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Assessment of rural credit impact on land and labor productivity for Brazilian family farmers

Impacto do acesso ao crédito rural na produtivididade da terra e do trabalho para agricultores familiares brasileiros

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Abstract

The objective of this study was to evaluate the impact of rural credit on land and labor productivity for Brazilian family farmers and assess factors influencing the rural credit approval process. The study employs data contained in the 2006 Brazilian Municipality Agricultural Census and a "trade index" (TI) specifically constructed to differentiate family farmers. The impact of credit on land and labor productivity was calculated by comparing the productivity of a group of family farmers that received credit with the productivity of a group of family farmers that were credit restricted. The groups were constructed with the aid of propensity score matching. When statistically significant, the average effect of credit was found to increase the recipient's productivity of land and labor. It was also found that productivity increases due to the use of credit aligned with the level of the family farmer's integration into the commercial market and, therefore, one credit policy does not fit for all Brazilian family farmers.

Keywords

family farming; trade index; rural credit; propensity score matching.

JEL Codes R15.

Resumo

O objetivo do estudo é avaliar o impacto da restrição ao crédito rural sobre a produtividade da terra e a produtividade do trabalho para os agricultores familiares do Brasil. Para estimar esse impacto, foram utilizados dados do Censo Agropecuário de 2006 por município. Para diferenciar os agricultores familiares, foram utilizados quartis do índice de mercantilização. O impacto da restrição ao crédito sobre a produtividade da terra e a produtividade do trabalho foi calculado a partir da comparação entre o grupo que recebeu crédito e o que não recebeu crédito, obtido através do escore de propensão (propensity score matching). As estimativas do efeito médio de tratamento sobre os tratados, quando apresentaram resultados estatisticamente significativos, mostraram que o crédito aumenta a produtividade do trabalho e da terra e que os valores diferem entre os diferentes níveis de mercantilização dos agricultores familiares e, portanto, requerem políticas distintas.

Palavras-chave

agricultura familiar; mercantilização; crédito rural; propensity score matching.

Códigos JEL *R15.*

1 Introduction

On July 24, 2006, the Brazilian National Policy of Family Agriculture and Rural Family Enterprises was enacted by the passage of Law 11.326, also known as the "Law of Family Farming." Among other things, this document set forth a legal definition of "family farming" and established concepts, principles and tools for the formulation of public policies directed towards family farming. This law defined a family farmer as an agricultural product producer who meets the following requirements: (i) does not have an area greater than four fiscal modules; (ii) uses primarily family labor; (iii) family income comes principally from economic activities related to the property itself; and (iv) the family manages its property. With this law's institution, the universe of Brazilian family agriculture was defined by a specific legal framework that made possible the formulation of a directed public policy.

The 2006 Brazilian Agricultural Census, compiled by the Brazilian Institute of Geography and Statistics (IBGE, 2009), identified more than four million family farming units, which represented 84% of Brazil's farming enterprises. Family farming was found to be a significant participant in the production of plant and animal products, especially those from cassava, beans, corn, coffee, pork and poultry.

The legal definition of family farms does not make a distinction between different economic levels of family farming activities, which can range from subsidence farming to farming for economic gain and, possibly, the control of a significant share of a specific market. In this sense, Carneiro *et al*. (2003) address the multifunctionality of family farming, focusing on different groups and emphasizing the important role of family farmers as a social group. Conterato (2004) and Perondi (2007) made efforts to identify the social and economic effects of the market entrance by the family farmer.

The 2006 Brazilian Agricultural Census provided data on the per-farm value of production and the per-farm value of quantity sold. It was the first Brazilian census to include these data. In the present study, those data were used to create a new variable: the *Trade Index* (TI). The TI is a ratio defined by the value of the quantity sold divided by the value of the quantity produced.[1] This variable can be used as an indicator of farmer integration into the commercial market.

1 This ratio will equal 1 when all production is sold and 0 when production is not sold (directed to self consumption).

The Brazilian government has used rural credit manipulation as one of its main agricultural policies for some time; however, despite credit's importance in the process of agricultural modernization, early efforts to employ this tactic have benefited mainly large producers (Araujo, 2011; Bacha; Danelon; Belson, 2006). In the mid-1990s, the National Program to Strengthen the Family Farm (PRONAF) was created in an attempt to provide credit to small farming operations. One of this Program's efforts was designed to reduce impediments generated between the 1960s and 1980s restricting the family farmer's access to credit.

PRONAF improved access to credit for the family farm, but competition between family farms and non-family farms still hindered the development of many family farm units. More recently, new lines of credit have emerged to extend credit access to more family farms. These efforts include the National Program of Support to the Middle Rural Producer (PRONAMP[2]), which promotes the development of medium-sized rural producers.

This study's analysis of the impact of credit and credit restriction on the productive capacity of family farms did not treat these enterprises as a homogeneous unit but differentiated the farms by their trade index (TI) levels, their location in each of the Brazilian regions, and, of course, their access to credit. Family farmers are considered affected by a credit restriction if their demand for credit is not met. The TI level indicates the portion of each farm's production that is sold. Specifically, we intend to determine whether access to funds through the use of credit impacts family farm land and labor productivity and evaluate the effect of several specific factors on the credit qualification process.

Mattei (2014) evaluated the distribution of PRONAF subsidized rural credit between 2000 and 2010 and discussed aggregate credit distribution in the household sector. The study's main conclusion is that the use of PRONAF assistance to secure financing is concentrated in the southern Brazilian states and that this credit is focused on the household sector to the exclusion of other sectors, particularly family farmers that were given their land as part of an agrarian reform measure.

Assunção and Alves (2007) gave empirical evidence showing that access to credit is restricted in rural Brazil, after an analysis of the farms in the

2 Farmers, squatters, tenants or partners who have at least 80% of their annual gross income originating from agriculture or extractive activity and an annual gross income of up to R$ 1.6 million can apply for this line of credit (BNDES, 2015).

country's five geographical regions. The highest level of credit restriction was found to be in the Northeast.

Resende and Silveira Neto (2009) conducted an evaluation of the effectiveness of government subsidized credit in Brazil. The authors concluded that the allocated resources are best employed in the Northeast region and poorly employed in the North and Midwest. This work made it evident that regional factors influence credit effectiveness.

