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**IMPACT OF THE BRAZILIAN LOW-CARBON AGRICULTURE PROGRAM ON
RECOVERY OF DEGRADED PASTURES AND MILK PRODUCTION**

Dissertação apresentada à Universidade Federal de Viçosa como parte das exigências do Programa de Pós-Graduação em Economia Aplicada, para a obtenção do título de *Magister Scientiae*.

Orientador: Marcelo José Braga

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RESUMO

PINTO, Bruno Chaves Morone, M.Sc., Universidade Federal de Viçosa, março de 2020. **Impact of the Brazilian Low-Carbon Agriculture Program on recovery of degraded pastures and milk production.** Orientador: Marcelo José Braga. Coorientadores: Dênis Antônio da Cunha e Aléssio Tony Cavalcanti de Almeida.

Este trabalho buscou analisar o efeito do subprograma de recuperação de pastagens degradadas do Programa ABC sobre a produção de leite e a taxa de lotação animal dos municípios tratados. A taxa de lotação é utilizada como proxy para pastagens degradadas, haja vista que existe uma correlação negativa entre lotação animal e qualidade das pastagens (DIAS-FILHO, 2011). Além disso, buscou-se verificar a distribuição de recursos desse subprograma, da produção de leite e da taxa de lotação animal no território brasileiro. A hipótese do trabalho é que o crédito para a recuperação de pastagens teve um efeito positivo na produção de leite dos municípios, bem como elevou a taxa de lotação animal. Dado que há disponibilidade de dados antes e depois da política, foi-se utilizado o método de diferenças-em-diferenças, conjuntamente com o pareamento por Entropia. A ideia é parrear municípios tratados com os municípios de controle que apresentavam características parecidas (produção de leite, taxa de lotação animal, características socioeconômicas e características climáticas) antes do início do Programa. Ademais, a fim de analisar se o efeito variou entre os municípios em diferentes distribuições de lotação animal e produção de leite, fora utilizado a Regressão Quantílica, analisando os quantis 25, 50 e 75. Os dados de produção leiteira e taxa de lotação animal foram extraídos da Produção Agrícola Municipal (PAM – IBGE), os controles socioeconômicos e climáticos foram extraídos do IBGE (2018) e Xavier, King and Scanlon (2017), respectivamente. Dados sobre o crédito ABC e outros créditos recebidos pelos municípios foram disponibilizados pela SICOR (2019). Os resultados mostraram que os recursos do Programa ABC foram concentrados nos municípios da região centro-oeste e da região do Matopiba. Além disso, os resultados forneceram evidências de que o crédito para recuperação de pastagens degradadas do Programa ABC elevou a produção de leite dos municípios tratados. Os resultados foram positivos mesmo após a inclusão das variáveis climáticas e econômicas. Entretanto, não foi observado efeitos maiores em municípios que receberam crédito do Programa ABC em mais de

um período, quando comparados com municípios que receberam ao menos um ano do benefício. Ademais, os efeitos se mantiveram positivos e estatisticamente significativos em todos os percentis analisados, embora estatisticamente não tenha apresentado diferenças no efeito entre os percentis. Por outro lado, não foi possível concluir que houve efeito do crédito sobre a taxa de lotação animal dos municípios tratados. Os resultados mostraram que o efeito do Programa ABC sobre a taxa de lotação animal não foi estatisticamente significativo no primeiro ano de recebimento de crédito dos municípios tratados. Ainda, observou-se um efeito negativo do crédito sobre a taxa de lotação animal nos anos de ocorrência do segundo e terceiro recebimentos de crédito.

Palavras-chave: Programa ABC. Recuperação de pastagens degradadas. Produção de Leite. Taxa de lotação animal.

ABSTRACT

PINTO, Bruno Chaves Morone, M.Sc., Universidade Federal de Viçosa, March, 2020. **Impact of the Brazilian Low-Carbon Agriculture Program on recovery of degraded pastures and milk production.** Adviser: Marcelo José Braga. Co-advisers: Dênis Antônio da Cunha and Aléssio Tony Cavalcanti de Almeida.

This research aimed to analyze the effect of the ABC Program's recovery of degraded pastures subprogram on milk production and animal stocking rate in the treated municipalities. The animal stocking rate is utilized as a proxy for degraded pastures, as there is a positive relationship between animal stocking rate and pastures quality (DIAS-FILHO, 2011). In addition, this work aimed to verify the distribution of the funds of this subprogram, as well as the distribution of the milk production and animal stocking rate in the Brazilian territory. The hypothesis of this research is that the credit for recovering of degraded pasture had a positive effect on municipal milk production, as well as it elevated the animal stocking rate. Since there is availability of data in the pre and post-treatment periods, it was utilized the differences-in-differences method, in conjunction with Entropy Balancing. The idea is to match treated municipalities with the control municipalities that presented similar characteristics (milk production, animal stocking rate, socioeconomic variables and climatic characteristics) before the Program. Moreover, in order to analyze whether the effect varied between the municipalities in different distribution of animal stocking rate and milk production, it was utilized the Quantile Regression, using the 25th, 50th and 75th quantiles. The data of milk production and animal stocking rate are from da Produção Agrícola Municipal (PAM – IBGE), the socioeconomic and climatic controls were extracted from IBGE (2018) and Xavier, King and Scanlon (2017), respectively. Data of ABC credit and other types of credit were extracted from SICOR (2019). The results presented that the distribution of the funds of the ABC Program's recovery of degraded pasture subprogram concentrated in the Midwest and in Matopiba regions. Furthermore, the result provided signs that the credit of ABC Program's recovery of degraded pastures has increased the milk production of the treated municipalities. The results maintained positive even after the inclusion of the climate and economic variables. However, there is no evidence of the existence of larger effects in municipalities that receive credit in more than one year when compared to those which were treated by the program once. In

addition, the effects remained positive and statistically significant at 25th, 50th and 75th percentiles, even though was not observed differences in the effect between the percentiles. On the other hand, it was not possible to conclude whether there was effect of the credit on animal stocking rate in the treated municipalities. In fact, the results presented that the effect of the ABC Program on animal stocking rate was not statistically significant in the year of the first-time treatment. Further, it was observed a negative effect of the credit on animal stocking rate in the second and third-treatments periods.

