Impact Evaluation of the Brazilian crop insurance public program "*Proagro Mais*"

Carlos Andrés Oñate Paredes
PhD. Department of Economics, Business and Sociology, "Luiz de Queiroz" College of Agriculture - University of São Paulo (ESALQ/USP)
c_onate@hotmail.com

Vitor Augusto Ozaki
Professor. Department of Economics, Business and Sociology, "Luiz de Queiroz" College of Agriculture - University of São Paulo (ESALQ/USP)
vitorozaki@usp.br

Boris Bravo-Ureta,
Professor. Department of Agricultural and Resource Economics, University of Connecticut (UCONN)
boris.bravoureta@uconn.edu

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Abstract

This research evaluates the impact of a public risk management tool that provides insurance to small-scale farmers. In particular, we analyze the "Farm Activity Guarantee Program for Smallholders" or *Proagro Mais*, which is one of the largest Brazilian public programs that uses crop insurance indemnity mechanisms. This program covers financial debts incurred by smallholders related to rural credit operations, and which payment was hampered by the occurrence of pests, diseases or climatological effects. The relevance of this research relies on the considerable size of the program, both in terms of number of operations and money invested to cover crop losses. We use a sample of small-scale corn producers from the State of Paraná, which included *Proagro Mais* beneficiaries and non-beneficiaries. One should note that all growers in the sample contracted credits associated with their corn crop, but not all subscribed to the insurance Program. We use 2003 as the baseline since it is the year prior to the launch of *Proagro Mais* and then used 2005 as the endline considering the indemnity mechanism of the Program. The database used in this study was provided by the Federal Accounting Court of Brazil (TCU), and includes 25,877 corn growers that contracted with *Proagro Mais* between 2003 and 2005 (treatment group), and 68,312 growers who were not beneficiaries of that program in this same period (control group). The relevant variables include crop and growers characteristics such as area financed, complementary economic activities for additional income (dummy), education, and expected yield. We also added meteorological and regional variables from other public sources to control farm location. Our main objective is to evaluate the impact of *Proagro Mais* on the amount of credit per hectare granted to the beneficiaries of the Program. The methodology includes Propensity Score Matching (PSM) along with Difference-in-Difference (DID). We use longitudinal data and apply the conditional DID estimator proposed by Heckman et al. (1997), and the conditional DID estimator with repeated cross-sections, proposed by Blundell and Costa Dias (2000).The econometric estimates with both methods described above, show that the effect of the treatment on the tread was not positive. This suggests that after the yield loss period, the control group got a higher average amount of credit per hectare than *Proagro Mais* beneficiaries. Thus, the question that arises is whether there may be other agricultural risk management mechanisms more suited for smallholders than *Proagro Mais*, or whether the evaluated program could not achieve its main goal because it does not cover all risks faced by its beneficiaries. Therefore, this study could serve to promote discussions about the economic performance and efficiency of agricultural policy in Brazil.

Keyword: Brazil, impact evaluation, agricultural risk management policy

JEL Classification: Q18, C54, Q12, G22

Introduction

In Brazil, there are several public and private agricultural risk management mechanisms as crop insurance, futures and options contracts, instruments that conform the Minimum Price Guarantee Policy (PGPM), smallholders'[1] mechanisms of commercialization, renegotiations of rural debt, subsidies of crop insurance premiums paid by producers, and programs whose indemnity mechanisms are similar to those of private crop insurance. In the latter group, there is the Farm Activity Guarantee Program for Smallholders (*Proagro Mais*), which is the object of study of this article.

Proagro Mais was implemented by Resolution No. 3234 of August 31, 2004 (BRASIL, 2004). Its goal is to support smallholders who contracted *Pronaf*[2] for agricultural costs or investment operations. *Proagro Mais* loss compensation mechanism is similar to the Brazilian crop insurance based on cost indemnity mechanisms. However, it main focus is to avoid default of agricultural credit operations caused by the risks associated to the activity. Farmers who hire this program pay a premium, having the Federal Government as insurer that will bear the costs in case of agricultural disasters (BACEN, 2015a).

The interest of analyzing *Proagro Mais* is based on the importance of that mechanism in the context of Brazilian agriculture, and also in the absence of literature that presents quantitative analysis of the effects of this public policy on the management of agricultural risk.

Regarding the magnitude of *Proagro Mais,* according to the Central Bank of Brazil – BACEN (BACEN 2015b; BACEN, 2015c; BACEN, 2015d; BACEN, 2015f), the value covered by this Program from the beginning of operations (2004/2005) to the season

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[1] According to the Law No. 11,326 of July 24, 2006, smallholder is defined as a farmer who practices activities in rural areas, and simultaneously addressing the following requirements: 1) does not possess, under any title, an area greater than four fiscal modules, 2) use predominantly familiar labor force in the economic activities of its enterprise, 3) have familiar income predominantly originated from his own enterprise, and iv) lead his rural enterprise with his family.
Additionally, fiscal module is an agrarian measure used in Brazil, established by the Law No. 6,746 of December 10, 1979. It is expressed in hectares and its variable in each municipality, depending on four aspects: 1) predominant type of agricultural activity in the municipality, 2) income earned from the predominant agricultural activity in the municipality, 3) other existing agricultural activities in the municipality that although not predominant, are significant in terms of income or used area, and 4) familiar property concept.

[2] The National Program for Strengthening Family Agriculture (*Pronaf*) is intended to "stimulate income generation and improve the use of family labor, through financing activities of agricultural rural services and non-agricultural services developed in rural establishments or nearby community areas" (BRASIL, 2012, p. 2).

2013/2014 was 57,566 BRL million (USD 26,136 million), over 5,332,839 operations. However, despite the magnitude of these numbers, there are a few studies that deal directly on this agricultural policy and its various implications for economic agents. Among the published academic works stand out the detailed reports of BACEN, Maia et al. (2010), Ferreira e Ferreira (2009), Ramos (2009). None of these, however, approaches the impact of *Proagro Mais* on the farmers, standing out some uncertainty about the cost-effectiveness to maintain or increase investment in this Program.

Based on the factors mentioned, this article will focus on the analysis of *Proagro Mais* using quasi-experimental impact evaluation methodologies. The main objective of this case study research is to evaluate the impact of *Proagro Mais* in a sample of corn smallholders in State of Paraná using as resulting variable the amount of offered credit per hectare. The hypothesis associated to this objective is the following: after a period of low production, corn farmers in the State of Paraná who hired *Proagro Mais*, present an average cost of credit per hectare superior than those farmers who have not hired this Program. The hypothesis reinforces the idea that, from a possible reduction in productivity, farmers could have their ability to pay the financial institutions reduced, however, due to *Proagro Mais*' compensation mechanism, those farmers could pay off the corresponding debts, avoiding default with the financial entity and thus maintaining the debt capacity to levels prior to crop failure.

This article presents six sections besides the introduction: 1) literature review, 2) methodology, 3) data and variables, 4) results, 5) discussion, and 6) concluding remarks.