Magalhães Neto and Dias *et al*. (2006) found that PRONAF beneficiaries in the state of Pernambuco were less effective than producers who did not have access to the program. Magalhães and Filizzola (2005) conducted a study in Paraná that determined that PRONAF had no effect on land productivity; however, the value of output per capita was positive for producer categories B and C, indicating that PRONAF credit policy was effective for some producers.

Kageyama (2003), after analyzing data from nearly 2000 farmer households in 21 municipalities of eight states, found that the presence of PRONAF promotes increases in labor and land productivity.

Santos (2010) showed that PRONAF assistance provided an increase of land and labor productivity in Brazil's Northeast in 2006. However, this analysis involved family farms in aggregate form and did not distinguish between different farms' levels of trade.

Buainain (2006) and others have determined that family farming is heterogeneous. It remains to be seen whether results obtained from previous studies are equally valid when family farming is disaggregated into different groupings, as in the present study.

2 **Methodology**

An evaluation of public policy normally seeks to determine the policy's impact and if there is a causal relationship between that policy and variables of interest. This study estimates the impact of the family farm credit policy on the productivity of family farmer land and labor using observational data and propensity scores.

The initial estimates of the impact of the credit policy were made using multiple regression; thus, it follows that:

$$Y_i = \beta_0 + \gamma D_i + \beta_1 X_i + u_i \quad (1)$$

Y_i, for example, is the productivity of land and labor in agricultural establishmenti; D_i is a dummy variable indicating amount of participation in a rural credit program; X_i the set of covariates; β_0 and β_1 are the parameters; u_i is the term of the random error and e γ measures the estimated value of the impact of "treatment" on establishmenti.

According to Angrist & Pischke (2008), the conditional expectation of equation (1) in situations $D_i = 1$ (treated) e $D_i = 0$ (control), is evaluated by the expressions:

$$E[Y_i \mid D_i = 1] = \beta_0 + \gamma + E[u_i \mid D_i = 1] \quad (2)$$

$$E[Y_i \mid D_i = 0] = \beta_0 + E[u_i \mid D_i = 0] \quad (3)$$

For someX_i,

$$E[Y_i \mid D_i = 1] - E[Y_i \mid D_i = 0] = \gamma + E[u_i \mid D_i = 1] - E[u_i \mid D_i = 0] \quad (4)$$

In this expression, γ is the effect of treatment and $E[u_i \mid D_i = 1] - -E[u_i \mid D_i = 0]$, the selection bias. The selection bias corresponds to the correlation between u_i and D_i, whereas:

$$E[u_i \mid D_i = 1] - E[u_i \mid D_i = 0] = E[Y_{0i} \mid D_i = 1] - E[Y_{0i} \mid D_i = 0] \quad (5)$$

The $E[Y_{0i} \mid D_i = 1]$ is the counterfactual: what would have happened to the average productivity of land and labor for establishments in the control group if they had been credit beneficiaries; and $E[Y_{0i} \mid D_i = 0]$ symbolizes actual average control group productiveness given that the establishments have had their access to credit restricted. If D_i were randomly defined, regression of Y_i in function of D_i would estimate the causal effect of interest γ. To obtain a good estimate of γ, the variable of interest D_i must be independent of potential results Y_i. This assumption ensures the hypothesis of conditional independence and allows the causal interpretation of estimated parameters. Under this condition, the treatment and control groups being compared are in fact comparable.

According to Angrist and Pischke (2008, p.11), the observed difference is composed of a causal effect of treatment and a selection bias:

$$E[Y_i|D_i=1]-E[Y_i|D_i=0]=E[Y_{1i}-Y_{0i}|D_i=1]+E[Y_{0i}|D_i=1]-$$
$$-E[Y_{0i}|D_i=0] \quad (6)$$

The term $E[Y_{1i}-Y_{0i}|D_i=1]$ measures the average causal effect of rural credit policy on agricultural establishments' land and labor productivity.

Angrist and Pischke (2008) claim that it is possible to eliminate selection bias if sample establishments with identical observable characteristics are selected, the only difference among them being whether they are treated or not. However, given the model's data sources, the task of selecting establishments with identical observable characteristics is extremely difficult. The control group must be extremely large and the data sources extremely detailed if an individual with the same characteristics is to be found in the treatment group. Rosenbaum and Rubin (1983) proposed propensity score matching (PSM) to solve the common support issues.

In this method, the treatment group will be based on the probability $p(\boldsymbol{X}_i)$ that the agricultural establishments are credit beneficiaries from the covariates vector. The treatment group will be composed of agricultural establishments with characteristics similar to those of the control group except that treatment group establishments are considered credit beneficiaries and the control group's are not.

According to Rosenbaum e Rubin (1983), the propensity score can be used to compare two individuals and is based on $P(\boldsymbol{X_i}) \equiv \Pr(D=1|X) =$ $= E(D|X)$.

Following Becker and Ichino (2002), the Average Treatment Effect (ATE) can be written as follows:

$$\tau \equiv E\{Y_{1i}-Y_{0i}\mid D_i=1\}$$
$$\tau = E\left[E\{Y_{1i}-Y_{0i}\mid D_i=1, p(\boldsymbol{X_i})\}\right]$$
$$\tau = E\left[E\{Y_{1i}\mid D_i=1, p(\boldsymbol{X_i})\}-E\{Y_{0i}\mid D_i=0, p(\boldsymbol{X_i})\}\mid D_i=1\right] \quad (7)$$

Where Y_{1i} is the measure of a treatment group member's land and labor productivity, and Y_{0i} is the measure of a control group member's land and labor productivity.

The first step in calculating the effect of credit is to estimate the propensity score. This can be done using a probability model. The dependent

variable is a dummy indicating whether the family farms were considered participants or non-participants in the rural credit program. For the logit model, it is:

$$\Pr(D_i = 1|X_i) = \frac{1}{1 + e^{(-\mathbf{X}_i'\beta)}} \tag{8}$$

The probability of one matched establishment receiving treatment will be defined by equation 9 below:

$$p(\boldsymbol{X_i}) \equiv \Pr(D_i = 1|\boldsymbol{X_i}) = E(D_i \mid \boldsymbol{X_i}) \tag{9}$$

After the propensity score is estimated, following assumption $X_i \perp D_i \mid p(\boldsymbol{X_i})$, the distribution of covariates among treatment and control groups should be similar. The propensity score were submitted to a*t-test* to determine whether the average of the differences between groups was not statistically different from zero after matching.