Keywords: ABC Program. Recovery of degraded pastures. Milk production. Animal stocking rate.

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1 INTRODUCTION

1.1 Initial considerations

The subject of greenhouse gases (GHG) emissions has increasingly been discussed among countries, especially from the late twentieth century. The excessive emissions of GHG may lead to a climate change process resulting in increase in the average global temperature (SHINE et. al., 1990).

The climate change process proves to be a challenge to agriculture, since many current agricultural techniques harm the environment and are relevant sources of GHG emissions (GARNETT et. al, 2013). In Brazil, the Amazon deforestation is one of the most important source of GHG emission, being responsible for more emissions than the burning of fossil fuels (MCTIC, 2016), which is widely seen as the main source in other countries. Generally, the deforestation in Brazil aims to increase the area of agricultural and livestock production. Moreover, the current agricultural practice itself has been a relevant source of GHG emission. In 2010, agriculture and land use, which include changes in land use and deforestation, account for 60% of Brazil's GHG emissions (MCTIC, 2016). Therefore, mitigation policies should be aimed at this sector, as there are efficient and economically viable agricultural techniques (CERRI et. al., 2009).

Recently, the discussion about the sustainable intensification of agriculture has been gaining relevance for the literature (TILMAN et. al, 2011; VERMEULEN, 2012; GARNETT et. al, 2013; CAMPBELL et. al, 2014). Such agricultural method aims to increase food production through existing production areas, in addition to reducing environmental degradation through sustainable practices. Thus, it aims both to reduce the pressure of agricultural production environment and to increase food production capacity for the future, since food security is one of the priorities on the global policy agenda (GARNETT et. al, 2013). Therefore, it is noticed that agricultural conservationist practices have positive effects on both environmental preservation and agricultural productivity.

In Brazil, it has been developed the *Plano de Agricultura de Baixo Carbono* (Plano ABC), which could be translated as Plan for the Low Carbon Agriculture. It is resulted from Brazil's voluntary commitment to reduce GHG emissions between 36.1% and 38.9% by 2020 (MAPA, 2012). The ABC plan aims to foster the adoption of GHG

mitigation policies by Brazilian farmers. The Plan consists of seven subprograms, six of them related to mitigation techniques, and one related to actions for climate change adaptation. The subprograms are recovery of degraded pasture; crop-livestock integration systems; no-tillage system; biological nitrogen fixation; planted forests, and treatment of animal waste. Based on the implementation of credit as an economic instrument for fostering sustainable agricultural techniques, the plan contains a credit line called ABC Program. With this, it aims to finance fixed and semi-fixed investments in the listed mitigation technologies (MAPA, 2012).

1.2 Subject and its importance

Based on the above, this work aims to answer the following questions: has the ABC Program's subsidized rural credit been successful in increasing the agricultural production of the treated municipalities? Moreover, what has been the impact of these credit resources on land productivity (animal stocking rate) in the treated Brazilian municipalities?

First of all, it is necessary to show the rural credit situation in Brazil. Assunção and Chein (2007) aimed to report the credit conditions for families living in rural Brazil. The authors concluded that, between 1991 and 2000, credit constraint was active for all Brazilian regions. Yet, for the same period, there was an increase in the amount of credit operations.

Therefore, according to the authors, that finding shows the rural households' need for credit was not correlated to formal credit supply. Rather, it was demonstrated a weak relationship between the credit constraint, and bank credit categories. Lastly, these authors showed two implications based on the results found: (i) there is plenty of room for improvement in credit constraint; (ii) it is not clear that current policies aimed at agricultural sector would be able to solve this problem. Thus, it can be concluded that offering credit does not necessarily reduce credit constraint, because more than the supply of these credit resources, the constraint reduction depends on individuals' access to credit.

On the other hand, it is important to note that some individual will take out a loan only if it generates increase in his income. There are some papers in the literature that aim to show whether credit has impact on agricultural production and farmers' incomes. Feder et al. (1990) aim to analyze the effect of rural credit on agricultural products

supply. For this, were used cross-section data from northeastern China. The results imply that the provisioned credit for the studied area might have been utilized for consumption and investment, because the credit elasticity of supply was low, in average 23.5%. That is, for one-yuan credit for liquidity, the gross production value would increase by 0.235-yuan. Based on the results, the authors highlighted that two factors must be analyzed in order to evaluate the impact of rural credit expansion: (i) Not all farmers, and sometimes only a minority, have operations limited by credit constraint; (ii) sometimes credit supplies can be diverted to consume, in such a way that the credit likely effect on production may be less than the expected when compared to the situation where the credit are productively used. In addition, Castro and Teixeira (2010) advocated that if the expenditure amount is not enough to afford the necessary amount of inputs, rural credit can support farmers in buying more inputs, and consequently, in raising agricultural production. Thus, the raise of rural credit supply can have a positive impact on agricultural production, by expanding the capacity of total expenditure of farmers.

As such, the present work aims to analyze the effect of a carbon-mitigation policy at the agricultural sector on the production and land productivity. For that, the credit provisioned by the ABC program for degraded pasture will be used as an instrument of analysis, since this subprogram financed about R\$3,027,492,568.81 between 2013 and 2017, equivalent to 22.83% of total ABC program credit for this period (SICOR, 2019).

Some authors have researched about the ABC Program, especially its distribution among the Brazilian regions. Leal (2016) aimed to respond which were the determinants factors of the distribution of the ABC Program funds among the Brazilian states, as well as the elements that caused some states to demand more funds than others, and which factors other than the value of production affected the regional demand for credit loan through ABC Program. The author made an exploratory analysis of the data, and calculated the Spearman correlation of the Program funds and other variables, between 2011 and 2014.