Literature review

The above hypothesis is based on the assumption that *Proagro Mais*, as a risk management mechanism, follows the same theoretical implications of agricultural insurance. That said, there are no significant differences between the indemnity mechanisms of this program and the indemnity mechanisms of private crop insurance based on cost. Thus, the theoretical literature review is based on Financial Risk approach and the von Neumann-Morgenstern utility function (VN-M).

Financial Risk approach

Hogan and Aubey (1984) analyzed the impact of crop insurance associated to rural credit in the financial structure of farms, using a simple model of financial risk that has as its starting point the gross income (eq.(1)).

$$Y = r(K + L) \tag{1}$$

Where *Y* is the gross income, *K* is the equity of the producer, *L* is the debt or rural credit, and *r* is the rate of return on investment.

Considering that the rural debt *L* is acquired to finance productive activities have a price represented by the interest rate *i*, the net income *I* follows eq. (2):

$$I = Y - iL = r(K + L) - iL \tag{2}$$

Hogan and Aubey (1984) considered a scenario in which the equity of the producer remains constant, while the level of foreign investment increased through public credit programs. In this case, the effect of the increase in rural debt raises the relative risk of cash flow, because with the provision of agricultural credit opens up the possibility of increased investments, resulting in higher returns (in case the agricultural project is successful), or losses (in case of agricultural claims). Thus, the analysis conducted by the mentioned authors follow the reasoning of the positive correlation between risk and return and the foundations of Financial Risk[3].

In order to display the impact of credit on the financial decisions of the farmers, the authors chose the coefficient of variation (CV) of *I* as risk variable, so that from eq. (2), they derived it in relation to credit, obtaining a positive variation of risk in investment by increasing agricultural debt:

$$\frac{\partial CV(I)}{\partial L} = \frac{\mathrm{iK}\sigma_r}{[\mathrm{E}(I)]^2} > 0 \tag{3}$$

In this equation, E $(I)$is the mathematical expectation of net income and σ_r the standard deviation of the investment interest rate *r*.

[3] Barges (1963); Gabriel e Baker (1980).

A way to reduce the magnitude of the risk of hiring an agricultural credit operation is to secure the total investment, or at least cover the debt acquired for the harvest. Hogan and Aubey (1984) named this type of insurance as crop credit insurance, which characteristics are similar to the Program analyzed in this paper, due to the similarity *Proagro Mais* presents at its operating mechanism with a traditional cost crop insurance. The Brazilian program is also linked to the coverage of *Pronaf* credit line, designed specifically for smallholders.

Using eq. (1), it is added the term *C*, which represents the coverage or indemnity[4] granted by a crop insurance, obtaining new gross and net income equations:

$$Y_c = r(K + L) + C \tag{4}$$

$$I_c = r(K + L) + C - iL \tag{5}$$

Here, Y_c is the gross income and I_c the net income of a farmer when there is a crop insurance contract.

Similarly to the case of producers without agricultural insurance contracts, in case of coverage *C*, it is estimated the CV and then derivate in relation to the amount of agricultural credit.

$$\frac{\partial CV(I_c)}{\partial L} = \frac{\mathrm{iK}\sigma_r\sqrt{2(1+\rho)}}{[\mathrm{E}(I)]^2} \tag{6}$$

Eq. (6) shows that while the negative correlation coefficient ρ is lower than -0.5, the risk derived from the increase of credit when crop insurance is contracted will be inferior than the risk measured by the same indicator in the case of no insurance (eq.(3)).

Approach based on the von Neumann-Morgenstern utility function

Preferences for uncertain events can be expressed in terms of expected utility. It is assumed that there are only two possible states in nature, S = 1 and 2, and I_1 and I_2 are the amounts of contingent commodities in the states 1 and 2 respectively. Considering I_1 and I_2 have probabilities π_1 and π_2 respectively, itis obtained the von Neumann-Morgenstern utility function (SILBERBERG and SUEN 2000):

$$U(I_1, I_2; \pi_1, \pi_2) = \pi_1 u(I_1) + \pi_2 u(I_2) \tag{7}$$

[4] Coverage or indemnity is defined as the difference between the indemnified amount and the insurance premium paid by farmers.

The eq.(7) can be rewritten as follows:

$$\bar{u}^0 = \pi_1 u[r(K+L) - iL - P] + \pi_2 u[(r(K+L) - iL)] \tag{8}$$

Where $\bar{u}^0$ is the expected utility in the case where there is no hiring of crop insurance, K is the equity of the producer, L is the debt or rural credit, r is the rate of return on investment, i is the interest rate of L, and P is the loss of the farmer.

For the case of contracting crop insurance, the VN-M utility function should present itself as follows:

$$\bar{u} = \pi_1 u[r(K+L) - iL - P - \delta z + z] + \pi_2 u[r(K+L) - iL - \delta z] \tag{9}$$

Having $\bar{u}$ as the VN-M utility function in the presence of crop insurance, z is the contracted amount of insurance, δ is the insurance premium rate, and, δz is the insurance premium.

According to eq. (8) and (9), through the acquisition of a crop insurance contract, the producer will reach a different level of utility, reducing the damage when there is a loss in production for reasons included in the insurance policy. Table 1 shows the situation of the individual with and without insurance in both states of nature.

Based on the VN-M utility function, Cai (2015) demonstrated and compared mathematically the agricultural credit value that maximizes the utility of the individual with and without the presence of crop insurance. Specifically, this author compared the initial consumption (C_1) with the expectation of future consumption (C_2) that was measured by the VN-M function. Cai (2015) used a return on investment function $F(\cdot)$ and three variables (C_1, family savings - S, and agricultural credit - L) to set up the optimization model of two periods with and without the hiring of crop insurance.

By solving the maximization problem, Cai (2015) found that the optimum level of agricultural credit with insurance was higher than the level without insurance. This positive impact of insurance provision in the agricultural credit may mean that farmers who hired the insurance could demand for larger amounts of money from the financial institutions. It is understood that such action is taken to support the current growing of the farmer, or at least keep similar investments in production, which is a consequence of having a risk management tool that minimized the losses caused by crop failure.

Methodology

The impact evaluation methodologies applied in this study were chosen considering that the information used was not raised specifically to carry out the study of impact evaluation of *Proagro Mais*. Therefore, there was no possibility to select a random sample, so that we estimated the counterfactual groups using statistical methods of matching. Thus, the analysis were restricted to the following quasi-experimental techniques: Difference in Difference (DID) with Propensity Score Matching (PSM) using longitudinal data and repeated cross-section data.

Conditional DID using panel data

The method of the difference of differences combined with PSM (MMDID[5]), known as nonparametric conditional difference-in-difference estimator (HECKMAN et al., 1997) was proposed by James Heckman, Hidehiko Ichimura, Jeffrey Smith and Petra Todd in the working paper submitted in 1994, and published in 1998 (Heckman et al., 1998). According Heckman et al. (1997), the MMDID method, different from the traditional DID, defines conditional results to the covariate vector **x,** and uses nonparametric methods to build the differences. According to Blundell and Costa Dias (2000) and to Heckman et al. (1997), the MMDID method can be used both with panel data and cross-sectional data (repeated cross-section).