The calculated $p(\boldsymbol{X}_i)$ for the effect of credit $\tau|_{Di=1}$ will be:

$$\tau|_{D_i=1} = E_{p(X_i)}\left[\left(\tau|_{D_i=1,p(X_i)}| D_i = 1\right)\right] \tag{10}$$

The evaluation of the government' rural credit policy in Brazil presented in this study is intended to answer the following questions: Do Brazil's rural credit policies impact its beneficiaries' land and labor productivity indicators? What are these impacts? How can one say that any impacts are a result of the policies, when impacts noticeably differ among its intended beneficiaries?

In equation (1), Y_i is the variable of interest (land and labor productivity i) and D_i is a dummy variable that indicates either treatment or control group member, with $D_i = 1$ representing a member of the treatment group, and $D_i = 0$ representing a member of the control group; Y_{1i} is a measure of a treatment group member's land and labor productivity, and variable Y_{0i} is a measure of a control group member's land and labor productivity.

Different methodologies can be used to propensity score match, i.e., selecting members belonging to the treatment and control groups, each of which adopts a specific weighting. However, we used the nearest neighbor without replacement, nearest neighbor with replacement and the ker-

nel methods in this work. These three methods were employed to check the results' robustness.

In the matching method that considered the nearest neighbor without replacement, a member in the control group with the closest score to the individual considered in the treatment group is selected, after that the individual in the control group is removed from the sample. Using the replacement method, the five nearest neighboring municipalities with the most similar covariate scores are compared and replaced from the sample. Using the kernel method, an individual in the control group with a score most similar to a member of the treatment group is selected.

3 **Data source**

Data used in this study came from the "Family Farming: First Results" section of the 2006 Brazilian Agricultural Census. This new statistical reference was made possible by the establishment of criteria legally defining a "family farm" (Law 11.326), and was compiled by the Brazilian Ministry of Agricultural Development in cooperation with IBGE.

The publication of "First Results" was not the first attempt to measure family farming activities but followed a study conducted through a partnership between the Food and Agriculture Organization and the Brazilian National Institution of Agricultural Reform (FAO/INCRA), which used statistics from the 1995-96 Census; however, information available from that census were not designed for this purpose.

The concept of family farm agriculture is related to the family unit while the property is related to the production unit. Although the most common situation is a family linked to only one establishment, there are cases of families that farm more than one agricultural establishment. In the current study there may be a slight overestimation of the population involved in family farming as one family unit is assumed to have done the work at each family farm.

The 2006 Agricultural Census captures changes resulting from the creation of the Ministry of Agricultural Development (MDA) in 2000 and several other programs created around this time, such as PRONAF (created in 1995 and often redesigned, the Brazilian Program for Income Generation (PROGER) Rural (1995), and Garantia Safra (2002).

3.1 Empirical strategy

In this study, the unit of interest is the agricultural establishment and whether or not that establishment received some sort of rural credit. It would have been helpful if the IBGE site[3] provided 2006 microdata that broke down the municipal data into individual farms, but due to confidentiality issues, the site provides only information aggregated by municipality[4]. The Census microdata can be accessed, but access is both too difficult and too costly for our endeavor.[5] We were therefore forced to address the same objectives using the municipality rather than the individual family farm as the research unit.

The 2006 Agricultural Census presents the following information by municipality: number of agricultural establishments that did not receive funding, number of family farms that were not approved to receive funding, number of non-family agricultural establishments that were not approved to receive a funding, number of family agricultural establishments that obtained funding, number of non-family agricultural establishments that obtained funding, and the total value of family farm funding.

Table 1 **Proportion of establishments by the reasons why they did not obtain funding in Brazil and by regions**

Brazil and regions	Did not obtain	Type of failed to obtain financing						
		No warranty	Do not know how to obtain	Bureaucracy	Absence of previous payment	Afraid of debt	Others	Do not apply
Brazil	84.25	1.62	1.32	7.08	2.75	18.42	10.87	42.21
North	86.86	2.55	3.44	12.32	2.72	14.79	11.89	39.15
Northeast	88.89	1.94	1.44	7.3	3.82	23.86	14.6	35.94
Southeast	76.36	0.67	0.7	4.81	1.39	14.76	5.37	48.66
South	83.22	1.12	0.48	4.93	1.1	10.63	5.44	59.53
Midwest	69.03	1.55	0.76	8.55	2.15	10.45	8.68	36.89

Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

3 http://sidra.ibge.gov.br/

4 A "municipality" in Brazil would be considered a county in many other counties, as it contains both urban and rural areas. In this paper the term "municipality" will continue to be employed, but it can be considered to represent a county.

5 To use microdata of the agricultural census, one must submit research project and, if approved, should pay appropriate costs and use them in the center of the institution documentation.

Table 1 shows the proportion of establishments in Brazil by the reasons why they did not obtain funding, by region and by municipality in accordance with the 2006 Agricultural Census. It can be observed that 42.21% of family farming establishments (84.25% of total) did not apply for credit. Of the total family farming establishments in a municipality, the portion that did not demand credit was removed from our sample.

Those eligible family farmers that applied for some credit but were denied are considered to have had their credit restricted. According to Chaves *et al*. (2001, p.55-56), the credit restriction concept is relative, arising from the comparison between demand for credit funds and the available supply. A family farmer that does not demand credit cannot be considered restricted while those who are eligible for but are denied credit have a credit restriction. Starting from this definition, it was possible to create a credit restriction variable to differentiate establishments that effectively suffered restriction from those that were relatively free from restriction. This dummy variable is either 0 or 1: One, if the majority of the municipal establishments suffered restriction; 0 if the minority of the municipal establishments suffered restriction. The variable will be used in the land and labor productivity comparison to distinguish between family farms that received credit and those that suffered a credit restriction.

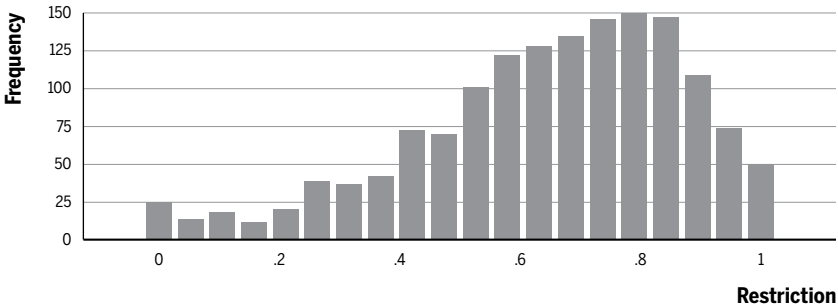
Table 2 presents the descriptive statistics of the credit restriction variable. The regions with the highest share of the total data are the Northeast, Southeast and South, with 1,765, 1,515 and 1,169 municipalities, respectively.

