the approximate degree of technification of these producers. The mechanical traction variable (*TRAMEC*) highlights the discrepancy between the different regions. For example, for Group 2 (with access to credit), in the Northern and Northeast regions, less than 40% of farms utilized mechanical traction, while in the Central-South of the country, over 75% of the farms employed this form of traction.

When comparing access to technical guidance (*TECH*) and the adoption of productive techniques (*SOILTR* and *PEST*) among producers, Group 2 presented better production conditions. Discrepancies were also noted between the regions regarding the access to technical guidance - for Group 2, 77.7% (25.1%) of non-family farmers in the Southern region (Northeast) had some type of technical guidance. This difference was also observed in the percentage of soil treatments realized. While in the Southern region, 92.1% of non-family famers with credit carried out some type of soil treatment; in the North, this percentage fell to 29.4%. Independent of the regional differences, Group 2 had greater access to technology orientation, soil treatments and mechanical traction.

The degree of specialization was measured by the ratio between the value of production of the main agricultural product and the total production value. The analysis of this variable was separated into four categories: i) highly specialized (*SPEC*1), with a degree of specialization equal to 1; ii) specialized (*SPEC*2), with a degree of specialization less than 1 and above 0.65; iii) diversified (*SPEC*3), with a degree of specialization between 0.65 and 0.35; iv) highly diversified (*SPEC*4), with degree of specialization less than 0.35. For all regions, the percentage of specialized establishments was higher among those that accessed credit in 2006. The Central-West stood out with around 80% of Group 2 with highly specialized activities.

Finally, the degree of market integration is measured by the ratio between the total revenue of the agricultural activity and the total value of agricultural production, separated into three categories: i) highly integrated (*INT*1), with degree of integration above 0.9; ii) integrated (*INT*2), with degree of integration between 0.5 and 0.9; iii) slightly integrated (*INT*3), with degree of integration between 0 and 0.5. The percentage of establishments integrated or highly integrated into the market was higher among Group 2 (with access to credit), in all of the regions, with the exception of the Northeast. The percentage was again high between the establishments in the Central-West, where approximately 70% of non-family famers with access to credit were highly integrated into the market.

[3] Appendix B presents the production system variables employed in the study.

Table 2. Average values of the production system characteristics.

Description	Northern (NO)		North-eastern (NE)		South-eastern (SE)		Southern (SU)		Center-West (CW)	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Animal traction force and/or mechanical (%) - *TR*	49.3	64.9	59.2	68.4	71.2	87.4	71.7	94.7	76.9	91.8
Animal traction force (%) – *TRAN*	37.0	45.6	42.4	47.5	38.5	37.0	30.9	27.6	52.4	45.1
Mechanical force (%) – *TRAMEC*	22.3	36.1	30.3	38.8	52.0	75.8	55.6	85.8	53.2	79.9
Technical orientation (%) – *TECH*	25.3	41.7	17.9	25.1	46.6	67.7	47.0	77.7	42.9	69.2
Fertilization and/or soil treatment (%) – *SOILTR*	15.9	29.4	27.8	35.2	59.9	83.1	62.2	92.1	37.0	67.2
Pesticides (%) – *PEST*	17.8	34.3	24.7	39.5	33.2	61.3	45.8	83.9	21.7	52.5
Super specialized (%) – *SPEC*1	26.7	19.6	22.0	13.8	32.4	25.9	22.7	11.5	30.7	21.2
Specialized (%) – *SPEC*2	42.4	55.4	37.6	41.3	39.1	50.0	40.0	45.4	46.0	57.8
Diversified establishment (%) – *SPEC*3	16.0	18.1	28.4	36.8	14.7	19.7	25.0	38.7	10.0	17.2
Very diversified establishment (%) – *SPEC*4	1.9	1.9	3.6	5.7	1.2	1.4	2.8	3.2	0.5	0.5
Very integrated establishment (%) – *INT*1	36.2	46.0	32.2	29.1	49.0	61.2	41.1	57.0	51.3	69.7
Integrated establishment (%) – *INT*2	22.9	27.6	22.7	29.8	17.1	21.0	22.0	27.3	17.1	16.9
Poorly integrated establishment (%) – *INT*3	27.8	21.3	36.8	38.8	21.3	14.7	27.3	14.5	18.8	10.2
Number of workers – *NW*	6.0	5.8	5.5	9.4	9.9	20.7	4.4	8.6	6.5	18.4

Source: 2006 Agricultural Census, IBGE.

4. RESEARCH METHODOLODY

We applied a two-stage technique of estimation to analyze the relationship of double causality between value of production (*VOP*) and access to credit. Linear functions were adjusted for the logarithm of the value of production (Y^{VOP}) and multinomial logistic functions were adjusted for the access to credit. To consider the different sources of credit available in Brazil, we differentiated the group of producers with access to credit according to the source of financing obtained: from banks; or via other sources, including cooperatives and credit unions, suppliers, merchants, non-financial companies, other financiers, NGOs, family members, and other agents. The binary dependent variables in this case are: Y^{Cr_Bank} (1 if the farm accessed credit from a bank and 0 otherwise) and Y^{Cr_Other} (if the farm accessed another source of credit and 0 otherwise). The reference category is the non-access to credit. The structural equations are given by:

$$\begin{cases} Y_i^{VOP} = \lambda_0 + \lambda_1 Y_i^{Cr\_Bank} + \lambda_2 Y_i^{Cr\_Other} + \sum \lambda_j X_{ji}^{VOP} + u_i \\ \ln\left(\dfrac{Y_i^{Cr\_Bank}}{1 - Y_i^{Cr\_Bank}}\right) = \gamma_{10} + \gamma_{11} Y_i^{VOP} + \sum \gamma_{1k} X_{ki}^{Cr} + v_{1i} \\ \ln\left(\dfrac{Y_i^{Cr\_Other}}{1 - Y_i^{Cr\_Other}}\right) = \gamma_{20} + \gamma_{21} Y_i^{VTP} + \sum \gamma_{2k} X_{ki}^{Cr} + v_{2i} \end{cases} \tag{1}$$