The results indicated that there was a strong correlation between the destination of ABC Program funds and soy production, corn production and cattle raising. Further, the author pointed out that the investments in low-carbon agriculture have been

directed to locations that have already been productive and well-developed in these production activities. Moreover, it was calculated a low correlation between ABC Program credit and degraded pastures. The author concluded that the amount of funds could have not been demanded by rural producers in locations that present higher potential of GHG emissions reduction, and consequently, have a higher need of technological improvements. According to Leal (2016), these aspects are results of the lack of divulgation and training among the farmers, as well as the low knowledge of the benefits bring by ABC Program credit. Furthermore, the author pointed out that the requirements to take out credit from ABC Program regarding the investment project, and the fact that the ABC Program is based on agricultural production system and not on specific agricultural activities, can make the propagation of the ABC Program credit harder. Finally, the author suggested that could be relevant to evaluate the causality between some variables that have presented a correlation to the amount of credit granted by ABC Program.

Gianetti (2017) analyzed the distribution of the funds of ABC Program credit on Brazil's territory. The objective was to verify whether the credit was properly disseminated, based on the original goals of ABC Plan. For that, the author analyzed the distribution of ABC Program contracts given the ABC subprograms, modalities, granted credit, area, agricultural aptitude, and agricultural pattern. In addition, it was calculated the correlation between ABC Program's subprograms and agricultural aptitude with some indicators, such as livestock production, vegetal production and degraded areas. It was used the Spearman Correlation to verify the relationship between the above-cited variables.

The results presented that subprograms of Recovery of Degraded Pasture Area, Direct Planting, Agriculture-Cattle-Forest Raising Integration, and Planted Forests concentrated more than 98% of the available funds. The main subprogram was Recovery of Degraded Pasture Area, which accounted for more than 50% of the ABC Program funds. Regarding the distribution on Brazil's territory, the results showed that the funds concentrated in the Southeast and Midwest regions. Furthermore, the funds concentrated in municipalities with high and medium agricultural aptitude, where the agricultural production was already developed and well-established. The author advocated that in regions with high agricultural aptitude the investments of ABC Program contributes less to environmental aspects than if they would allocated to

regions with low agricultural aptitude. Finally, it was noticed that the correlation of the ABC credit loans and cattle was greater than the correlation with degraded pastures. Plus, the greater the agricultural aptitude, the greater is the correlation between the ABC funds and temporary crops, as well as the correlation between ABC funds and local GDP.

In addition, it is expected that the credit aimed to recovering degraded pastures increases the agricultural production. According to Townsend, Costa and Pereira (2012), the degraded pasture recovery optimizes the use of the area, recovers chemical, physical and biological properties of soil, as well as makes the animal protein production viable. Moreover, the degraded pasture recovery process generates both environmental, economic and social benefits. Additionally, Dias-Filho (2011), analyzing the pastures in Midwestern and Northern Brazil, concluded that about 70 millions of hectares of pastures presented some kind of degradation. Therefore, the author advocated that the current meat and milk production of such regions could be increased without need for deforestation, through pasture recovery process.

Thus, the hypothesis of the research is that the ABC Program's pasture recovery subprogram has been able to fulfill its role as: (i) generates reduction of degraded pastures area in municipalities that have received the program funds; (ii) positively affects the milk production in such municipalities. In addition, it is expected that the effect was higher in municipalities located in higher percentiles of milk production and animal stocking rate, since the credit was concentrated in areas that presented more agricultural aptitude (GIANETTI, 2017). It was decided to analyze only milk production, not meat for example, for availability of data.

That said, the general objective of this study is to analyze whether there was reduction of degraded pastures, through animal stocking rate analysis, in municipalities that received funds from the ABC program, as well as to measure the variation of milk production in such municipalities.

As specific objectives, there are the following:

- To describe the distribution of the funds of ABC Program's recovery of degraded pasture subprogram, milk production and animal stocking rate;

- To compare and balance the agricultural, climatic and economic variables of the treated and non-treated municipalities before the implementation of the Program;
- To measure whether the impacts were the same in the different percentiles.

Hence, this research aims to contribute to literature by analyzing whether credit incentive is able to influence the farmers' decisions regarding the adoption of sustainable practices. This work contributes to literature by verifying whether the credit for sustainable practices in agriculture affects the agricultural production.

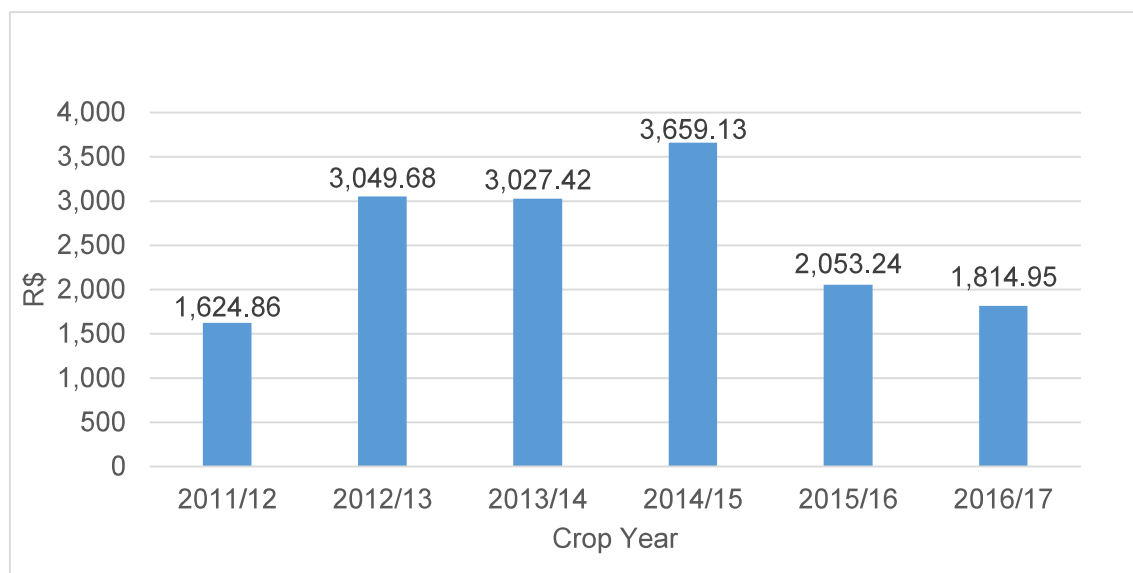
Moreover, it aims to support alternative policies recommendations that can generate such incentives if ABC program credit has not been effective. Therefore, this research seeks to trace a causal relationship between ABC Program and both animal stocking rate and milk production in treated municipalities.