Table 2 **Descriptive statistics of credit restriction variable**

Brazil and regions	Number of observations	Mean	S.D.	Min	Max
Brazil	5312	0.640	0.246	0	1
Midwest	431	0.698	0.194	0.000	1
Northeast	1765	0.776	0.127	0.024	1
North	432	0.825	0.131	0.167	1
Southeast	1515	0.635	0.218	0.000	1
South	1169	0.355	0.213	0.000	1

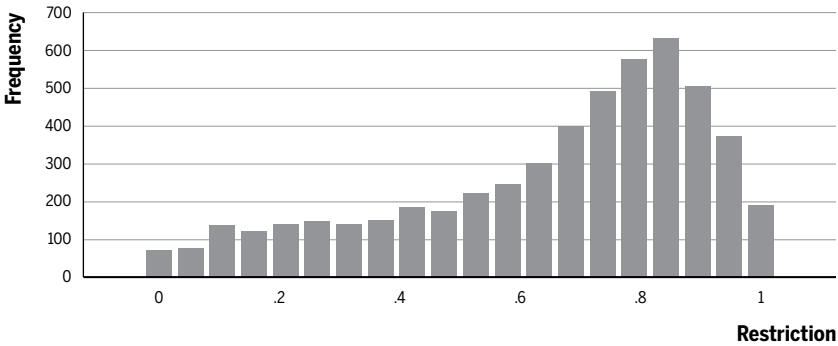
Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 1 **Dispersion of restriction values among the municipalities of Brazil**



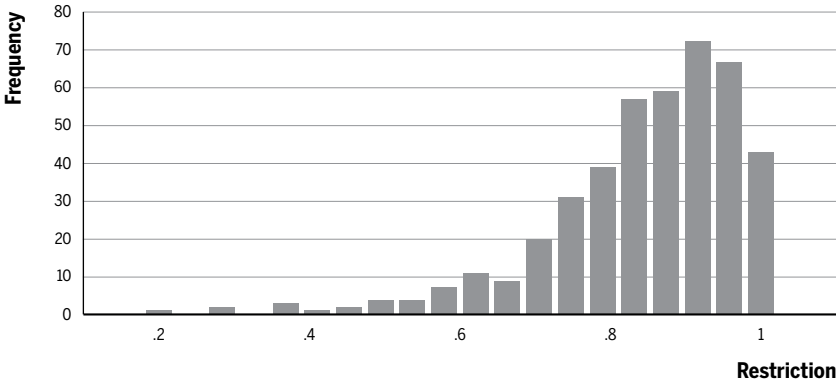
Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 2 **Dispersion of restriction values among the municipalities of Midwest region**



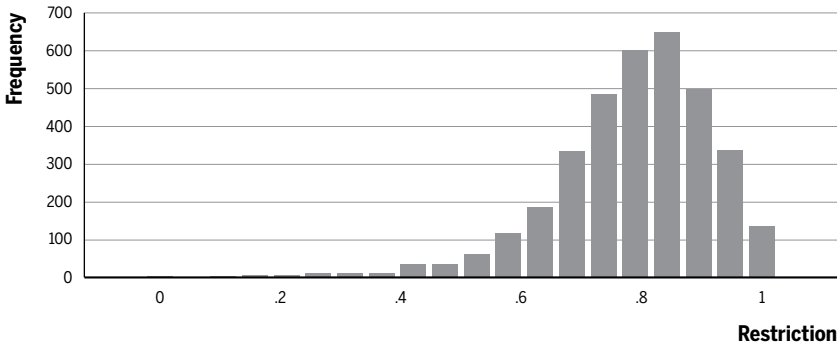
Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 3 **Dispersion of restriction values among the municipalities of Northeast region**



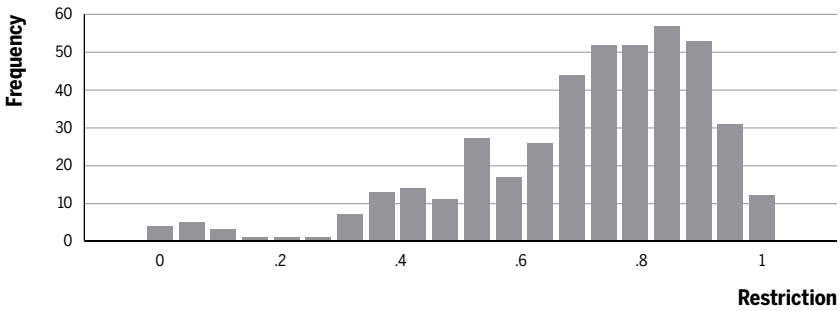
Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 4 **Dispersion of restriction values among the municipalities of North region**



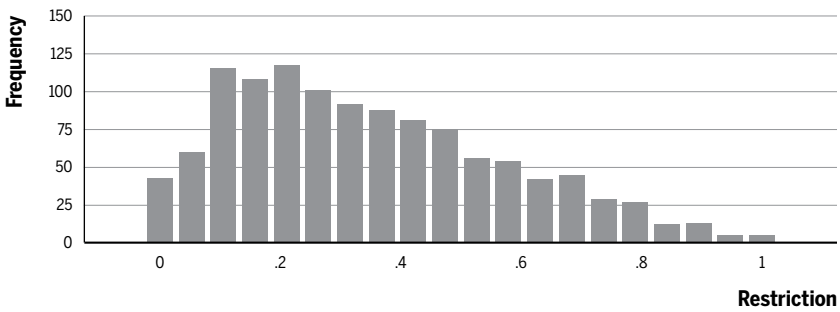
Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 5 **Dispersion of restriction values among the municipalities of Southeast region**



Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 6 **Dispersion of restriction values among the municipalities of South region**



Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

In terms of credit restriction averages, there is great heterogeneity among the five regions. Midwest and Southeast are closest to the national average, with 69% and 63% of the establishments that demanded credit affected by credit restriction. North and Northeast regions have the highest restriction averages, with 82% and 77% of farms that demanded credit rejected. In contrast, the Southern region has a credit restriction average of only 35%.