Where the variables X_{ji}^{VOP} and X_{ki}^{Cr} are the exogenous factors that influence, respectively, the *VOP* and the establishment's access to credit; u_i and v_i are unexplained random errors. In all models, unobserved regional heterogeneity was controlled by fixed effects for the 558 microregions in the country.

The existence of the mutual relationship between *VOP* and access to credit required estimates at two stages to eliminate the inconsistency due to the existence of correlation between endogenous independent variables and the error terms (Pindyck and Rubinfeld, 1998). At the first stage, we estimated the equations in the reduced form, in which each endogenous variable was adjusted in function of all exogenous variables related to the problem. These equations in the reduced forms also contain instrumental variables that were highly related to independent endogenous variables, but not correlated to the error terms.

In the reduced form for the access to credit, the instrument is the sum of the farm's debts (*TD*), since this variable is highly related to the decision of the credit providers to grant the loan or not, but does not directly affect the farm's production, nor is there a link to the individual capacity of the farmer (Xi & Li, 2007). In the reduced form for the *VOP*, the instruments are: animal traction (*TRAN*), mechanical traction (*TRAMEC*), soil treatment (*SOILTR*) and use of agrichemicals (*PEST*). These variables are related to the farm's production, but do not influence the decision of the creditor to grant the loan. The equations in the reduced form are:

$$
\begin{cases}
Y_i^{VOP} = \pi_{10} + \sum \pi_{11j} X_{ji}^{VOP} + \sum \pi_{12k} X_{ki}^{Cr} + u'_{1_i} \\
\ln\left(\dfrac{Y_i^{Cr\_Bank}}{1 - Y_i^{Cr\_Bank}}\right) = \pi_{20} + \sum \pi_{21j} X_{ji}^{VOP} + \sum \pi_{22k} X_{ki}^{Cr} + u'_{2_i} \\
\ln\left(\dfrac{Y_i^{Cr\_Other}}{1 - Y_i^{Cr\_Other}}\right) = \pi_{30} + \sum \pi_{31j} X_{ji}^{VOP} + \sum \pi_{32_k} X_{ki}^{Cr} + u'_{3_i}
\end{cases} \tag{2}
$$

The absence of endogenous independent variables in the reduced form (2) would guarantee, according to the presuppositions of the classic linear regression model, consistent and non-tendentious estimates of the equations (Pindyck and Rubinfeld, 1998). In the second stage of the analysis, the endogenous independent variables of the structural equations (1), were substituted by the respective predicted values in equation (2), i.e. $\hat{Y}_i^{VOP}$, $\hat{Y}_i^{Cr\_Bank}$ and $\hat{Y}_i^{Cr\_Other}$. The new system of equations with instrumental variables is given by (3).

$$
\begin{cases}
Y_i^{VTP} = \lambda_0 + \lambda_1 \hat{Y}_i^{Cr\_Bank} + \lambda_2 \hat{Y}_i^{Cr\_Other} + \sum \lambda_j X_{ji}^{VOP} + u_i \\
\ln\left(\dfrac{Y_i^{Cr\_Bank}}{1 - Y_i^{Cr\_Bank}}\right) = \gamma_{10} + \gamma_{11} \hat{Y}_i^{VOP} + \sum \gamma_{1k} X_{ki}^{Cr} + v_{1i} \\
\ln\left(\dfrac{Y_i^{Cr\_Other}}{1 - Y_i^{Cr\_Other}}\right) = \gamma_{20} + \gamma_{21} \hat{Y}_i^{VOP} + \sum \gamma_{2k} X_{ki}^{Cr} + v_{2i}
\end{cases} \tag{3}
$$

The dependent variables of the models of access to credit refer to the natural logarithms of the odds, i.e. of the ratio between the probabilities of success (Y=1) over failure (Y=0). The odds expresses how many times the chance to access credit is greater than the chance of not accessing it. The coefficients of these models express the logarithm of the odds ratio, in other words, the logarithm of the ratio between two odds, one for each value of X. To obtain the direct relationship between the variation in X and the odds ratio, we compute the antilogarithm of β_h, i.e. e^{β_h}. The percentage change in the odds ratio in favor of variation in X is given by $100(e^{\beta_h} - 1)$.

The estimates obtained in this two stage procedure (2S) were compared to those obtained by only one stage (1S) for the equations in the structural form (1), using ordinary least squares and maximum likelihood. The Hausman specification test was then used to evaluate if $\hat{Y}_i^{VOP}$, $\hat{Y}_i^{Cr\_Bank}$ and $\hat{Y}_i^{Cr\_Other}$ are endogenous or not. If the test is significant, the estimates of 1S and 2S are distinct. In this case, only the estimates of 2S are consistent.