The estimator of the Average Treatment Effect on the Treated (ATET) using the MMDID model with panel data ($MMDID_{LD}$[6]), is defined according to the following expression (KHANDKER et al., 2010; BLUNDELL and COSTA DIAS, 2000):

$$\hat{\alpha}_{MMDID}^{LD} = \frac{1}{N^T}\sum_{i \epsilon T}\left[\left({Y_{it_1}}^T - {Y_{it_0}}^T\right) - \sum_{j \epsilon C(i)} w_{ij}\left({Y_{jt_1}}^C - {Y_{jt_0}}^C\right)\right] \qquad (10)$$

Where w_{ij} is the weight of the matching between *i* and *j* and can be calculated by an kernel estimator, or using a Nearest Neighbor Matching one to one (NNM 1-1) estimator, as seen in Bravo-Ureta et al. (2010) and Rodriguez et al. (2007).

[5] Method of matching with difference-in-difference.
[6] The suffix LD means "longitudinal data".

Conditional DID using repeated cross-section data

The MMDID method can be implemented since there is a representative sample of panel data. When there is insufficient panel information or when only there is cross-section information, one should implemented the MMDID using three PSM, one to create the control group in the endline, and two to create the treatment and control groups in the baseline (AERTS and SCHMIDT, 2008; BLUNDELL and COSTA DIAS, 2000). Figure 1 graphically displays the estimation mechanism of MMDID using repeated cross-section data ($MMDID_{RCS}$).

In Figure 1, the letters A, B and C represent the three PSM required in the model. For each individual treated *i* in the period t_1, the "twin" individual *h* should be found in the same period t_1 (PSM_A). The second step consists in finding the base year groups: for every individual treated *i* and untreated *h* during the period t_1, "twins" individuals are found *k* and *j* respectively in the period t_0 (PSM_B e PSM_C). The matching method used in the estimation of the three PSM is the NNM 1-1 without replacement.

The estimator of the ATET using the $MMDID_{RCS}$, is defined according to the following expression (BLUNDELL and COSTA DIAS, 2000):

$$\hat{\alpha}_{MMDID}^{RCS} = \frac{1}{N^T} \sum_{i \epsilon T_1} \left[\left(Y_{it_1} - \sum_{k \epsilon \mathrm{T}_0} w^T{}_{ikt_0} Y_{kt_0} \right) - \left(\sum_{h \epsilon \mathrm{C}_1} w^C{}_{iht_1} Y_{ht_1} - \sum_{j \epsilon \mathrm{C}_0} w^C{}_{hjt_0} Y_{jt_0} \right) \right] \quad (11)$$

In this expression, T_0. T_1, C_1, C_1 represent the treatment and control groups before and after program implementation, w_{ik}, w_{ih}, and w_{hj}, are the weights of the three matchings performed (see Figure 1). Y_{it_1} is the variable result of the group treatment in period 1, Y_{kt_0} is the variable result of the treatment group in the period 0, $Y_{ht_1}$is the variable result of the control group in period 1, and, Y_{jt_0} is the variable result of the control group in period 0.

Data and Variables

The empirical analysis for this research focuses on the period 2003-2005. The choice of this period is based on two aspects: 1) 2003 is the year preceding the implementation of *Proagro Mais*, so it is an appropriate period to be considered as the baseline of the impact evaluation, and 2005 is the year after a significant drop of productivity of corn in Paraná State[7]. This latter situation is important due to the fact of *Proagro Mais* being an agricultural risk management tool, implying a noteworthy drop in production to enable the "trigger" that allows the payment of indemnity to farmers who suffered losses in crops for reasons that fall under the Program regulations.

Data

The main component of the set of this research's information is a microdata basis of rural credit borrowers, provided by the Federal Accounting Court of Brazil (TCU), corresponding to a sample of farmers who received credit to produce corn in the State of Paraná between 2003 and 2005. The database contains two types of producers: those who besides hiring agricultural credit, hired *Proagro Mais* as an agricultural risk management tool, and those who hired agricultural credit for corn but did not hire *Proagro Mais*.

Whereas the search period has the baseline 2003 and endline in 2005, the number of database observations used consisted of 94,189 individuals, 68,312 being in the control group (25,235, 14,279 and 28,798 in the years 2003, 2004 and 2005, respectively), and 25,877 in the treatment group (17,213 and 8,664 in 2004 and 2005, respectively).
To know if the number of the sample in the years 2004 and 2005 are statistically relevant in the context of *Proagro Mais*, we applied the sampling method of proportions and percentages (COCHRAN, 1965) shown in eq. (12), using as population the data from *Proagro* report (BACEN, 2015b).

$$n = \frac{n_0 + 1}{1 + \frac{\frac{t^2 pq}{d^2}}{N}} \tag{12}$$

Where: n is the sample size, N is the sample universe, t is the quantile value of parametric distribution "t", d is the sampling error, and p and q are fixed ratio of 50%.

[7] Between 2003 and 2005 there was an average drop of -40.43% in corn production in the state of Paraná.

Using a 95% confidence interval, the sampling error was 0.58% and 0.96% in 2004 and 2005 respectively, indicating that the sample used in the survey is statistically significant in relation to the population of producers who hired *Proagro Mais* for the period, the fields of corn in the State of Paraná.

The previously described microdata database contains the treatment variable "PROAGROM", which is a dummy that identifies with 1 the producers in the treatment group (those hired *Proagro Mais*) and 0 to the control group (those who did not). It also contains the outcome variable "CREDIT_HA" which is the credit value per hectare (BRL/ha), and the dummy variable "YEAR" which is 1 if the operation was in the impact year 2005 and 0 if the operation was in the base year 2003.

In this same database there are several covariates that were used to estimate the scores for the matching procedure: variable "AREA" is the size of the funded area (hectares), "EXP_PROD" which is the expected productivity (tons / ha) which is the average of the last five years of productivity of family farmers, "EDUC" that is educational level of the family farmers (years of study), and "ADITIONAL_ACT" which is a dummy variable that identifies with 1 the producers with at least one additional agricultural credit to the loan to produce corn.

Additionally, we incorporated other variables that complemented the aforementioned micro database, such as the climatological variables, average annual temperature (measured in degrees Celsius) named "TEMP" and annual precipitation (in millimeters) named "PRECIP", sourced fromthe agro-meteorological Monitoring System Agritempo (AGRITEMPO, 2015). It is noteworthy that the climatological information was grouped by micro-region[8].