Figures 1 to 6 show the dispersion of restriction values within Brazil. As the family farm population affected by credit restriction differs from region to region, the regional restriction values rather than the average national value were used in the creation of the control and treatment groups.

This study employed the following model to estimate the propensity score in each of the geographic regions:

$$D_i^* = \beta_0 + \beta_1 v\_adubo_i + \beta_2 v\_condicao_i + \beta_3 v\_cpragasdoenca_i + \beta_4 v\_coopclasse_i + \beta_5 v\_experien_i + \beta_6 v\_internet_i + \beta_7 v\_idade_i + \beta_8 v\_escolaridade_i + \beta_9 v\_orient_i + \beta_{10} v\_prepsolo_i + \beta_{11} v\_masculino_i + \beta_{12} v\_invest_i + \beta_{13} v\_divida_i + u_i \quad (11)$$

D_i^* is a dummy variable, the value of which denotes whether the majority or minority of municipal establishments receive credit. The explanatory variables represent characteristics of producers and production, βs are the parameter of the model and u_i is the random error term. Each trade index group will have a specific estimation.

The variables are defined below:

D_i^* - dummy variable; municipalities in which more than half of the demanding establishments received credit take a value of 1 (treated); municipalities in which less than half received credit take a value of 0 (control);[6];

v_adubo_i - Percentage of municipal establishments that use some type of fertilizer;

$v\_condicao_i$ - Percentage of establishments with manager/owner;

6 Tests were conducted with different specifications as to the treatment group and control group (40% -40% 45% -45% 35% -35%), however, the most robust results were found by separating municipalities that present restricting credit and those that exhibit 50%.

$v\_cpragasdoenca_i$ - Percentage of establishments that take measures to control pests and diseases;
$v\_coopclasse_i$ - Percentage of establishments associated with cooperatives and/or professional associations;
$v\_experien_i$ - Percentage of establishments that have a manager with 10 years or more of experience;
$v\_internet_i$ - Percentage of establishments with internet access;
v_idade_i - Percentage of establishments where the manager is at least 35 years old;
$v\_escolaridade_i$ - Percentage of establishments in which the manager has a least high school degree;
v_orient_i - Percentage of establishments that receive technical, public or private advice;
$v\_prepsolo_i$ - Percentage of establishments that perform some type of soil tillage;
$v\_masculino_i$ - Percentage of establishments in which the manager is male;
v_invest_i - Percentage of establishments that make some type of investments;
v_divida_i - Percentage of establishments that have existing debts;

Table 3 shows the mean, standard deviation, minimum, maximum and the number of observations for each variable. The *v_invest* and *v_divida* variables have fewer observations due to IBGE's confidentiality rules. According to IBGE criterion, if a municipality has 1-3 establishments with information for a particular characteristic, that information will not be divulged.

Variables *v_condicao*, *v_experien*, *v_idade* and *v_masculino* have mean values above 60%, which indicates that most family farmers in the municipalities' sample are owners of the property they farm, that most managers have over 10 years' experience, that most managers are at least 35 years old and, as might be expected, that most managers are male, respectively.

The following are the land and labor productive variables' definitions:

(i) Gross land productivity - the total value of production divided by the total area of the family farming establishment;

(ii) Gross labor productivity - the total value of production divided by the number of workers employed in production.

In each of the five geographic regions, the average effect of credit restric-

tion on enterprises from different TI levels was assessed. The control and treatment groups' populations were separated into four different categories determined by TI value, making it possible to identify differences in treatment and productivity associated with the enterprises' TI level.

The TI quartiles were defined as follows:

1st quartile – family farms that sold 0% to 25% of their production;

2nd quartile - family farms that sold 25% to 50% of their production;

3rd quartile - family farms that sold 50% to 75% of their production;

4th quartile - family farms that sold 75% to 100% of their production.

Table 3 **Descriptive statistics for each covariate - Brazil**

Variable	Observations	Mean	D. S.	Min	Max
v_adubo	5317	0.363	0.294	0.000	0.992
v_condicao	5317	0.784	0.189	0.000	1.000
v_cpragas	5317	0.104	0.132	0.000	0.890
v_coopclasse	5317	0.380	0.233	0.000	0.977
v_experien	5317	0.613	0.144	0.018	1.000
v_internet	5317	0.017	0.035	0.000	0.449
v_idade	5317	0.865	0.069	0.551	1.000
v_escolaridade	5317	0.110	0.093	0.000	0.917
v_orient	5317	0.262	0.228	0.000	0.976
v_prepsolo	5317	0.427	0.270	0.000	1.000
v_masculino	5317	0.880	0.065	0.272	1.000
v_invest	5316	0.196	0.120	0.000	0.780
v_divida	5278	0.194	0.156	0.000	0.836

Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Table 4 shows average productivity of land and labor for each quartile of both the control (0) and the treatment groups (1). The distribution was divided into four sections according to the trade index variable to create smaller but more homogeneous family farm groups.

The different quartiles' land and labor productivity values are noticeably dissimilar. Higher quartiles had much higher productivity values. Also, most quartiles in which more than half of the applicants' credit applications were approved had higher productivity levels against family farms in the same quartiles but from the more restricted control group. The question now is if there is in fact a relationship between treatment –

more than half of the stablishments in the municipalities have access to credit – and the levels of productivity.

Table 4 **Average productivity of land and labor for each quartile of both the control (0) and the treatment groups (1) - Brazil**

Trade Index	Land productivity (Thousand Reais/hectare)		Labor productivity (Thousand Reais/worker)	
	0	1	0	1
1	0.5746	0.9889	3.0408	6.7840
2	0.7037	1.3895	3.7857	8.1400
3	1.1984	1.4390	4.8741	9.0792
4	1.9278	2.8950	7.7093	15.8572

Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

4 **Results**

This section presents the results of the study of the effect of credit on the productivity of land and labor and the effect of producer characteristics on the credit restriction process.

4.1 **Probability of establishments in municipalities suffering credit restriction**

Results from the logit model make it possible to discuss the effect of each covariate on the probability of credit restriction in each geographic region (see: Table 5). Not all the variables' coefficients were statistically significant at a 10% level in their ability to explain the probability of establishments in a municipality suffering credit restriction.