In the following section, we will present an analysis of the results of the determinants of credit access, the determinants of the value of production for the country as a whole, and finally, a desegregated analysis for each Brazilian region, with the aim of identifying the existence of asymmetries on the impact of access to credit between the more or less developed areas.

5. RESULTS

5.1. Determinants of access to credit

The estimated coefficients for the multinomial logistic model, that illustrate the determinants of credit access, are reported in Appendix A. While 82.7% of non-family farmers presented no credit access, 15.2% (2.1%) of establishments obtained credit from banks (other sources). The explanatory variables used in the model are described in Tables 1 and 2, however, some of them were disconsidered as they lacked discriminative power in determining the behavior of *Y*. In addition, certain categories were aggregated to facilitate and give greater significance to the analyses.

Results show that the total value of production (*VOP*) was an important determinant of credit access. On the other hand, the acquirement of financing was inversely related to the size of the establishment (*AE*) and the use of labor (*NW*). These findings suggest that the access to credit was greater among the more productive establishments. With respect to the different regions, the analysis shows that the establishments from the Southeastern (*SE*) and Southern (*SU*) areas were more inclined to obtain credit from other sources. The establishments in the South also had the greatest chance of obtaining bank loans. As expected, the participation of cooperatives (*COOP*) and associations (*ASSOC*) increased the possibility to obtain credit. Other variables utilized in the model also presented interesting results. The socioeconomic characteristics, such as gender (*GEN*) and schooling (*EL*) impacted the access to credit. Finally, the producer's total debt (*TD*) also determined access: the larger the debt, the greater the probability to obtain credit.

5.2. Determinants of production value

To analyze the impact of access to financing on the total value of production of agricultural establishments (*VOP*), the 1S and 2S estimates were compared in terms of the parameters of the structural equations (1). In the first stage of the 2S, the reduced form of the equations was obtained, considering the logarithm of *VOP* and the types of credit, represented by the system of equations (2). After the adjustment to create the instruments of the two equations, the equations for the logarithm of *VOP* and for the types of credit were estimated, using the estimated values with the instrument, as represented in (3). At this stage, the analysis focused on the results in terms of the value of production.

Table 3 presents the regression model estimates. The adjustment was based on 699,501 observations with valid information; 96,921 observations presented invalid values for at least one of the variables. The estimation for 2S adjusted relatively well to the sample information, as shown by the statistics related to the quality of the adjustment. The coefficient of determination (R^2) had a significance of 0.01%, indicating that approximately 60.1% of the *VOP* variability was explained by the variations in the independent variables.

The estimated coefficients associated for 1S and 2S models were largely distinct, suggesting a potential source of bias in the OLS estimates with a tendency to underestimate the impact of credit on production value. The estimate of the Hausman[4] specification test was significant for the access to credit and for the total value of production. Thus, the 1S and 2S estimates were distinct, and only the 2S estimates were considered. Given the size of the sample, the 2S estimates can be considered as consistent.

[4] The results of the Hausman specification test on the determinants of access to credit and production are presented in Appendixes D and E.

When the establishments' characteristics were controlled, there was a significant difference in the value of production for the non-family farmers with access to credit, compared to the others. The estimated coefficient relative to the instrumental variable, $\hat{Y}_i^{Cr\_Bank}$, shows that the acquirement of financing via banks elevated the average total production value by 63.3% ($e^{0.49055}$-1). With respect to other source of credit, the impact was even higher, with an increase of 213.3% ($e^{1.1421}$-1).

Results also indicate a significant quadratic relationship between age (*AGE*2) and total value of production. In other words, production increases up until the person responsible for the establishment reaches a certain age. In addition, there is a strong positive relationship between the producer's education level (*EL*) and *VOP*. A difference of 15.8% of average total production was observed when comparing the producers who knew how to read and write (*EL*1) and those who did not (reference). Regarding the producers who had completed elementary school (*EL*4), the total average value of production was 58.7% higher than regarding those with no formal education. The greatest impact was found in the farmers who had a higher education (*EL*6) - *VOP* was 73% higher in relation to those with no formal education.

The estimated coefficient of the binary variable for gender (*GEN*) was negative and statistically different from zero - i.e. the average value of production of the establishments managed by women was observed to be 25.4% lower than the properties controlled by men. Furthermore, if the non-family producer was a member of a cooperative (*COOP*), his total average value of production was 28.4% higher than those who were not part of a cooperative.

Table 3. 1S and 2S estimation results

Variable	1S		2S	
	Coefficient		Coefficient	
Cr_Bank	0.2768	***	-	-
Cr_Other	0.2862	***	-	-
$\hat{Y}_i^{Cr\_Bank}$	-	-	0.4905	***
$\hat{Y}_i^{Cr\_Other}$	-	-	1.1421	***
AE	0.3606	***	0.3590	***
NW	0.5393	***	0.5344	***
NO	0.1929	***	0.1927	***
SE	0.4755	***	0.4613	***
SU	0.5076	***	0.4788	***
CW	0.5184	***	0.4972	***
COOP	0.2970	***	0.2503	***
ASSOC	-0.0444	***	0.0738	***
GEN	-0.2938	***	-0.2925	***
AGE	0.0138	***	0.0128	***
AGE2	-0.0001	***	-0.0001	***
*EL*1	0.1471	***	0.1465	***
*EL*2	0.0995	***	0.1089	***
*EL*3	0.2908	***	0.2931	***
*EL*4	0.4571	***	0.4620	***
*EL*5	0.5506	***	0.5563	***
*EL*6	0.5338	***	0.5479	***
TCAP	0.6858	***	0.6510	***
PCAP	0.5605	***	0.5713	***
PAP	0.0020	***	0.0021	***
TRAN	-0.0050		-0.0061	
TRAMEC	0.3206	***	0.3137	***
TECH	0.4150	***	0.4017	***
SOILTR	0.3172	***	0.3049	***
PEST	0.3367	***	0.3176	***
SPEC_INT	1.1320	***	1.1297	***
SPEC_NINT	-0.2593	***	-0.2587	***
NSPEC_INT	0.8536	***	0.8315	***
C	4.4642	***	4.6222	***
Endogeneity test - $\hat{Y}_i^{Cr\_Bank}$			-0.3631	0.0162
Endogeneity test - $\hat{Y}_i^{Cr\_Other}$			-0.7074	0.1027
R^2	0.6018		0.6010	
F	11,127.0		33,998.8	