On the other hand, using IBGE information published in SIDRA (2015), we added other variables related to agricultural production in the municipalities, such as the number of corn farms ("NUMBER_FARMS"), the rates: harvested area of corn / total area of temporary crops ("HARVESTED_AREA"), and corn yield (tons / ha) named "MUNIC_PROD". Finally, using information sourced from the Statistical Yearbook of Rural Credit (BACEN, 2015e), it was obtained the number of agricultural funding credit

[8] Micro-region is a geographical unit established by the Brazilian Institute of Geography and Statistics (IBGE), which is defined as the grouping of neighboring municipalities.

agreements in each municipality of Paraná State for each year under evaluation ("MUNIC_CRED").

Finally, , in addition to the resulted variable "CREDIT_HA", the treatment variable "PROAGROM" and the variable period "YEAR", there are ten covariates that we used to generate the scores to estimate each PSM in both the $MMDID_{LD}$ and $MMDID_{RCS}$.

Results

Following the methodology description, we present in this section the ATET results using three different models: $MMDID_{LD}$ with kernel matching, $MMDID_{LD}$ with NNM 1-1 and $MMDID_{RCS.}$

$MMDID_{LD}$ with kernel matching results

The first procedure in the $MMDID_{LD}$ is the formation of balanced panels before performing PSM using the kernel matching and NNM 1 -1. For this purpose, there were identified producers in the years 2003, 2004 and 2005 who contracted loans to corn production without *Proagro Mais* (control group), and the producers who were part of the sample in all three years, this is, hired credit for production of corn without *Proagro Mais* in 2003, and later hired credits with *Proagro Mais* in 2004 and 2005 (treatment group). Descriptive statistics of the treatment and control groups in the baseline and endline periods are presented in Table 2.

The first step in calculating the ATET from $MMDID_{LD}$ with kernel matching[9] is the generation of scores by the probit model, which results are presented in Table 3. According to these results, although there are two variables which *p* values do not reject the null hypothesis (H0 = 0), the probit model, as a whole, is statistically significant at the 1% level. This result indicates that the probabilities generated from the model can be used to perform the kernel matching. We emphasize that "NUMBER_FARMS" was not used in the PSM because this variable does not have data in baseline year[10].

[9] To calculate the $MMDID_{LD}$ with kernel matching was used the *diff* command of STATA, published by Villa (2012).
[10] The variable "NUMBER_FARMS" is only present in the Brazil Agricultural Census of 2006, therefore its use in this study was restricted to estimates scores in the endline period (2005), as this is the year closer to the Census data.

For the estimation of the matching with kernel procedure, we tested five different kernel functions[11]. The kernel function *uniform* presented the best fit in the model, so the results based on this function are published in this article. According to the model results, the common support area excluded 19 observations, of which 18 are from the control group and one from the treatment group, as seen in Figure 2. However, the common support area is a majority relative to the number of individuals in the sample (99.25%).

The ATET using $MMDID_{LD}$ with *uniform* kernel matching was -1.78; however, this coefficient is not statistically significant (Table 4). According to this result, there is no statistical evidence that *Proagro Mais* is a predominant policy in the risk management of smallholders. Additionally, the results of the balancing test (Table 5) shows that in most of the variables were reduction in bias between the means of treatment and control groups of matched samples with respect to unmatched ones. Only the variable "EDUC" has lower quality after the matching, but its *p* value is still significant at 10%.

$MMDID_{LD}$ with NNM 1-1 matching results

Comparable to $MMDID_{LD}$ with kernel matching, after generating the panels in the periods 2003 and 2005, it was calculated the PSM in the base year using a logit model to get the scores (Table 6). It should be noted that the sample used in this case is the same as analyzed in Table 2. The results show that the vector of probabilities or propensity score generated from logit model is statistically significant at a level of 1%, according to the χ^2 test.

Using the vector of probabilities generated with logit and applying the matching method NNM 1-1 without replacement, we obtain the counterfactual treatment group for 2003.

The ATET results of matching NNM 1-1 in 2003 are shown in Table 7, and the results of the balancing test, in which most of the variables had lower bias between the means of control and treatment groups after treatment, are shown in Table 8.

The next step was seek individuals generated with PSM in 2003 in 2004 and 2005, thus conforming the balanced panel that will serve as a basis for estimating ATET by eq.(13) (KHANDKER et al., 2010; ATHEY e IMBENS, 2006):

[11] Uniform, Biweight, Tricube, Gaussian and Epanechnikov.

$$Y_{it} = \alpha + \rho T_{it} + \gamma P_{it} + \beta T_{it} P_{it} + \varepsilon_{it} \quad i = 1, \ldots, n; \;\; t = 0, 1 \tag{13}$$

We considered that the outcome of interest Y_{it} is "CREDIT_HA", α is the constant or intersection of linear regression ("CONSTANT"), T_{it} is the isolated effect of *Proagro Mais* - "PROAGROM", P_{it} is the time variable dummy " YEAR " where 1 = 2005 as endline and 0 = 2003 as the baseline. Finally, $T_{it}P_{it}$ is the "ATET".

The results of the regression presented in Table 9 consider that, using as result variable "CREDIT_HA", there is a negative impact, but not statistically significant of *Proagro Mais* to corn producers in Paraná State during the evaluated period of 2003 to 2005. These results, although not confirming the deficiency of *Proagro Mais* against other agricultural risk management tools, validate the fact that this Program cannot be consolidated as an indispensable tool to Brazilian smallholders.

$MMDID_{RCS}$ results

Similarly to $MMDID_{LD}$, the $MMDID_{RCS}$ controls characteristics observed and unobserved invariant to time. Empirically, the advantage of this model in the context of this research is the significant increase in the sample.

As noted in the description of the model, in order to estimate ATET using $MMDID_{RCS}$ it is necessary to create statistically control groups in the endline (PSM_A), and treatment and control groups in the baseline (PSM_B and PSM_C, respectively).

For the PSM_A it was used the model that showed better results in the balancing test, and it excludes two variables: "PRECIP" and "MUNIC_PROD". Unlike the $MMDID_{LD}$ that only uses panel data, the $MMDID_{RCS}$ uses all observations in the sample, so to estimate the PSM_A, the number of observations in the treatment group and control in 2005 was 17,158 (8,579 in each group[12]) of which 410 were part of the treatment group panel data, and 825 were part of the control group panel data[13]. The results of the logit for the PSM_A, its ATET and its balancing test are shown in Table 10, Table 11, and Table 12 respectively.

[12] The difference between the number of producers of the PSM_A treatment group (8,579) and the total producers in the sample treatment group previously presented (8,664), follows that there is a micro-region of the State of Paraná without meteorological data, so when the scores were estimated, the records of that micro-regions were eliminated (85 observations).
[13] The period of time of both panels begins in 2003 and finish in 2005.

After generating the control group in the endline, we estimated the PSM_B, considering the 2005 treatment group and all observations from the baseline. It is noteworthy that individuals who were in the baseline and then hired *Proagro Mais* in 2004 and 2005, that is, the panel data, were removed from the sample, since they are their own peers.Table 13 shows the results of the logit model of PSM_B which binary dependent variable takes the value of 1 when the observation belongs to the group that hired *Proagro Mais* on endline period, and 0 when the observation belongs to an observation in the baseline (*Proagro Mais* was implemented in 2004, so had not data in 2003).