2 ABC PROGRAM AND RECOVERY OF DEGRADED PASTURE AREA SUBPROGRAM

This topic aims to discuss relevant information about ABC Program and its subprogram of Recovery of Degraded Pasture, whose analysis is the main focus of this research.

According to Observatório ABC (2020), until 2016/17 crop year, the total amount of ABC Program credit totalized R\$15,229,281,870.80. The Figure 1 presents the evolution of the total amount of ABC credit between the crop years of 2011/12 and 2016/17.

Figure 1 – ABC credit amount by crop years (in R\$ millions).

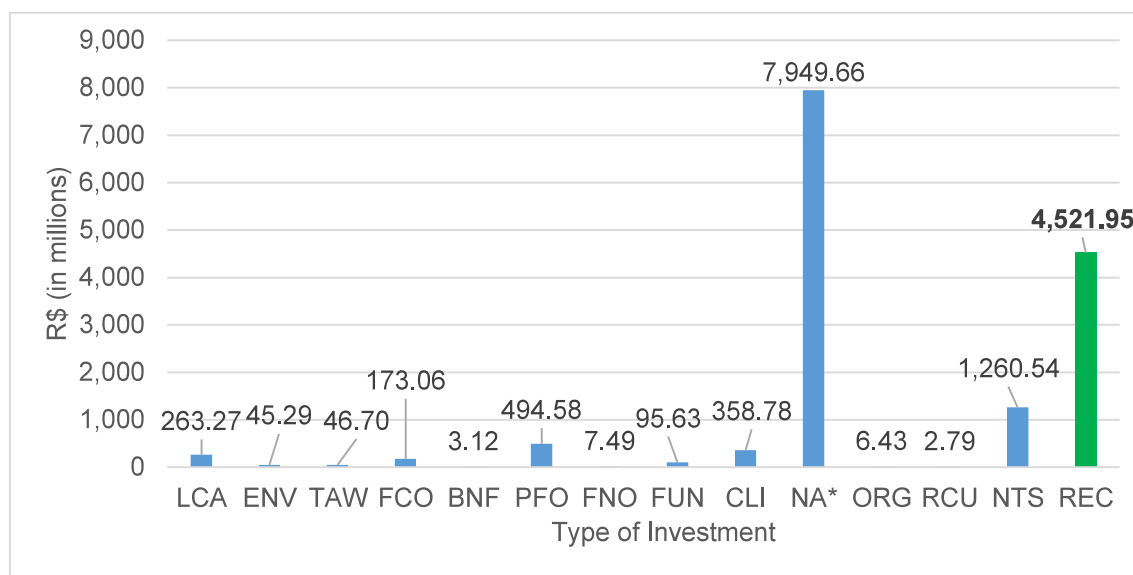


Source: Elaborated by the author. Data from Observatório ABC (2020).

Based on the Figure 1, it can be seen that the total amount of credit increased between the crop years of 2011/12 and 2014/15 – jumped from R\$1,624,863,385.78 in 2011/12 to R\$3,659,130,676.68 in 2014/15 (125.20% growth rate). However, between 2014/15 and 2016/17 crop years, the ABC total amount of credit fell to R\$1,814,949,262.59, half of the amount observed in 2014/15.

In addition, it is important to analyze the distribution of the ABC Program credit in the different types of investment. The Figure 2 presents the total amount of credit allocated to each ABC Program's Subprograms.

Figure 2 – ABC credit amount by types of investment (in R\$ millions).



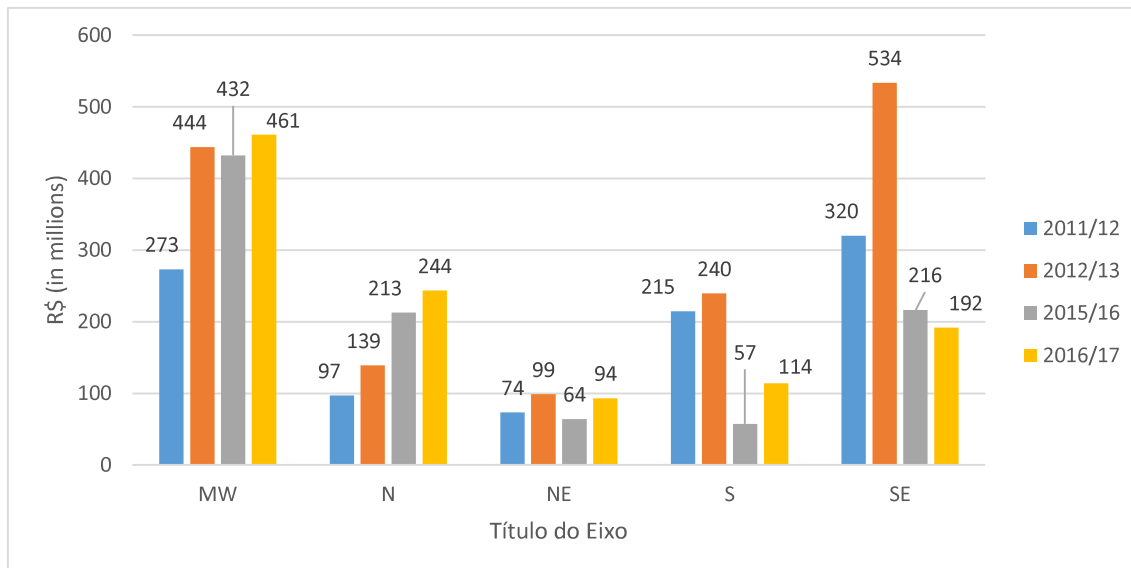
Source: Elaborated by the author. Data from Observatório ABC (2020). Acronyms: LCA – Low-Carbon Agriculture; ENV - Environmental; TAW – Treatment of Animal Waste; FCO – FCO Pronatureza; BNF – Biological Nitrogen Fixation; PFO – Planted Forests; FNO – FNO; FUN – Funds; CLI – Crop-Livestock Integration Systems; NA – Not Available; ORG – Organics; RCU – Rice Cultivation; NTS – No-Tillage System; REC – Recovery of Degraded Pasture Area.