Note: *, ** and *** denote significance at the 0.1%, 1%, and 5% levels, respectively.
AE = area of the establishments; *NW* = number of workers; *NO* = Northern; *SE* = South-eastern; *SU* = Southern; *CW* = Center-West; *COOP* = cooperative membership (%); *ASSOC* = association membership (%); *GEN* = gender; *AGE* = age; *EL* = educational level; *TCAP* = temporary crop area (%); *PCAP* = permanent crop area (%); *PAP* = pasture area (%); *TRAN* = animal traction force (%); *TRAMEC* = mechanical force (%); *TECH* = technical orientation (%); *SOILTR* = fertilization/ soil treatment (%); *PEST* = pesticides use (%); *SPEC_INT* = specialized and integrated establishment; *SPEC_NINT* = specialized and non-integrated establishment; *NSPEC_INT* = non-specialized and integrated establishment.

The analysis of the estimated coefficients related to the characteristics of the establishment shows that the size of the property (*AE*) had a positive and statistically significant impact on *VOP*. For a 1% increase in the total area of the establishment, there was an increase of 0.36% in the total average value of production. In addition, the binary variables for the regions (*NO*, *CW*, *SU* and *SE*) were positive and statistically significant. In other words, in all of the regions we observed a higher *VOP* than in the Northeast, the reference region.

The estimated coefficients of the production system variables show that the employment of mechanic traction (*TRAMEC*), technical guidance (*TECH*), soil treatments (*SOILTR*), and use of pesticides (*PEST*) all had a highly positive and statistically significant impact on *VOP*. A non-family farmer with access to technical guidance presented, for example, a 49.4% higher total average value of production than the producers with no access.

To analyze the effect of market integration and the degree of specialization on *VOP*, four variables related to integration and specialization were used. Findings suggest that when the establishments were integrated into the market (*SPEC_INT* and *NSPEC_INT),* independent of the degree of specialization, the effect on the value of production was positive and significant. Regarding the establishments that were specialized but not integrated into the market (*SPEC_NINT*), the average total value of production was 22.8% less than that observed in non-specialized and non-integrated establishments.

5.3. Estimates for the Brazilian regions

The model was also estimated for each Brazilian region (Appendix F). The 2S estimates supports previous results. Once again, findings indicate that the model was well adjusted to the sample information, as shown by the statistics related to the quality of adjustment[5].

The coefficient associated to the instrumental variable, $\hat{Y}_i^{Cr\_Bank}$, shows that the acquirement of financing via banks increased *VOP* variable in all regions. The region that stood out most was the South, with an impact of 245%, followed by the North (70.5%), the Southeast (60.4%), Central-West (49.2%) and the Northeast (31.3%). These positive relationships are consistent with previous work (Sidhu et al., 2008; Xin and Li, 2011; Akram et al., 2013; Moura, 2016) and highlight the heterogeneous impact of credit access among the regions.

The access to financing via other sources also presented positive results, with an increase in the average total value of production in the Northern, Northeast and Central-West regions. Regarding the Northern and Northeastern regions, this result can be explained by loans given by family members and other agents. With respect to the Central-West region, the greater impact of access to financing via other sources could be associated to the fact that large producers in this area typically accessed financing from suppliers.

[5] Regarding the estimation of the 2S models for each Brazilian region, the exogenous factors were controlled, including the fixed effects for the microregions.

6. CONCLUSIONS

This work evaluated the influence of credit on the agricultural production value of non-family farmers in Brazil. Despite the importance of agricultural activity in Brazil, it is the first study that investigates the impact of rural credit on the value of production of non-family farmers in this country using microdata.

Data from the 2006 Agricultural Census show that around 137,000 non-family establishments had access to some type of financing - considering the total number of producers, 15.2% utilized bank credit and 2% other sources. Even with the increase in the volume of rural credit in Brazil in the last decades, the number of properties that obtained financing is small and heterogeneous among regions.

Findings confirm a higher value of production in the group of producers that obtained credit in all regions. The Central-West region stood out, where the value of production of the establishments with access to financing was three times greater in relation to the other regions. This can be explained by the fact that we are dealing with a new agricultural frontier in the country, where the access to credit is a relevant input driving production. In addition, the average productivity of the establishments with access to financing was higher across all regions. Access to technology and use of more efficient production practices were also higher among the producers with access to credit, in all regions.