According to Table 13, the logit model is significant at 1% significance level. Note also that the covariates vector only includes the variables "AREA" and "EDUC"; this is due to the fact that "EXP_PROD", "MUNIC_PROD", "MUNIC_CRED" and "HARVESTED_AREA" may change in the same municipality or micro-region between the baseline and the endline depending on weather or market conditions, which could negatively influence the matching. Furthermore, the variable "ADITIONAL_ACT" was excluded because its inclusion deteriorates the quality of the matching. After the scores were estimated with the logit model, we found the matched observations of the treatment group in 2003 using the estimated NNM 1-1 without replacement. The results of ATET and balancing test are shown in Table 14 and Table 15.

After being removed from the baseline the matched sample in PSM_B and the individuals that conform the panel data (both the treatment and control group), we estimated the last PSM (PSM_C) using the 2003 producers sample and the 2005 control group estimated in PSM_A (without the panel data of that year). In this case, the dependent variable of the logit assumes the value of 1 when the observation belongs to the group that did not contract *Proagro Mais* in 2005, and the value of 0 when the observation belongs to a smallholder in the baseline. After that, the matched observations in the control group were found by the method NNM 1-1 without replacement, such as occurred in the PSM_A and PSM_B. The results of the logit, ATET and balancing test are shown in Table 16, Table 17, Table 18 respectively.

With the estimation of the three PSM described above, we obtained treatment and control pseudo-panels generated probabilistically. We added the panel data to these pseudo-panels, resulting in the final database $MMDID_{RCS}$ used in the current research.

The number of information by group in each period is 8,579, totaling 34,316 observations. As in the case of the $MMDID_{LD}$, after the pseudo-panels have been formed, we use the equation $Y_{it} = \alpha + \rho T_{it} + \gamma P_{it} + \beta T_{it} P_{it} + \varepsilon_{it}$ (eq. (13)) for estimating the ATET (Table 19).

The results of the regression show an ATET negative and statistically significant (1%). Thus, it is highlighted once again that given the sample used, the *Proagro Mais* cannot be consolidated as an indispensable tool in the Brazilian agribusiness risk management, since the statistical evidence suggests the existence of other factors that should contribute to the minimization of agricultural risk in the control group.

The survey results of all models proposed differ from the hypothesis in the introductory chapter, as well as the economics foundations. However, these results should be considered as an opening door toa relevant discussion about the validity and efficiency of public risk management tools existing in Brazil.

Discussion

The results of the econometric models proposed indicated that, a sample of corn producers in the State of Paraná that are part of *Pronaf* and hired *Proagro Mais* as a risk management tool in the period 2003 - 2005, on average, received not greater amounts of agricultural credit to the sample of farmers who did not contract such crop insurance mechanism. This result rejects the null hypothesis in the introductory chapter, but also opens the discussion on the reasons why the producers with no visible protection of their crops after a period of two years of crop failure, can maintain higher levels of farm debt to fund next year's crop. Given this reality, the discussion starts on the possible reasons that were behind the phenomenon derived from the research results.

Whereas in the analyzed period there was a drop in corn production in the State of Paraná, firstly it was analyzed the instruments that can cope with the loss of agricultural production. In this sense, for the region and crop analyzed there are two other tools despite *Proagro Mais*: securitization mechanisms or renegotiation of rural debts and private insurance, with or without subsidy from the Federal Government (PSR). Thus, the insurance market in Brazil is analyzed at first.

The use of private insurance by the corn producers in the given period may be considered a valid option in risk management, considering that in accordance to SUSEP (2015), between January 2004 and December 2005 a total premium of 12.55 BRL million (5.36 USD million) was paid in the State of Paraná to the products associated to crop insurance. This amount was distributed in three insurers: Alliance Insurance Company of Brazil with 63.03% (3.37 USD million), Mapfre Insurance with 34.19% (1.83 USD million) and Zurich Brazil with 2.78% (0.149 USD million). Although the premium amounts for crop insurance in the State of Paraná present a significant magnitude, it is emphasized that before 2005 there was no support from the PSR program, so the farmers who wanted to use crop insurance to protect their production had to pay 100% of the premiums. Moreover, according to official information from PSR (2015), the Federal Government did not subsidize corn in Paraná in the first year of operation of the program (2005). Thus, considering that there was no subvention of private insurance in the period under review, and, the sample used in the case study is restricted to farmers with *Pronaf* credit, it is unlikely that a large portion of the producers of corn that did not hire *Proagro Mais* during the evaluated period, hired a private crop insurance with high costs.

The second mechanism that could replace the benefits of hiring the *Proagro Mais* in low productivity periods is the securitization or renegotiation of debts. The analysis of the renegotiation of rural debt in the context of this research is linked to the outcome variable, which is the credit per hectare of corn smallholders who contracted *Pronaf*. In this sense, according to Távora (2014) there are three laws that represent this policy in the analyzed between 2003 and 2005: Law No. 10,696 of July 2, 2003, Law No. 10,823 of December 22, 2003, and Law No. 11,011 of December 20, 2004. The first one lengthened the period of payment to ten years, with two-year grace period, and rebate of 8.8% on the outstanding balance. The second one extended the deadline for the renegotiation of debts until May 31, 2004. Later, according to Law No. 11,011 of December 20, 2004, the risk of loans granted with resources from the Constitutional Fund Financing to *Pronaf* beneficiaries from July 1, 2004, should have been fully taken by its respective Constitutional Fund.

In any agricultural market, the smallholders are exposed to several factors that can affect the performance of their production. Those factors force the smallholders to take appropriate management actions, depending on which type of risk is negatively affecting their economic performance. In this article, *Proagro Mais* was evaluated as a natural disaster crop insurance; however, there could be exist be other risks as price production fluctuation that should have interfered with the results. This statement is the starting point to discuss the feasibility of *Proagro Mais* as an ideal tool in the management of agricultural risk in Brazil because, since it covers only losses in production, there may be a percentage of considerable smallholders that while hiring the mentioned mechanism could not rely on it when the nature of the loss comes from the market price.

Considering the historical trend of the average spot price for the bag of 60 kilos of corn in the State of Paraná (Figure 3), there was a fall of 32.95% in the average price between December 2003 and December 2005. Thus, there is a possibility that the crops of smallholders of the geographical areas in question have been affected not only by changes in production, but also by changes in the price per product.

If the main factor in the production fall had been the decline in the price of corn in the period, smallholders could have used other tools for the management of agricultural risk that minimizes market risk, as the marketing support mechanisms CAAF, CGCAF, CAEAF, or maybe informal mechanisms such as the diversification of economic activities. In this case, if within the sample used in the survey there are smallholders who have not hired *Proagro Mais* and were affected by price risk, they could have overcome the fall period without incurring bigger losses and credit default using these other cited mechanisms. Thus, the results obtained in the previous chapter would be consistent with this reality.