By analyzing the Figure 2, it can be seen that the available data for the ABC Program is not as robust as it should be, since most funds of the ABC Program did not contain the information about the type of investment. Still, based on the Figure 2, excluding the data that did not present the subprogram (not available), the Recovery of Degraded Pasture Area subprogram presented the higher value of funds from ABC Program – R\$4,521,953,516.32 -, followed by No-tillage System subprogram with R\$1,260,536,101.01. The amount of credit for Recovery of Degraded Pasture Area subprogram accounted for 29.69% of the ABC Program funds, which is a relevant rate, since some amount for this subprogram that may be contained in the NA series is not being considered.

By taking into account that most of the funds of ABC Program is addressed to the Recovery of Degraded Pasture Area subprogram, the present research is focused on analyzing particularly this type of investment. Thus, from that moment onwards, the statistics and results that will be presented in this work will refer to this subprogram.

The Figure 3 refers to the distribution of the amount of credit for the Recovery of Degraded Pasture Area subprogram in the Brazil's regions, by crop years.

Figure 3 – ABC’s Recovery of Degraded Pasture Area subprogram credit amount by regions and crop years (in R\$ millions).



Source: Elaborated by the author. Data from Observatório ABC (2020). Acronyms – MW: Midwest; N: North; NE: Northeast; S: South; SE: Southeast.

According to the Figure 3, in general, the most of the funds of the ABC’s Recovery of Degraded Pasture Area credit is demanded by individuals located in the Midwest and Southeast regions of Brazil. Of the total amount of R\$4,521,953,516.32, R\$2,872,990,496.55 were directed to those regions – about 64% of the total funds. The North region comes next with R\$692,928,018.04, followed by the South region with R\$625,728,679.05. Lastly, the Northeast region received R\$330,306,322.68 from the referred subprogram.

In addition, in the Midwestern Brazil, the amount of credit for recovering degraded pastures jumped from R\$273,398,975.06 in 2011/12 to R\$444,036,720.65 in 2012/13. After that crop year, the amount of credit did not change expressively: R\$432,082,785.13 in 2015/16 and R\$461,048,829.61 in 2016/17. As in the Midwest region, the Southeast region significantly received more ABC’s Recovery of Degraded Pasture area funds in 2012/13 when compared with 2013/14: from R\$320,413,865.00 to R\$533,813,848.33. On the other hand, different from the Midwest region, the values in the Southeast region reduced a lot after the crop year of 2013/14 – R\$216,386,872.52 in 2015/16 and R\$191,808,600.25 in 2016/17. It is important to note that, in the crop years of 2011/12 and 2013/14, the Southeast region was the one that received the most of the funds of the Recovery of Degraded Pasture Area subprogram. After that, in the crop years of 2015/16 and 2016/17, the Midwestern Brazil became

the region that present the most of the amount of credit of that subprogram. Regarding the Northern Brazil, this region was the only one that presented positive growth rate in every year (when the value is compared with the immediately preceding crop year). In the crop years of 2011/12, 2012/13, 2015/16 and 2016/17 the values totalized, respectively, R\$97,163,838.49, R\$139,285,359.74, R\$212,779,136.32 and R\$243,699,683.49.

Besides, the South region received R\$214,854,435.67 in 2011/12. Subsequently, this region observed a huge decrease in the total received amount of credit between 2012/13 and 2015/16: from R\$239,503,191.87 to R\$57,088,263.61. Finally, in 2016/17 the total amount of credit increased to R\$114,282,787.90. The Northeastern Brazil received R\$73,681,662.38 in 2011/12 and R\$93,544,479.59. The lowest value was observed in 2015/16 – R\$64,300,859.22 -, whereas the highest value of credit was observed in 2012/13 – R\$98,779,321.49.

In spite of the values presented in the last paragraphs, the most of the amount of credit offered by the program was not demanded, according to a report from Observatório ABC (2017a). That is, in all years, the demanded credit value was lower than its supply.

3 METHODOLOGY

This section exposes the methodological approach of this research. It is divided in two subsections. The first section introduces the differences-in-differences regression model, whereas the second part presents information about the database.

3.1 Empirical approach

3.1.1 Differences-in-differences

This work aims to trace the ABC Program effect on degraded pasture area and the milk production of the treated municipalities. Since there are available data for the pre and post policy periods, it can be used the diff-in-diff method (Greene, 2012):

$$y_{i,t} = \beta_1 + \beta_2 T_t + \beta_3 D_i + \beta_4 T_t * D_i + X'_{i,t} + e_{i,t} \quad (1)$$

where $X'_{i,t}$ is a vector of explanatory variables, D_i the dummy that is equal to 1 in municipalities that have received funding from the ABC Program, T_t is the dummy referring to the duration of the ABC Program (assumes value 1 if $t > 2011$), $T_t * D_i$ the interaction of the municipality dummy and post-period dummy, and $e_{i,t}$ the regression error. $\beta_1, \beta_2, \beta_3$ e β_4 are the parameters of the regressions, with the later representing the average treatment effect of ABC Program.