To analyze the impact of access to financing on the value of production of non-family farmers, the 2S model was employed, since the variables related to access to credit can be non-exogenous, which results in bias ordinary least square estimates. To correct this problem, we estimated an equation with credit together with the instrumental variable correspondent to the establishments' total debts, with the estimates used in the equation for the value of production. The results show that the impact of credit, from both the bank and other sources, was positive and significant. Variables relative to the characteristics of the farmer (e.g. age, schooling, gender and cooperative membership), of the property (size and location) and of the production system (mechanization, use of inputs and technical guidance, as well as the degree of market integration and level of specialization) also had a significant impact on the value of production. Estimates for each of the five regions in the country were also carried out and confirmed the results provided above. The influence of each credit source varies considerably between the Brazilian regions, highlighting the heterogeneous impact of credit access.

This study provides new insights into how credit access impacts agricultural activity. It can be particularly useful for policy makers since it provides parameters that evaluate how financing influences the value of agricultural production. This topic can be further investigated taking into account the possible impact of credit on the socioeconomic and productive characteristics (including the adoption of technologies and management practices), which also tends to contribute to an increase in the value of production.

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REFERENCES

Akram, W.; Z. Hussain; N. Ahmad; I. Hussain (2013). Does agriculture credit affect production efficiency? Frontier production function approach. *Pakistan Economic and Social Review*, 51(2), 179-190.

Ali, D. A.; K. Deininger; M. Duponchel (2014). Credit constraints and agricultural productivity: evidence from rural Rwanda. *The Journal of Development Studies*, 50(5), 649-665.

Anjos, F. S.; W. I., Godoy, N. V. Caldas, M. C. Gomes (2004). Agricultura familiar e políticas públicas: impacto do PRONAF no Rio Grande do Sul. *Revista de Economia e Sociologia Rural*, 42(3), 529-548.

Assunção, J. J.; F. Chein (2007). Condições de crédito no Brasil rural. *Revista de Economia e Sociologia Rural*, 45(2), 367-407.

Binswanger, H. P., S. R. Khandker (1995). The impact of formal finance on the rural economy of India. *The Journal of Development Studies*, 32(2), 234-262.

Briggeman, B. C., C. A. Towe, M. J. Morehart (2009). Credit constraints: their existence, determinants, and implications for U.S. farm and nonfarm sole proprietorships. *American Journal of Agricultural Economics*, 91(1), 275-289.

Ciaian, P., J. Fałkowski, d'A Kancs (2012). Access to credit, factor allocation and farm productivity: evidence from the CEE transition economies. *Agricultural Finance Review*, 72(1), 22-47.

Damasceno, N. P., A. S. Khan, P. V. P. S. Lima (2011). O impacto do Pronaf sobre a sustentabilidade da agricultura familiar, geração de emprego e renda no Estado do Ceará. *Revista de Economia e Sociologia Rural*, 49(1), 129-156.

Dong, F., J. Lu, A. M. Featherstone (2012). Effects of credit constraints on household productivity in rural China. *Agricultural Finance Review*, 72(3), 402-415.

Duong, P. B., and Y. Izumida. (2002). Rural development finance in Vietnam: a microeconometric analysis of household surveys. *World Development*, 30(2), 319-335.

Foltz, J. D. (2004). Credit market access and profitability in Tunisian agriculture. *Agricultural Economics*, 30, 3, 229-240.

Goldsmith, R. W. (1969). *Financial Structure and Development*. New Haven: Yale University Press.

Guanziroli, C. E. (2007). PRONAF dez anos depois: resultados e perspectivas para o desenvolvimento rural. *Revista de Economia e Sociologia Rural*, 45(2), 301-328.

Gurley, J. G., and E. S. Shaw. (1955). Financial aspects of economic development. *The American Economic Review*, 45(4), 515-538.

IBGE (The Brazilian Institute of Geography and Statistics) (2006). *Brazilian Census of Agriculture*. Brasília, DF, IBGE.

Khandker, S. R., R. R. Faruqee (2003). The impact of farm credit in Pakistan. *Agricultural Economics*, 28(3), 197-213.

King, R. G., R. Levine (1993). Finance and growth: Schumpeter might be right. *Quarterly Journal of Economics*, v. 108(3), 717-737.

Kumar, C. S., C. G. Turvey, J. D. Kropp (2013). The impact of credit constraints on farm households: survey results from India and China. *Applied Economic Perspectives Policy*, 35(3), 508-527.

Levine, R. (1997). Financial development and economic growth: views and agenda. *Journal of Economic Literature*, 35, 688-726.

Li, X., C. Gan, B. Hu (2011). The welfare impact of microcredit on rural households in China. *The Journal of Socio-Economics*, 40, 404-411.

Li, R., Q. Li., S. Huang, X. Zhu (2013). The credit rationing of Chinese rural households and its welfare loss: an investigation based on panel data. *China Economic Review*, 26, 17-27.

Lopes, M. R., G. S. Souza, I. V., Lopes, G. Honczar (2011). O problema do acesso ao capital na agricultura brasileira. *Revista de Política Agrícola*, 10(4), 16-25.

Narayanan, S. (2016). The productivity of agricultural credit in India. *Agricultural Economics*, 47, 399-409.

Magalhães, A. M., R. Silveira Neto, F. M. Dias, A. R. Barros (2006). A experiência recente do PRONAF em Pernambuco: uma análise por meio de propensity score. *Economia Aplicada*, 10(1), 57-74.