Concluding Remarks

This research provided an overview of the importance of Proagro Mais as an agricultural policy of risk management. From a micro data bank and using different methodologies quasi-experimental of impact evaluation, we verified that our sample of smallholders who hired *Proagro Mais*, in general, had no significant impact on the amount of agricultural credit per hectare , if compared to the sample of smallholder who did not opt to employ this tool.

This document is a pioneer in the academic literature not only to conduct the impact evaluation of a program related to crop insurance market in Brazil, but also to formally evaluate the *Proagro Mais* as a risk management tool. As for the econometric models used, there was a significant effort to show the results in different ways, using regressions with panel or repeated cross-section data.

It is noteworthy that considering the use of secondary data, there was no possibility of creating variables and / or collect directly the research information. This fact limited our possibilities of knowing exactly the choice of smallholders for the various instruments of rural management. However, the econometric estimates were clear in rejecting the null hypothesis and confirming that, in the specific case of the sample worked, the existence of *Proagro Mais* is not a key factor in managing the risk of production of corn crops in Paraná between 2003 and 2005. Finally, this research' results can be considered an opening door to a broad discussion of public policy with the purpose of identifying the practical impact of the agricultural risk management tools in Brazil.

Table 1 – Situation of an individual with and without insurance in the states of nature

Situation	Income	State
Without insurance	$r(K+L)-iL$	1
	$r(K+L)-iL-P$	2
With insurnce	$r(K+L)-iL-\delta z$	1
	$r(K+L)-iL-P-\delta z+z$	2

Source: Rees e Wanbach (2008); Silberberg e Suen (2000); Goodwin e Smith (1995)

Table 2 – Mean and standard deviation of "CREDIT_HA" in treatment and control groups used in $MMDID_{LD}$

Group	Year	Mean (BRL)	Standard Dev. (BRL)	Number
Treatment	2003	60.85	30.04	410
Control	2003	67.37	25.32	2,135
Treatment	2005	78.35	29.36	410
Control	2005	80.52	33.77	2,135

Note: According to BACEN (2016), the average exchange rates (USD/BRL) for 2003, 2004 and 2005 were 3.0783, 2.5259 and 2.4352 respectively.

Table 3 – Results of *probit* model, $MMDID_{LD}$ with kernel

Variables	Coefficient	Standard Error	Z value
AREA	0.006	0.003	2.27**
EXP_PROD	-0.22	0.05	-4.52***
EDUC	0.009	0.012	0.79
ADITIONAL_ACT	0.13	0.128	1.03
TEMP	-0.48	0.04	-12.53***
PRECIP	-0.22	0.09	-2.48**
MUNIC_PROD	-0.14	0.04	-3.44***
MUNIC _CRED	-0.0001	0.00003	-3.00***
HARVESTED_AREA	-1.66	0.22	-7.49***
CONSTANT	11.58	0.82	14.10***

Treatment variable: "PROAGROM"
Number of observations: 2,545
χ^2= 466.52
$p > \chi^2$ = 0.0000
Pseudo R^2 = 0.2076

*, p<0.10; **, p<0.05; ***, p<0.01

Table 4 – ATET of $MMDID_{LD}$ using kernel matching (BRL)

Year	Treatment Group	Control Group	*t* value
2003	60.82	68.71	-5.42***
2005	78.35	88.02	-6.64***

ATET = -1.78
Result variable: "CREDIT_HA"

*, p<0.10; **, p<0.05; ***, p<0.01

Note: According to BACEN (2016), the average exchange rates (USD/BRL) for 2003, 2004 and 2005 were 3.0783, 2.5259 and 2.4352 respectively.

Table 5 – *Balancing test* of kernel matching, $MMDID_{LD}$

Variable	Sample type	Mean		% bias	% reduct bias	*t* Test	
		Treatment	Control			*t* value	*p* > t
AREA	Unmatched	46.73	44.03	10.4	56.2	1.82	0.069
	Matched	46.80	46.61	4.5		0.64	0.522
EXP_PROD	Unmatched	1.987	2.00	-1.2	81.9	-0.20	0.844
	Matched	1.989	1.99	-0.2		-0.03	0.974
EDUC	Unmatched	7.004	6.99	0.4	-666	0.08	0.939
	Matched	7.007	6.92	3.2		0.47	0.636
ADITIONAL_ACT	Unmatched	0.082	0.05	12.7	27.6	2.56	0.011
	Matched	0.083	0.10	-9.2		-1.12	0.262
TEMP	Unmatched	20.09	21.17	-105	94.3	-21.14	0.000
	Matched	20.08	20.14	-6.0		-0.77	0.439
PRECIP	Unmatched	3.669	3.97	-69.7	96.0	-13.38	0.000
	Matched	3.668	3.68	-2.8		-0.38	0.700
MUNIC_PROD	Unmatched	5.08	4.52	49.6	75.0	9.90	0.000
	Matched	5.08	5.23	-12.4		-1.61	0.108
MUNIC_CRED	Unmatched	1,472.1	1,229.1	25.6	94.0	5.09	0.000
	Matched	1,473.2	1,458.6	1.5		0.20	0.839
HARVESTED_AREA	Unmatched	0.4327	0.60	-79.1	90.4	-13.97	0.000
	Matched	0.4326	0.41	7.6		1.13	0.258

Table 6 – Results of *logit* model, $MMDID_{LD}$ with NNM 1-1

Variables	Coefficient	Standard Error	Z value
AREA	0.01	0.005	2.11**
EXP_PROD	-0.40	0.09	-4.34***
EDUC	0.03	0.02	1.14
ADITIONAL_ACT	0.17	0.23	0.74
TEMP	-0.86	0.70	-12.18***
PRECIP	-0.35	0.16	-2.18**
MUNIC_PROD	-0.32	0.07	-4.29***
MUNIC_CRED	-0.0001	0.00007	-2.73***
HARVESTED_AREA	-3.19	0.41	-7.83***
CONSTANT	21.13	1.49	14.16***

Treatment variable: “PROAGROM”
Number of observations: 2,545
χ^2= 467.19
$p > \chi^2$ = 0.0000
Pseudo R^2 = 0.2079

*, p<0.10; **, p<0.05; ***, p<0.01

Table 7 – ATET of NNM 1-1, $MMDID_{LD}$. Year 2003 (BRL)

Sample	Treatment Group	Control Group	Difference	Standard Error	*t* value
Unmatched	60.85	67.37	-6.52	1.40	-4.63***
ATET	60.85	68.58	-7.73	2.41	-3.21***
Result variable: "CREDIT_HA"					

*, *p*<0.10*;* **, *p*<0.05*;* ***, *p*<0.01

Note: According to BACEN (2016), the average exchange rates (USD/BRL) for 2003, 2004 and 2005 were 3.0783, 2.5259 and 2.4352 respectively.