Some producer characteristics were found to greatly influence the credit restriction process. Results showed that in all regions, the higher the percentage of establishments in a municipality in which the producer has over 10 years of experience, the lower the probability of credit restriction. The magnitude of this effect is even greater in the South, the region that receives the largest share of rural credit resources.

It was found that the higher the percentage of indebted establishments

in a municipality, the lower the probability of credit restriction, which may be directly related to the need for credit to provide working capital. This result was significant and positive in all geographical regions.

Table 5 **Coefficients of the logit model in each geographic region**

Variable	Coefficients				
	Midwest	**Northeast**	**North**	**Southeast**	**South**
v_adubo	*2.326	0.026	-0.297	*1.557	*2.102
	(0.906)	(0.336)	(1.089)	(0.335)	(0.759)
v_condicao	1.213	*-1.191	1.217	*2.622	*2.741
	(0.828)	(0.33)	(0.796)	(0.631)	(1.058)
v_cpragasdoenca	***-1.456	-0.015	-0.161	**-1.075	**-1.334
	(0.809)	(0.624)	(1.601)	(0.445)	(0.663)
v_coopclasse	0.163	-0.172	0.87	-0.405	**1.058
	(0.714)	(0.312)	(0.708)	(0.336)	(0.479)
v_experien	*2.909	*2.307	***1.804	***1.165	*3.395
	(0.922)	(0.53)	(0.934)	(0.656)	(0.944)
v_internet	-0.231	0.294	***55.125	-2.205	-1.279
	(9.475)	(6.693)	(34.369)	(1.401)	(2.375)
v_idade	3.324	**2.716	2.568	**3.949	-0.714
	(3.128)	(1.156)	(2.291)	(1.755)	(2.171)
v_escolaridade	-0.089	-0.325	***5.822	**1.936	0.683
	(1.785)	(1.576)	(3.498)	(0.773)	(1.708)
v_orient	*2.622	0.815	**1.956	*2.031	*2.132
	(0.761)	(0.552)	(0.801)	(0.412)	(0.545)
v_prepsolo	***-1.614	0.148	0.474	*-1.009	-0.392
	(0.898)	(0.236)	(0.866)	(0.362)	(0.715)
v_masculino	**6.602	1.209	2.898	*8.717	**5.389
	(3.076)	(0.815)	(2.882)	(1.481)	(2.404)
v_invest	0.906	*2.231	0.869	**-1.443	***1.484
	(0.973)	(0.685)	(1.126)	(0.687)	(0.858)
v_divida	*4.577	*7.563	*5.049	*9.548	*5.262
	(1.053)	(0.717)	(1.281)	(0.851)	(0.756)
_cons	*-13.312	*-5.733	*-9.207	*-16.516	*-13.241
	(3.654)	(1.04)	(2.985)	(2.009)	(2.704)

Source: Authors' estimation based on 2006 Brazilian Agricultural Census (s.d).

*Note: ***, **, * significant at 1% level, 5% and 10% level respectively.*

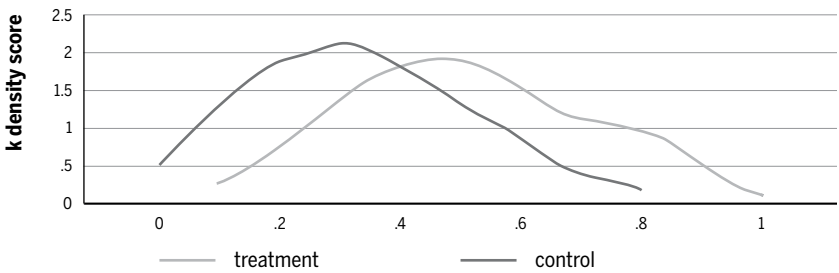
Results also showed that the higher the percentage of establishments in a municipality that receive technical guidance, the lower the probability of credit restriction. This result was observed in all regions except the Northeast. It seems that technical assistance, for the most part conducted by technicians from state agencies, facilitates credit approval.

Other variables, such as use of fertilizers, land ownership, the farm manager's gender, and internet access, also showed significant results in some regions.

Scores generated by the logit model also serve as indicators of the correlation between the treatment and control groups, which is useful when selecting municipalities in each group for comparison. Figures 7 to 11 graphically illustrate the treatment and control group's density function scores for all geographic regions. The curve in bold represents the estimated scores for control group municipalities, and the finer curve represents scores for treatment group municipalities.

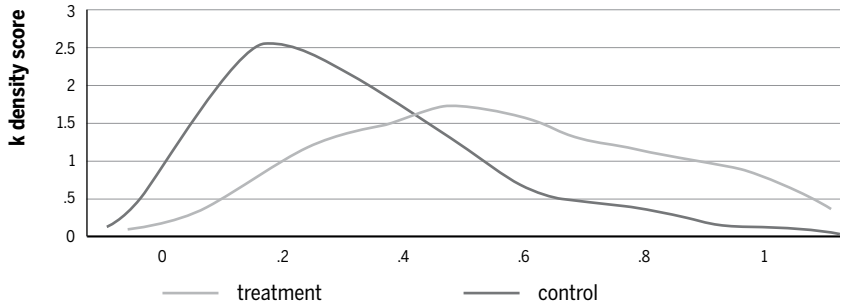
One can observe that in all regions there is ashared area below the treatment and control groups' density curves. Similar and therefore comparable municipalities are included in this region, i.e., they will have similar covariate scores, differing only in restriction or access to credit. Municipalities from the treated and control groups occupying this shared area were then selected for matching and their land and labor productivity values were compared. Note that the major criticism of this method of selection is its inability to control and account for unobservable effects, which can lead to bias and inconsistency in parameter estimates.