Moura, F. R. (2016). O nexo causal entre crédito rural e crescimento do produto agropecuário na economia brasileira. Doctoral Thesis – Luiz de Queiroz College of Agriculture, University of São Paulo.

Petrick, M. (2004). Farm investment, credit rationing, and governmentally promoted credit access in Poland: a cross-sectional analysis. *Food Policy*, 29(3), 275-294.

Pindyck, R. S.; D. L. Rubinfel (1998). *Econometric models and economic forecasts*. 4th ed. New York: Irwin McGraw-Hill.

Rajan, R. G., L. Zingales (1998). Finance dependence and growth. *The American Economic Review*, 88(3), 559-586.

Robinson, J. (1952). *The Generalization of the General Theory*. In J. Robinson. The Rate of Interest and Other Essays. London: MacMillan.

Rooyen, C. V., R. Stewart, T. de Wet (2012). The impact of microfinance in Sub-Saharan Africa: a systematic review of the evidence. *World Development*, 40: 2249-2262.

Shaw E. S. (1973). *Financial deepening in economic development*. New York: Oxford University Press.

Schumpeter, J. A. (1911). *The theory of economic development*. Cambridge, MA: Harvard University Press.

Sidhu, R. S., K. Vatta, A. Kaur (2008). Dynamics of institutional agricultural credit and growth in Punjab: contribution and demand-supply gap. *Agricultural Economics Research Review*, 21, 407-414.

Stiglitz, J., and A. Weiss (1981). Credit rationing in markets with imperfect information. *American Economic Review*, 71(3), 333-421.

Xin, L., and Y. Li (2011). Relationship between agricultural credits and agricultural economy based on error correct model in Heilongjiang province. *Journal of Northeast Agricultural University*, 18(1), 75-78.

Tu, T. T. T., N. P. Ha, T. T. H. Yen (2015). Socio-economic impact of rural credit in northern Vietnam: does it differ between clients belonging to the ethnic majority and the minorities? *Asian Social Science*, 11, 159-167.

Yaron, J., M. Benjamin, G. Piprek (1997). *Rural finance: issues, design and best practice*. Washington: World Bank.

Zhu, X., and Z. Li (2007). Heterogeneous impact of farmer credit: an empirical investigation based on IVQR model. *Systems Engineering – Theory & Practice*, 27(2), 68-75.

APPENDIX A – List of farmer and farm characteristics variables.

Parameter	Description
AGE	Age (in years) of the farmer
GEN	Binary variable which assumes 1 if a woman directs the establishment and 0 otherwise
EL1	Binary variable for educational level; 1 if maximum education level is can write and read and 0 otherwise
EL2	Binary variable for educational level; 1 if maximum education level is the adult literacy and 0 otherwise
EL3	Binary variable for educational level; 1 if maximum education level is incompleted elementary school and 0 otherwise
EL4	Binary variable for educational level; 1 if maximum education level is completed elementary school and 0 otherwise
EL5	Binary variable for educational level; 1 if maximum education level is completed high school and 0 otherwise
EL6	Binary variable for educational level; 1 if maximum education level is completed undergraduate and 0 otherwise
COOP	Binary variable which assumes 1 if the farmer is a member of a cooperative and 0 otherwise
ASSOC	Binary variable which assumes 1 if the farmer is a member of an association and 0 otherwise
CAP	Crop area percentage
PAP	Pasture area percentage
AE	Area of the establishment (in hectares)
VOP	Value of agricultural production (BRL)
PRONAF	Binary variable which assumes 1 if the farmer access PRONAF credit and 0 otherwise
OGP	Binary variable which assumes 1 if the farmer access credit from other government program and 0 otherwise
NO	Binary variable which assumes 1 if the establishment is located in Northern area and 0 otherwise
NE	Binary variable which assumes 1 if the establishment is located in North-eastern area and 0 otherwise
SE	Binary variable which assumes 1 if the establishment is located in South-eastern area and 0 otherwise
SU	Binary variable which assumes 1 if the establishment is located in Southern area and 0 otherwise
CW	Binary variable which assumes 1 if the establishment is located in Center-West area and 0 otherwise

APPENDIX B – List of production system characteristics variables

Parameter	Description
TR	Binary variable which assumes 1 if the farmer uses animal traction force and/or mechanical and 0 otherwise
TRAN	Binary variable which assumes 1 if the farmer uses animal traction force and 0 otherwise
TRAMEC	Binary variable which assumes 1 if the farmer uses mechanical force and 0 otherwise
TECH	Binary variable which assumes 1 if the farmer receives technical orientation and 0 otherwise
SOILTR	Binary variable which assumes 1 if the farmer uses fertilization and/or soil treatment
PEST	Binary variable which assumes 1 if the farmer uses pesticides to control pests and/or diseases and 0 otherwise
SPEC1	Binary variable which assumes 1 if establishment is super specialized and 0 otherwise
SPEC2	Binary variable which assumes 1 if establishment is specialized and 0 otherwise
*SPEC*3	Binary variable which assumes 1 if establishment is diversified and 0 otherwise
*SPEC*4	Binary variable which assumes 1 if establishment is very diversified and 0 otherwise
*INT*1	Binary variable which assumes 1 if establishment is very integrated and 0 otherwise
*INT*2	Binary variable which assumes 1 if establishment is integrated and 0 otherwise
*INT*3	Binary variable which assumes 1 if establishment is poorly integrated into and 0 otherwise
NW	Number of workers in the farm (contracted and family).