The main objective of this methodology is to find whether the trend of the dependent variable of the treated unit – in this case, degraded pasture and milk production-, would have been the same dynamic if the intervention had not occurred. In order to reach this objective, the treated group is compared with the control group. However, this contrafactual is not directly testable (FOGUEL, 2012). Therefore, the choice of the control group must be made in such a way that the selection bias can be reduced. The selection bias occurs when the participation in the program is correlated with some non-observable characteristics of the municipality. Consequently, the treatment variable becomes endogenous, and the coefficient that represents the program impact becomes biased (GREENE, 2012). If the bias is caused by time invariant characteristics of the treated municipalities, it can be used the DiD method with fixed effects.

In order to analyze whether there is a causal relationship between the explanatory ABC Program and the milk production, the differences-in-differences method is based on some assumptions. The first one is that the composition of both

treated group and control group do not change between pre- and post-intervention. If this assumption is violated, the ABC Program effects on milk production and degraded pasture area could be misidentified, since the estimated impact could have been caused by other non-observable variables that also ended up changing the groups' composition (FOGUEL, 2012). Also, DiD method relies on common trends assumption. This assumption means that the control group and the treated group would have followed the same trends if there was not an intervention. As noted, it is impossible to determine if the groups would have the same trends in the absence of the program, as we are dealing with a social policy – there is not a perfect contrafactual. In these cases, most researchers analyze the trends of the groups in the pre-years of the intervention, if there are available time units in the data.

However, according to Angrist and Pischke (2015), sample data that contain many observations of cross-sectional and time units allows the relaxing of common trends assumption. For that, it is necessary to include controls for specific time trends. Our research includes controls for municipality-specific trends, since we have a lot of municipalities (5,291) and 15 units of years. The models containing municipality-specific trends presume that, in absence of an ABC Program credit, milk production and animal stocking rate in municipality i deviate from common year by following the linear trend captured by the coefficient of μ_{it} (ANGRIST; PISCHKE, 2005).

Additionally, DiD assumes that the effect is homogeneous over the treatment period. However, not all interventions occur in a homogeneous way. By analyzing the micro-data of the ABC Program Credit for pasture recovery (SICOR, 2019), it could be seen that some municipalities were treated during at most 3 years after 2012, while others just for 2 years, and the rest of the municipalities treated received credit only in 1 year. Therefore, the model that captures heterogeneous effect by coverage time can be written as the following:

$$Y_{it} = \sum_{j=1}^J \beta_j C_{j,it} + X'_{it} + \phi_i + \gamma_t + \mu_{it} + e_{it} \quad (2)$$

where Y_{it} represents the outcome variable (milk and animal stocking rate) in the municipality i in year t , $C_{j,it}$ is a binary variable that assumes value 1 if the municipality i in the year t received some credit amount for pasture recovery from ABC Program for j times, X'_{it} is a vector of explanatory variables, ϕ_i is municipality fixed-effect, γ_t is

time fixed-effect, μ_{it} is the specific time trends for the municipality i in time t , e_{it} is the regression error.

To capture the effect of the ABC Program credit in periods following the receipt of funds by the treated municipalities, we rewrite Equation 2. The difference between the Equation 3 and 2 is that $C_{j,it}$ also equals 1 in all years following the treatment year.

$$Y_{it} = \sum_{j=1}^J \beta_j C_{j,it} + X'_{it} + \phi_i + \gamma_t + \mu_{it} + e_{it} \quad (3)$$

3.1.2 Quantile regression

More than analyze the overall effect of the ABC Program credit for recovery of degraded pasture, it is relevant to examine the effect of the Program on different percentiles of milk production and animal stocking rate. Since the distribution of ABC Program funds is strongly correlated to the agricultural production of the municipality (LEAL, 2016; GIANETTI, 2017), it is expected that the effect of the program varies between the percentiles of animal milk production. In addition, as we are analyzing the effect of the ABC Program's recovery of degraded pasture, the effect should be greater in the first percentiles, since there are a relationship between the degraded pasture area and animal stocking rate (DIAS-FILHO, 2014).

For instance, Dias-Filho (2014), by analyzing the distribution of pasture area and animal stocking rate in the regions of Brazil, estimated four different intervals of animal stocking rate that could represent the degradation rate of the pasture:

Table 1 – Classification of degraded pasture

Pasture classification	Minimum stocking rate	Maximum stocking rate
Strong degradation	-	0.4
Moderate degradation	0.4	0.8
Slight degradation	0.8	1.5
Productive	1.5	-

Source: Dias-Filho (2014)

For that, in addition to the least squares, it was utilized the quantile regression method. It differs from least squares by estimating the conditional median (or other quantiles) of the milk production and animal stocking rate across values of the predictor variables – the least squares method estimates the conditional mean of the milk production and animal stocking rate. Briefly, the least squares estimation asks the

question: “How does the conditional mean of Y depend on the covariates X?”. On the other hand, the quantile regression asks this question at each quantile of the conditional distribution (KOENKER, 2000).

The econometric model utilized is almost the same of the equation 2. However, it includes the quantiles.

$$Y_{it} = \sum_{j=1}^J \beta_j(\tau) C_{j,it} + X'_{it}(\tau) + \phi_i(\tau) + \gamma_t(\tau) + \mu_{it}(\tau) + e_{it} \quad (4)$$

Where τ represents the τ -th quantil - $\tau(0,1)$. We utilize three quantiles in this analysis: 25, 50 and 75. The model can be expanded for T years, as in equation 3, to capture the lasting effect of ABC Program credit:

$$Y_{it} = \sum_{j=1}^J \beta_j(\tau) C_{j,iT} + X'_{it}(\tau) + \phi_i(\tau) + \gamma_t(\tau) + \mu_{it}(\tau) + e_{it} \quad (5)$$

3.1.3 Entropy balancing

Additionally, the treated groups can be matched with the control groups, in order to make the DiD model more reliable. The objective of a matching process is to produce balanced samples, using covariates to approach control group with treatment group in the pre-intervention period. To this end, Hainmueller (2011) indicates that entropy balancing satisfactorily weighs the sample through the inclusion of a reweighting scheme that directly absorbs covariate balance into the weight function. The author advocates that the entropy balancing has some appealing features. The first one cited is that this approach allows the researcher involves the first, second and third moment of the covariate distributions. Thus, it is possible to match the mean, variance and skewness of the covariates of the treated group with the control group before the treatment period.