Figure 7 **Function of density of scores generated by the logit model by treatment and control groups of Midwest region**



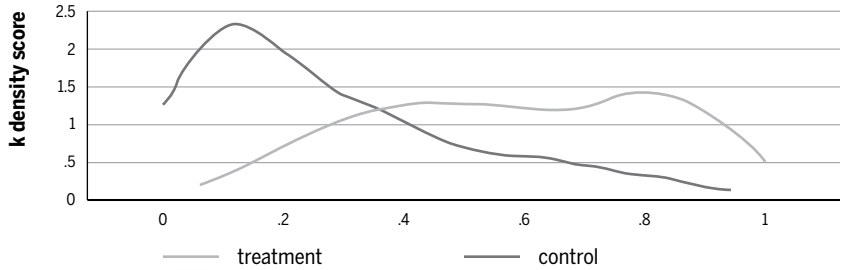
Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 8 **Function of density of scores generated by the logit model by treatment and control groups of Northeast region**



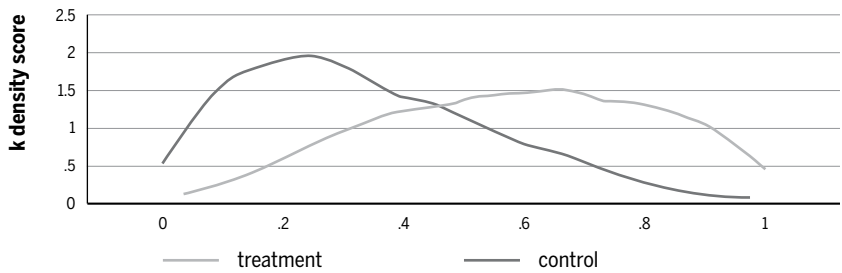
Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 9 **Function of density of scores generated by the logit model by treatment and control groups of North regionn**



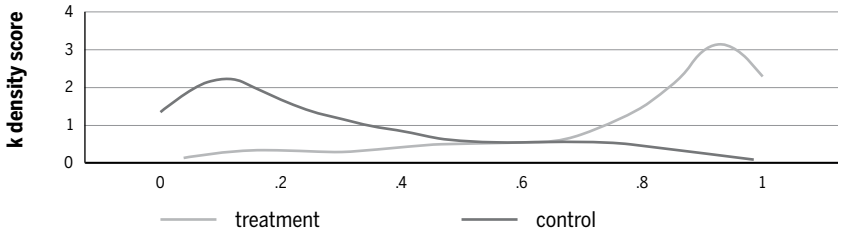
Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 10 **Function of density of scores generated by the logit model by treatment and control groups of Southeast region**



Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

Figure 11 **Function of density of scores generated by the logit model by treatment and control groups of South region**



Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

As noted in the Methodology section, the matching was performed using the nearest neighbor without replacement, replacement with the five closest neighbors, and the Kernel methods. Municipalities were matched for the four different TI levels and for all geographical regions.

An average difference test for each of similar municipalities' covariates was conducted to verify whether the matching was carried out satisfactorily. It was determined that the null hypothesis where means are the same should not be rejected, indicating that there is no difference between the average of the respective covariates for the treatment and control group municipalities. The results were not significant for almost all covariates, showing that the treatment and control groups are homogeneous.[7]

The next section shows the Average Treatment Effect (ATE) on land and labor productivity by region.

4.2 **The effect of credit restriction on land productivity**

Productivity differences between similar control and treated municipalities were used to determine the ATE in the five regions and at the four TI levels. Table 6 indicates the calculated average effect of no credit restriction on land productivity.

The first point worth highlighting is that there is a substantial difference in land productivity between treatment and control groups when comparing regions and different TI levels; however, not all results were statistically significant. This indicates that when comparing similar municipalities,

7 To check the results of tests of averages for each of the covariates see Garcias 2014.

there is often no land production difference that can be correlated with credit restriction, but that credit access and restriction have different effects depending on the farmer's TI value and production region.

Table 6 **Average effect of treatment on land productivity in different quartiles of the trade index, by regions in Brazil**

Region	TI	Land productivity (thousands reais/hectare)								
		Nearest neighbour without replacement			Kernel			5 nearest neighbour with replacement		
		ATE	S.D.	t-test	ATE	S.D.	t-test	ATE	S.D.	t-test
Midwest	1	-0.149	0.148	-1	-0.035	0.18	-0.19	-0.065	0.111	-0.58
	2	-0.012	0.121	-0.1	0.106	0.063	***1.680	-0.259	0.127	**-2.040
	3	-0.074	0.138	-0.54	-0.009	0.089	-0.1	-0.226	0.198	-1.14
	4	0.24	0.146	***1.640	0.283	0.139	**2.040	0.15	0.163	0.92
Northeast	1	0.005	0.083	0.05	0.101	0.083	1.22	0.084	0.082	1.02
	2	-0.24	0.281	-0.85	0.169	0.132	1.28	0.178	0.467	0.38
	3	0.259	0.488	0.53	0.176	0.596	0.3	0.15	0.505	0.3
	4	0.908	0.982	0.92	1.185	0.988	1.2	0.894	0.976	0.92
North	1	-0.0195	0.0318	-0.61	-0.035	0.0536	-0.66	-0.008	0.034	-0.26
	2	-0.0296	0.098	-0.3	-0.006	0.1129	-0.06	-0.026	0.108	-0.25
	3	-0.159	0.117	-1.35	-0.226	0.2059	-1.1	-0.187	0.159	-1.18
	4	-0.046	0.112	-0.41	-0.017	0.1782	-0.1	-0.009	0.13	-0.07
Southeast	1	0.282	0.101	*2.78	0.282	0.142	*1.99	0.222	0.37	0.6
	2	0.287	0.245	1.17	0.181	0.268	0.68	0.278	0.314	0.88
	3	-0.185	0.182	-1.02	-0.132	0.23	-0.58	-0.13	0.208	-0.63
	4	-0.057	0.779	-0.07	0.883	0.812	1.09	0.963	0.915	1.05
South	1	0.31	0.29	1.07	-0.376	0.823	-0.46	-0.12	0.664	-0.18
	2	0.213	0.19	1.12	-1.29	0.605	*-2.13	-1.155	0.364	*-3.17
	3	0.348	0.143	*2.43	0.296	0.332	0.89	0.198	0.315	0.63
	4	3.367	3.416	0.99	3.367	3.421	0.98	3.085	3.423	0.9

Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

*Note: ***, **, * significant at 1% level, 5% and 10% level respectively.*

Specifically, in the Midwest region, the effect of credit on land productivity was 0.24 using the nearest neighbor algorithm without replacement and 0.28 using the Kernel algorithm for the group of municipalities belonging to the 4th TI quartile (i.e., those selling more than 75% of their produc-

tion). In contrast, results for the group of municipalities in the same region but in the 2nd TI quartile become negative and significant when analyzed using either the kernel or without replacement models

These results indicate that rural credit policy often does have a positive effect on land productivity, but that effect depends on the family farmer's region and TI value; e.g., Midwest (2nd and 4th TI quartiles), Southeast (1st and 4th TI quartiles) and South (3rd and 4th TI quartiles).