APPENDIX C – Multinomial logistic model estimation results.

Parameter	Credit from banks		Credit from other sources	
	Coefficient		Coefficient	
$\widehat{Y^{VTP}}$	0.5811	***	0.9796	***
LN(AE)	-0.2206	***	-0.3587	***
LN(NW)	-0.2619	***	-0.4579	***
NO	-0.2775	***	-0.0429	
SE	-0.1498	***	0.2690	***
SU	0.1171	***	0.4435	***
CO	-0.3730	***	0.2188	***
COOP	0.1721	***	0.6597	***
ASSOC	0.4026	***	0.4264	***
GEN	0.1982	***	0.2679	***
AGE	-0.0024		-0.0014	
AGE2	-0.0000		-0.0000	
EL1	-0.1289	***	0.0770	
EL2	-0.2134	***	-0.1386	
*EL*3	-0.2971	***	-0.1908	***
*EL*4	-0.4272	***	-0.4540	***
*EL*5	-0.5704	***	-0.6302	***
*EL*6	-0.7149	***	-0.8194	***
TCAP	0.2154	***	-0.1309	*
PCAP	-0.0210		-0.5997	***
PAP	0.00066	***	-0.0073	***
TECH	-0.0392	**	-0.0842	**
SPEC_INT	-0.7417	***	-0.9862	***
SPEC_NINT	-0.0414	*	0.2048	***
NSPEC_INT	-0.3393	***	-0.6326	***
TD	0.2785	***	0.2357	***
C	-6.1261	***	11.1230	***
Endogeneity - *E_LN(VTP)*	-0.5000	***	-0.8988	***

Note: *, ** and *** denote significance at the 0.1%, 1%, and 5% levels, respectively.
AE = area of the establishments; *NW* = number of workers; *NO* = Northern; *SE* = South-eastern; *SU* = Southern; *CW* = Center-West; *COOP* = cooperative membership (%); *ASSOC* = association membership (%); *GE* = gender; *AGE* = age; *EL* = educational level; *TCAP* = temporary crop area (%); *PCAP* = permanent crop area (%); *PAP* = pasture area (%); *TECH* = technical orientation (%); *SPEC_INT* = specialized and integrated establishment; *SPEC_NINT* = specialized and non-integrated establishment; *NSPEC_INT* = non-specialized and integrated establishment; *TD* = total debt.

APPENDIX D – Hausman test results for credit

Parameter	Coefficient	
Cr_Bank	0.5271	***
Cr_Other	0.8714	***
$\hat{Y}_i^{Cr\_Bank}$	-0.3631	***
$\hat{Y}_i^{Cr\_Other}$	-0.7074	***
AE	0.3581	***
NW	0.5326	***
NO	0.1926	***
SE	0.4750	***
SU	0.4797	***
CW	0.5103	***
COOP	0.2580	***
ASSOC	-0.0687	***
GEN	-0.2907	***
AGE	0.0126	***
*AGE*2	-0.0001	***
*EL*1	0.1457	***
*EL*2	0.1042	***
*EL*3	0.2906	***
*EL*4	0.4576	***
*EL*5	0.5535	***
*EL*6	0.5450	***
TCAP	0.6518	***
PCAP	0.5551	***
PAP	0.0020	***
TRAN	-0.0046	
TRAMEC	0.3142	***
TECH	0.3988	***
SOILTR	0.3073	***
PEST	0.3140	***
SPEC_INT	1.1295	***
SPEC_NINT	-0.2567	***
NSPEC_INT	0.8350	***
c	4.5210	***
R^2	0.6026	
F	10935	

Note: *, ** and *** denote significance at the 0.1%, 1%, and 5% levels, respectively. *AE* = area of the establishments; *NW* = number of workers; *NO* = Northern; *SE* = South-eastern; *SU* = Southern; *CW* = Center-West; *COOP* = cooperative membership (%); *ASSOC* = association membership (%); *GEN* = gender; *AGE* = age; *EL* = educational level; *TCAP* = temporary crop area (%); *PCAP* = permanent crop area (%); *PAP* = pasture area (%); *TRAN* = animal traction force (%); *TRAMEC* = mechanical force (%); *TECH* = technical orientation (%); *SOILTR* = fertilization/ soil treatment (%); *PEST* = pesticides use (%); *SPEC_INT* = specialized and integrated establishment; *SPEC_NINT* = specialized and non-integrated establishment; *NSPEC_INT* = non-specialized and integrated establishment.

APPENDIX E – Hausman test results for value of production

Parameter	Bank source		Other sources	
	Coefficient		Coefficient	
LN(VOP)	0.5863	***	0.9863	***
E_LN(VOP)	-0.5000	***	-0.8988	***
LN(AE)	-0.2258	***	-0.3665	***
LN(NW)	-0.2641	***	-0.4603	***
NO	-0.2818	***	-0.0477	
SE	-0.1558	***	0.2580	***
SU	0.1109	***	0.4358	***
CW	-0.3796	***	0.2079	***
COOP	0.1741	***	0.6622	***
ASSOC	0.4062	***	0.4288	***
GEN	0.1997	***	0.2686	***
AGE	-0.0024		-0.0014	
*AGE*2	-0.0001		-0.0001	
*EL*1	-0.1306	***	0.0735	
*EL*2	-0.2166	***	-0.1445	
*EL*3	-0.3010	***	-0.1975	***
*EL*4	-0.4329	***	-0.4615	***
*EL*5	-0.5773	***	-0.6387	***
*EL*6	-0.7223	***	-0.8284	***
TCAP	0.2040	***	-0.1450	**
PCAP	-0.0377		-0.6172	***
PAP	0.0006	***	-0.0072	***
TECH	-0.0401	**	-0.0867	**
SPEC_INT	-0.7368	***	-0.9805	***
SPEC _NINT	-0.0596	***	0.1816	***
NSPEC _INT	-0.3360	***	-0.6312	***
TD	0.2793	***	0.2369	***
C	-6.1506	***	-11.1536	***