Hainmueller (2011) also argues that another advantage of entropy balancing is that this approach do not discard information from data. In fact, it seeks to weigh the variables as close as possible to the base weights, without losing the achievement of the balance. In other methods, such as the nearest neighbor, units are either matched or discard. Thus, it can be lost some relevant information after the sample balance.

The main goal of Entropy is reweight the sample of the control group in order to match the moments of the treatment group to estimate the Population Average Treatment Effect on Treated (PATT):

$$z = E[Y(1)|D = 1] - E[Y(0)|D = 1] \quad (6)$$

The difference is done between the mean outcomes of the treated units and the reweighted control units. Assume that w_i is the weight chosen for each control unit:

$$E[Y(0)|\widehat{D} = 1] = \frac{\sum_{\{i|D=0\}} Y_i w_i}{\sum_{\{i|D=0\}} w_i} \quad (7)$$

the reweighing scheme is giving by the following:

$$\min_{w_i} H(w) = \sum_{\{i|D=0\}} h(w_i) \quad (8)$$

subject to balance and normalizing constraints

$$\sum_{\{i|D=0\}} w_i c_{ri}(X_i) = m_r \quad (9)$$

$$\sum_{\{i|D=0\}} w_i = 1 \quad (10)$$

$$w_i \geq 0 \text{ for all } i \text{ such that } D = 0 \quad (11)$$

where $h(\cdot)$ is a distance metric and $c_{ri}(X_i) = m_r$ describes a set of R balance constraints imposed on the covariate moments of the reweighted control group (HAINMUELLER, 2011). The weights generated in the entropy balancing will be applied in the diff-in-diff regression.

The Stata's package "xtqreg", which estimates quantile regression with fixed effects, does not allow the including of weights. Therefore, the entropy balancing will not be included in the quantile regressions. Still, it is important to analyze the dynamic of the results throughout the quantiles.

To balance the sample, it was used the variables milk production, animal stocking rate, GDP and agricultural GDP (as a percentage of GDP), maximum temperature, minimum temperature, solar radiation, humidity, and wind. The years after the implementation of ABC Program were not used.

3.2 Variables and Database

This subsection contains information about the database of the present study, such as the variable names, the sources and the periods. The periodicity is annual for all variables, and all variables is in municipality-level.

The Table 2 presents information about database.

Table 2 – Characterization of the variables.

Variable (unit)	Source	Range
Milk Production (1,000 L)	IBGE (2018)	2003-2017
Animal Stocking Rate (AU/ha)	IBGE (2018) and LAPIG (2019)	2003-2017
Amount of ABC Program credit (R\$1,000)	SICOR (2019)	2012-2017
Amount of other credits than ABC Program (R\$1,000)	SICOR (2019)	2012-2017
GDP (R\$1,000)	IBGE (2018)	2003-2017
Agricultural GDP added value on GDP (%)	IBGE (2018)	2003-2017
Maximum temperature (°C)	XAVIER, KING AND SCANLON (2017)	2003-2017
Minimum temperature (°C)	XAVIER, KING AND SCANLON (2017)	2003-2017
Wind speed (m/s)	XAVIER, KING AND SCANLON (2017)	2003-2017
Relative air humidity (%)	XAVIER, KING AND SCANLON (2017)	2003-2017
Solar radiation (W/m ²)	XAVIER, KING AND SCANLON (2017)	2003-2017

Source: Elaborated by the author.

Acronyms – IBGE: Instituto Brasileiro de Geografia e Estatística; LAPIG: Laboratório de Processamento de Imagens e Geoprocessamento; SICOR: Sistema de Operações do Crédito Rural e do Proagro.

The animal stocking rate is used as a proxy for pasture degradation, since there is a relevant correlation between these variables. Degraded pastures have a lower number of cows per hectare than those with good grass condition (DIAS-FILHO, 2011). As there is no public database related to pasture degradation in a yearly periodicity, the dynamic of municipal stocking rate could give some relevant information about the effects of the program on the land productivity.

Furthermore, in order to capture the effect of the change of climate variables on milk production and animal stocking rate, the deviations of the municipality averages of maximum temperature, minimum temperature, wind speed, relative air humidity and solar radiation were utilized.

In order to have more reliable estimation, some outliers were excluded from the data. For instance, municipalities that presented values of animal stocking rate more than 15 animal unit per hectare were removed from the data. Also, municipalities that did not contain data about climate and economic variables were excluded as well. On the other hand, municipalities that did not contain data about stocking rate animal or milk production were not excluded. The explanation is that, since these variables are the dependent ones, it was not necessary to exclude them, because the number of observations do not vary when it is included the explanatory variables. After the data processing, remained 77,415 observations from municipalities in the regressions with milk production as dependent variable, and 77,688 in the regressions that the dependent variable is the stocking animal rate. In addition, 5,324 municipalities were analyzed in the regressions with milk production as dependent variable, whereas in the regressions with the animal stocking rate as dependent variable the number of municipalities was equal to 5,330. On the other hand, the number of treated municipalities was equal between these two groups. The municipalities that received credit for at least one year was equal to 1,120, whereas 461 and 149 municipalities received for at least 2 and at maximum 3 years, respectively. Plus, the third-time treatment of 147 out of the 149 treated municipalities occurred in 2017. Therefore, it is still not possible to analyze the effect of the third-time treatment in the following years because there are not data for post-2017 periods yet.