Table 8 – *Balancing test* of NNM 1-1, $MMDID_{LD}$

Variable	Sample type	Mean		% bias	% reduct bias	*t* Test	
		Treatment	Control			*t* value	*p* > t
AREA	Unmatched	46.73	44.06	10.3	10.6	1.80	0.073
	Matched	46.73	49.12	-9.2		-1.11	0.266
EXP_PROD	Unmatched	1.99	2.00	-1.4	-815.4	-0.24	0.814
	Matched	1.99	2.17	-12.9		-1.80	0.073
EDUC	Unmatched	7.00	6.99	0.4	-211.4	0.07	0.941
	Matched	7.00	7.04	-1.3		-0.18	0.857
ADITIONAL_ACT	Unmatched	0.08	0.05	12.6	14.6	2.52	0.012
	Matched	0.08	0.11	-10.7		-1.30	0.193
TEMP	Unmatched	20.09	21.17	-105	95.6	-21.14	0.000
	Matched	20.09	20.14	-4.6		-0.60	0.552
PRECIP	Unmatched	3.67	3.97	-69.7	99.3	-13.38	0.000
	Matched	3.67	3.68	-0.5		-0.07	0.942
MUNIC_PROD	Unmatched	5.08	4.52	49.2	63.5	9.81	0.000
	Matched	5.08	5.29	-18.0		-2.30	0.022
MUNIC_CRED	Unmatched	1,472.1	1,233.7	25.1	92.7	4.99	0.000
	Matched	1,472.1	1,454.7	1.8		0.23	0.815
HARVESTED_AREA	Unmatched	0.43	0.61	-79.4	85.5	-14.00	0.000
	Matched	0.43	0.41	11.5		1.74	0.083

Table 9 – ATET of $MMDID_{LD}$ with NNM 1-1 (BRL)

Variable	Coefficient	Stantard Error	*t* value
CONSTANT	68.59	1.88	36.42***
PROAGROM	-7.74	2.66	-2.90***
YEAR	21.48	2.66	8.06***
ATET	-3.98	3.77	-1.06
N = 1,640	*p* > F = 0.000	Ajusted R^2 = 0.0745	

*, *p*<0.10*;* **, *p*<0.05*;* ***, *p*<0.01

Note: According to BACEN (2016), the average exchange rates (USD/BRL) for 2003, 2004 and 2005 were 3.0783, 2.5259 and 2.4352 respectively.

Table 10 – Results of *logit* model - PSM_A, $MMDID_{RCS}$

Variables	Coefficient	Standard Error	Z value
AREA	0,005	0,001	3,17***
EXP_PROD	-0,41	0,03	-16,36***
EDUC	-0,04	0,004	-8,40***
ADITIONAL_ACT	-0,70	0,06	-12,54***
TEMP	-0,14	0,01	-11,22***
NUMBER_FARMS	-0,0004	0,00002	-17,05***
MUNIC_CRED	0.0004	0,00002	28,55***
HARVESTED_AREA	0,98	0,08	13,04***
CONSTANT	2,02	0,27	7,53***

Treatment variable: "PROAGROM"
Number of observations: 36,992
χ^2= 3,156.41
$p > \chi^2$ = 0.0000
Pseudo R^2 = 0.0788

*, p<0.10; **, p<0.05; ***, p<0.01

Table 11 – ATET of PSM_A, $MMDID_{RCS}$ (BRL)

Sample	Treatment Group	Control Group	Difference	Standard Error	*t* value
Unmatched	74.35	83.77	-9.42	0.55	-17.00***
ATET	74.35	76.78	-2.43	0.44	-5.44***

Result variable: "CREDIT_HA"

*, p<0.10; **, p<0.05; ***, p<0.01

Note: According to BACEN (2016), the average exchange rates (USD/BRL) for 2003, 2004 and 2005 were 3.0783, 2.5259 and 2.4352 respectively.

Table 12 – *Balancing test* of PSM_A

Individual Test							
Variable	Sample type	Mean		% bias	% reduct bias	*t* Test	
		Treatment	Control			*t* value	*p* > t
AREA	Unmatched	40.75	52.09	-42.5	98.9	-30.27	0.000
	Matched	40.75	40.3	1.7		0.45	0.651
EXP_PROD	Unmatched	1.93	2.80	-45.8	99.2	-31.47	0.000
	Matched	1.93	1.94	-0.3		-0.43	0.664
EDUC	Unmatched	7.20	7.75	-17.5	91.0	-13.62	0.000
	Matched	7.20	7.25	-1.6		-1.11	0.269
ADITIONAL_ACT	Unmatched	0.049	0.10	-20.8	88.8	-15.58	0.000
	Matched	0.049	0.05	-2.3		-1.81	0.070
TEMP	Unmatched	19.98	20.32	-29.5	89.4	-23.20	0.000
	Matched	19.98	20.02	-3.1		-2.23	0.026
NUMBER FARMS	Unmatched	1,060.6	1.020.1	5.1	80.8	4.46	0.000
	Matched	1,060.6	1.068.4	-1.0		-0.61	0.539

MUNIC_CRED	Unmatched	1,805.3	1.442.5	29.8	93.8	26.58	0.000
	Matched	1,805.3	1783	1.8		1.10	0.273
HARVESTED_AREA	Unmatched	0.37	0.35	10.7	74.7	8.94	0.000
	Matched	0.37	0.37	2.7		1.72	0.085

Model test

Sample	χ^2	$p > \chi^2$	Mean bias
Unmatched	3,149.93	0.000	25.2
Matched	18.11	0.020	1.7

Table 13 – Results of *logit* model - PSM_B, $MMDID_{RCS}$

Variables	Coefficient	Standard Error	Z value
AREA	-0,01	0,0006	-18,65***
EDUC	0,018	0,004	4,25***
CONSTANT	-0,74	0,040	-17,97***

Dependent variable: "PSM"
Number of observations: 32,169
χ^2 = 438.70
$p > \chi^2$ = 0.0000
Pseudo R^2 = 0.012

*, p<0.10; **, p<0.05; ***, p<0.01

Table 14 – ATET of PSM_B, $MMDID_{RCS}$ (BRL)

Sample	Treatment Group	Control Group	Difference	Standard Error	*t* value
Unmatched	74.15	66.67	7.48	0.42	17.87***
ATET	74.15	67.61	6.54	0.57	11.46***

Treatment variable: "CREDIT_HA"
Number of observations in endline: 8,169
Number of observations in baseline: 24,000

*, p<0.10; **, p<0.05; ***, p<0.01

Note: According to BACEN (2016), the average exchange rates (USD/BRL) for 2003, 2004 and 2005 were 3.0783, 2.5259 and 2.4352 respectively.