Note: *, ** and *** denote significance at the 0.1%, 1%, and 5% levels, respectively.
AE = area of the establishments; *NW* = number of workers; *NO* = Northern; *SE* = South-eastern; *SU* = Southern; *CW* = Center-West; *COOP* = cooperative membership (%); *ASSOC* = association membership (%); *GEN* = gender; *AGE* = age; *EL* = educational level; *TCAP* = temporary crop area (%); *PCAP* = permanent crop area (%); *PAP* = pasture area (%); *TECH* = technical orientation (%); *SPEC_INT* = specialized and integrated establishment*;* *SPEC_NINT* = specialized and non-integrated establishment*;* *NSPEC_INT* = non-specialized and integrated establishment; *TD* = total debt.

APPENDIX F – 2SLS estimation results for each Brazilian region.

Parameter	Northern		North-eastern		South-eastern		Southern		Center-West	
	Coefficient		Coefficient		Coefficient		Coefficient		Coefficient	
$Y_i^{Cr\_Bank}$	0.534	***	0.2726	***	0.4726	***	1.2412	***	0.4003	***
$Y_i^{Cr\_Other}$	4.0374	***	5.4896	***	-0.4298	**	-3.7177	***	0.9674	***
AE	0.2646	***	0.3403	***	0.3799	***	0.3443	***	0.3838	***
NW	0.4828	***	0.4973	***	0.5026	***	0.5924	***	0.4813	***
COOP	0.1727	***	0.2325	***	0.2928	***	0.3748	***	0.1668	***
ASSOC	-0.0259		-0.1255	***	-0.0037		-0.0318	***	-0.0112	
GEN	-0.2442	***	-0.3631	***	-0.2400	***	-0.2806	***	-0.1704	***
AGE	0.0129	***	0.0167	***	0.0055	***	0.0124	***	0.0019	
*AGE*2	-0.0001	***	-0.0001	***	-0.0001	***	-0.0001	***	-0.0001	
*EL*1	0.0716	*	0.1292	***	0.2540	***	0.2398	***	0.1643	***
*EL*2	0.0378		0.0543	**	0.2766	***	0.0946	**	0.0871	*
*EL*3	0.1934	***	0.2691	***	0.4267	***	0.3698	***	0.1977	***
*EL*4	0.3291	***	0.4699	***	0.5375	***	0.5125	***	0.3394	***
*EL*5	0.4247	***	0.5687	***	0.6050	***	0.6312	***	0.4482	***
*EL*6	0.3624	***	0.5979	***	0.5799	***	0.6047	***	0.4783	***
TCAP	0.8792	***	0.3596	***	0.9190	***	0.4471	***	1.7103	***
PCAP	0.3881	***	0.5088	***	0.8067	***	-0.1967	***	0.4774	***
PAP	0.0050	***	0.0026	***	0.0012	***	-0.0004	*	0.0038	***
TRA	0.1769	***	0.1217	***	-0.0337	***	-0.0341	***	-0.0093	
TRAMEC	0.4883	***	0.2353	***	0.3593	***	0.3609	***	0.3676	***
TECH	0.2087	***	0.4247	***	0.3250	***	0.5327	***	0.2951	***
SOILTR	0.1153	***	0.4073	***	0.2656	***	0.1654	***	0.2284	***
PEST	0.3171	***	0.2978	***	0.3230	***	0.2405	***	0.2367	***
SPEC_INT	1.2463	***	0.9435	***	1.2255	***	0.9777	***	1.6405	***
SPEC_NINT	-0.5898	***	-0.1934	***	-0.1585	***	0.0081		-0.5653	***
NSPEC_INT	0.8427	***	0.6143	***	1.0170	***	0.7612	***	1.4126	***
c	5.0749	***	4.7453	***	5.0703	***	5.1622	***	4.8280	***
R^2	0.4581		0.5038		0.5511		0.5874		0.6013	
F	943.13		4,067.8		2,564.81		3,094.48		2,737.33	
n	52,482		232,388		190,146		139,134		85,351	

Note: *, ** and *** denote significance at the 0.1%, 1%, and 5% levels, respectively.

AE = area of the establishments; *NW* = number of workers; *COOP* = cooperative membership (%); *ASSOC* = association membership (%); *GEN* = gender; *AGE* = age; *EL* = educational level; *TCAP* = temporary crop area (%); *PCAP* = permanent crop area (%); *PAP* = pasture area (%); *TRAN* = animal traction force (%); *TRAMEC* = mechanical force (%); *TECH* = technical orientation (%); *SOILTR* = fertilization/ soil treatment (%); *PEST* = pesticides use (%); *SPEC_INT* = specialized and integrated establishment; *SPEC_NINT* = specialized and non-integrated establishment; *NSPEC_INT* = non-specialized and integrated establishment.