These estimates confirm results from studies by Anjos *et al*. (2004) and Silva (2008). Those authors found that access to credit has a positive effect on local development, but only in specific locations. There is still an indication that credit access can have a negative effect in relation to land productivity, as the results for most regions' establishments in the 2nd TI quartile demonstrate. Santos (2010), evaluating aggregated family farmers, noted that there was an increase in land productivity for establishments that suffered restricted credit only in the Northeast region.

4.3 **The effect of credit access and restriction on labor productivity**

Table 7 shows the calculated average effect of credit on labor productivity. As with the land productivity results, there is a gap between the treatment and control group results and substantial differences among regions and TI levels; again highlighting that the effect of credit on family farmers is not homogeneous. Although many of results for labor productivity were not statistically significant, they were more robust than those for land productivity.

Labor production values for municipalities in the Midwest, Southeast and South were found to be positively affected by credit. In these regions, labor productivity values were higher for municipalities in which the average family farmer was at a higher TI level and the majority received credit approval than for municipalities also at a higher average TI level but in which the majority of family farmers were credit restricted. The effects varied by region, with the labor productivity value differential between these two types of municipalities reaching R$ 3,970/worker in the Midwest.

The effect of TI value on the impact of credit approval was also quite noticeable. For example, in the Southeast region, for the group of municipalities in the treatment group, the value of production for the average family farmer in municipalities ranked in the lowest TI quartile was R$ 2,528/

worker while the value of production for the average family farmer in the group of municipalities ranked in the 4th TI level was R$6,945/worker.

Table 7 **Average effect of treatment on labor productivity in different quartiles of the trade index, by regions in Brazil**

Region	TI	Land productivity (thousands reais/worker)								
		Nearest neighbour without replacement			Kernel			5 nearest neighbour with replacement		
		ATE	S.D.	t-test	ATE	S.D.	t-test	ATE	S.D.	t-test
CO	1	-0.29	1.034	-0.28	0.423	0.995	0.43	-0.202	0.849	-0.24
	2	-1.856	3.327	-0.56	1.295	0.848	1.53	-9.367	3.48	*-2.690
	3	1.669	1.244	1.34	2.179	1.402	1.55	1.173	1.468	0.8
	4	3.972	2.247	***1.770	4.198	2.234	***1.880	3.368	2.282	1.48
NE	1	0.142	0.312	0.45	0.159	0.272	0.58	0.131	0.388	0.34
	2	-0.179	0.492	-0.36	0.385	0.355	1.08	0.25	0.814	0.31
	3	0.618	0.793	0.78	0.25	0.993	0.25	0.327	0.821	0.4
	4	2.757	3.438	0.8	2.898	3.467	0.84	2.762	3.428	0.81
N	1	-0.367	0.394	-0.93	-0.32	0.525	-0.61	-0.28	0.41	-0.68
	2	-0.6	0.796	-0.75	0.3562	0.595	0.6	-0.952	1.084	-0.88
	3	0.0072	0.533	0.01	-1.276	0.779	-1.62	-0.396	0.678	-0.58
	4	-0.008	0.708	-0.01	-0.18	1.073	-0.17	0.256	0.771	0.33
SE	1	2.528	1.154	*2.19	1.962	1.514	1.3	2.039	1.301	1.57
	2	1.807	1.476	1.22	1.946	1.674	1.16	1.585	1.789	0.89
	3	0.482	1.158	0.42	1.046	1.557	0.67	-0.191	1.323	-0.14
	4	6.945	3.14	*2.21	7.91	3.328	*2.38	7.517	3.708	*2.03
S	1	1.129	1.242	0.91	-2.987	4.194	-0.71	-1.18	3.019	-0.39
	2	2.505	0.911	*2.75	-5.897	2.529	*-2.33	-2.533	1.618	-1.57
	3	2.969	0.739	*4.02	0.843	1.778	0.47	0.666	1.622	0.41
	4	6.884	7.46	0.92	6.674	7.642	0.87	5.274	7.56	0.7

Source: Authors' estimation based on 2006 Brazilian Agricultural Census.

*Note: ***, **, * significant at 1% level, 5% and 10% level respectively.*

Kageyama (2003) also found that access to credit promotes increases in labor productivity, but did not examine whether the effect was differentiated. The sample in that paper was limited to eight states.

These results show that rural credit policy has an effect on family farm labor productivity, but that the effect is not uniform, rather it depends on

how integrated the family farm is into the commercial market and the farm's location.

5 **Conclusion**

This study evaluated the effects of family farm credit policy on the land and labor productivity of farmers located in different regions and at different levels of market integration, as determined by the farmer's Trade Index (TI) value.

The credit restriction process was also examined while conducting the study; however, as family farming was covered in aggregate form, it was not possible to ascribe results to a particular family farm group. Some producer characteristics were found to be important in determining which eligible family farmer received credit and which did not. Among these determinants for credit approval it was found that if the producer had more than 10 years of farming experience the possibility of approval improved. Other variables that increased chances for credit approval were the prior approval for credit and access to technical assistance.

The effect of credit on productivity were differentiated among farms at different TI levels, as was to be expected. When statistically significant, the results were more positive in municipalities where family farm TI averages were in the last quartile of the TI distribution, that is, farmers who marketed more than 75% of their agricultural production.

Although some results are not statistically significant, this work showed that credit restriction has a differential effect when family farming is disaggregated into specific groups according to the degree of market integration. In general, the effect of rural credit policy on the productivity of land and labor were positive; however, it may also have effects on other production or social indicators that were not examined. Credit can also be seen as a mechanism to address the needs of family farmers associated with the group's multifunctional role.

The effects of credit on productivity were positive and significant in most cases where the producer was an active market participant: the more integrated in the market, the greater the chance that credit would be beneficial. Success in the open market is dependent on efficient production of a demanded product. For this reason, it is recommended that the release of

funds from a government subsidized credit program be made contingent on the acceptance of technical assistance when reasonable, so the family farmer can get advice on proper resource allocation.

Within the scope that defines family farming, there are different subsegments, here differentiated using values from a Trade Index designed for use in this study. The model's results confirm that the effects of rural credit restriction depend on whether the family farming community is more or less integrated into the farm product market; thus, it is concluded that dissimilar groups of family farms require different policies.

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