Table 15 – *Balancing test* of PSM_B, $MMDID_{RCS}$

Individual test							
Variable	Sample type	Mean		% bias	% reduct bias	*t* Test	
		Treatment	Control			*t* value	*p* > t
AREA	Unmatched	40.49	47.63	-27.2	99.8	-18.79	0.000
	Matched	40.49	40.50	-0.0		-0.05	0.963
EDUC	Unmatched	7.21	7.11	3.5	-81.9	2.77	0.006
	Matched	7.21	7.39	-6.3		-3.81	0.000

Model test			
Sample	χ^2	$p > \chi^2$	Mean Bias
Unmatched	454.56	0.000	15.3
Matched	14.57	0.001	3.2

Table 16 – Results of *logit* model- PSM_C, $MMDID_{RCS}$

Variables	Coefficient	Standard Error	Z value
AREA	-0.01	0.0006	-22.85***
EDUC	0.05	0.005	10.87***
CONSTANT	-0.47	0.044	-10.50***

Dependent variable: "PSM"
Number of observations: 23,585
$\chi^2 = 765.09$
$p > \chi^2 = 0.0000$
Pseudo $R^2 = 0.0256$

*, *p*<0.10; **, *p*<0.05; ***, *p*<0.01

Table 17 – ATET of PSMc, $MMDID_{RCS}$ (BRL)

Sample	Treatment Group	Control Group	Difference	Standard Error	*t* value
Unmatched	76.92	66.17	10.74	0.43	25.16***
ATET	76.92	66.88	10.03	0.57	17.66***

Result variable: "CREDIT_HA"
Number of observations of endline: 7.754
Number of observations of baseline: 15.831

*, *p*<0.10; **, *p*<0.05; ***, *p*<0.01

Note: According to BACEN (2016), the average exchange rates (USD/BRL) for 2003, 2004 and 2005 were 3.0783, 2.5259 and 2.4352 respectively.

Table 18 – *Balancing test* of PSM_C, $MMDID_{RCS}$

Individual test

Variable	Sample type	Mean		% bias	% reduct bias	*t* Test	
		Treatment	Control			*t* value	*p* > t
AREA	Unmatched	40.77	51.31	-35.5	89.6	-23.2	0.000
	Matched	40.77	39.68	3.7		3.59	0.000
EDUC	Unmatched	7.31	6.96	12.3	83.85	9.08	0.000
	Matched	7.31	7.38	-2.2		-1.26	0.206

Model test

Sample	χ^2	$p > \chi^2$	Mean bias
Unmatched	783.89	0.000	23.9
Matched	15.39	0.000	2.9

Table 19 – ATET of $MMDID_{RCS}$ (BRL)

Variable	Coefficient	Standard Error	*t* Value
CONSTANT	66.50	0.38	175,19***
PROAGROM	0.19	0.54	1,46
YEAR	10.07	0.54	19,14***
ATET	-2.59	0.76	-4,23***
N = 34,316	$p > F = 0.000$		Ajusted $R^2 = 0.0160$

*, $p<0.10$; **, $p<0.05$; ***, $p<0.01$

Note: According to BACEN (2016), the average exchange rates (USD/BRL) for 2003, 2004 and 2005 were 3.0783, 2.5259 and 2.4352 respectively.

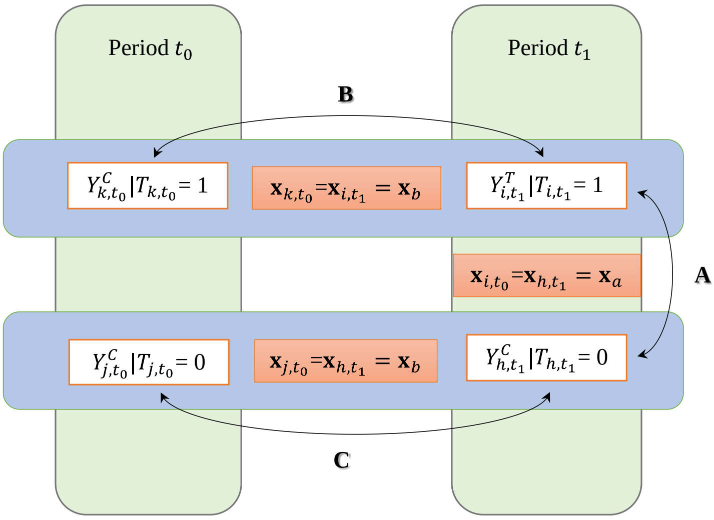

Figure 1 – Conditional DID using repeated cross-section
Based on Aerts e Schimidt (2008)

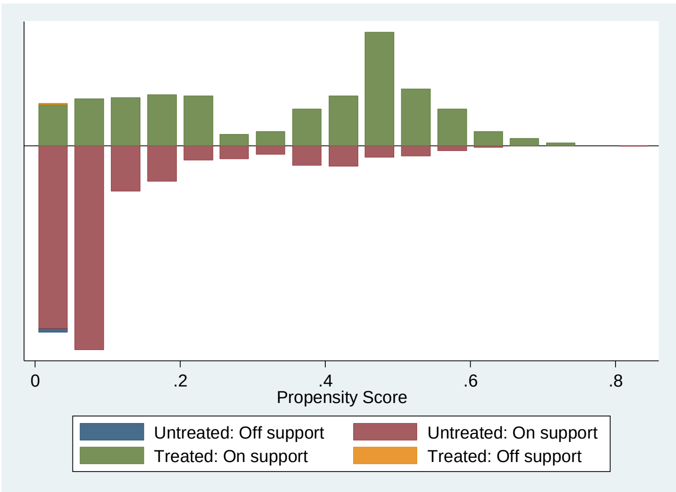

Figure 2 – Common support area in MMDID_{LD} with kernel matching

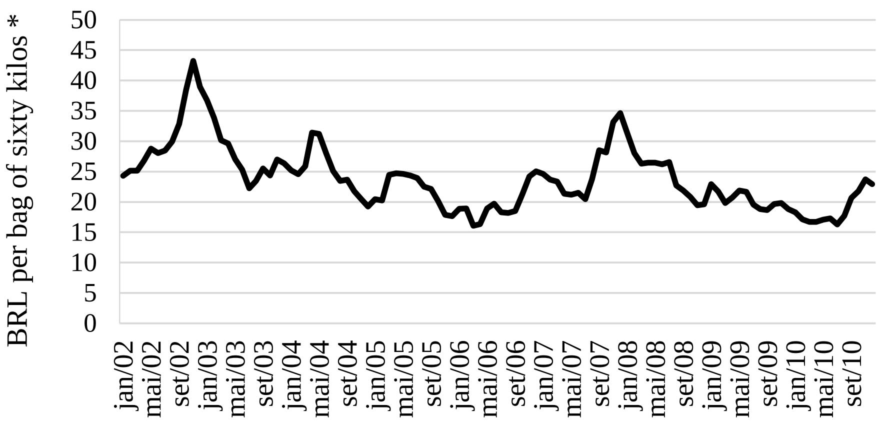

Figure 3 –. Corn prices in State of Paraná. Period: 2002-2010
Source: CEPEA (2016)
Note: * Real values for December 2010 using IGP-DI price index (IPEADATA, 2015).

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