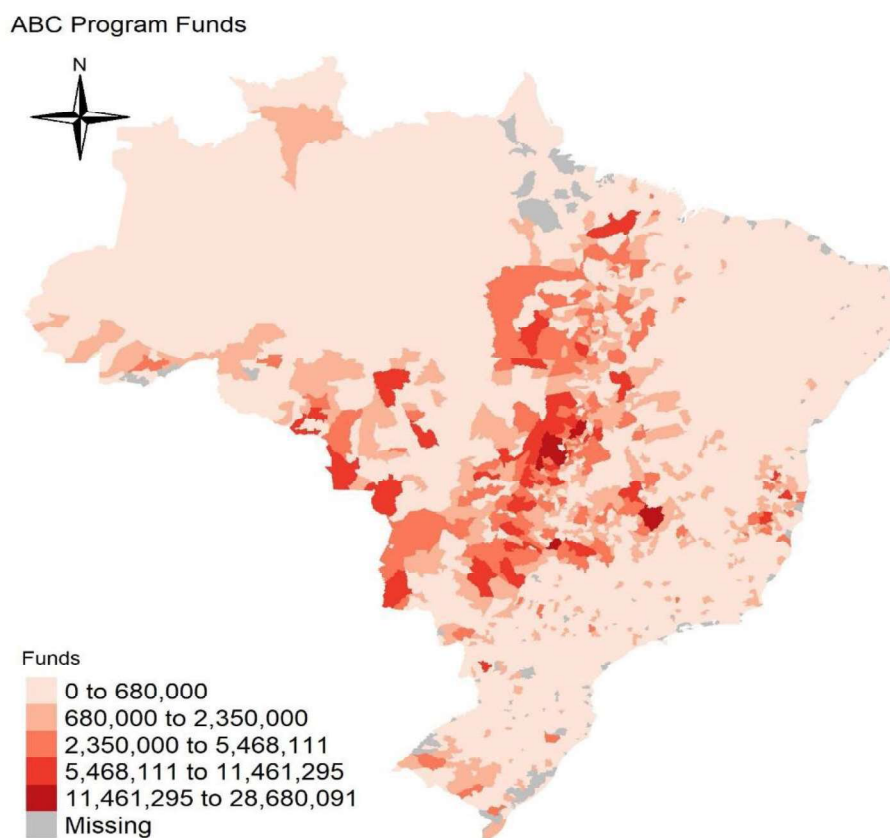
4 RESULTS AND DISCUSSIONS

This section is organized in 4 parts. The first one presents distribution of the ABC Program's recovery of degraded pasture subprogram, besides the distribution of Milk Production and Animal Stocking Rate. The second subsection expose the results of the entropy balancing. The third subsection presents the estimation of the differences-in-differences model – including the least squares and quantile regressions - with logarithm of milk production as the dependent variable. Finally, the fourth subsection presents the results of animal stocking rate.

4.1 Distribution of ABC Funds, milk production and animal stocking rate

The Figure 4 contains the distribution of the credit of the ABC Program's recovery of degraded pasture subprogram in Brazil's territory. It was calculated the sum of the amount of this type of credit between 2012 and 2017. The Figures 5 and 6 present, respectively, the mean of milk production and animal stocking rate in Brazil's territory between 2003 and 2017.

Figure 4 – Sum of ABC’s recovery of degraded pastures subprogram (R\$) – 2012-2017



Source: Elaborated by the author. Data from SICOR (2019).

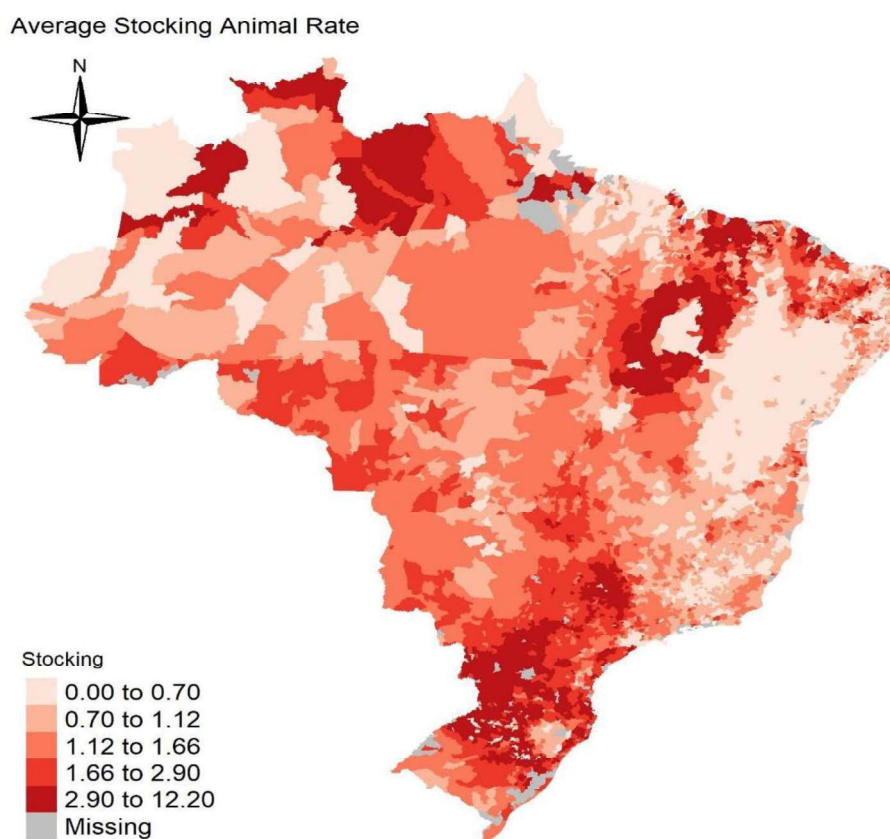
Through Figure 4, it can be seen that the funds of the ABC Program’s recovery of degraded pasture subprogram concentrate in the Midwest region and in the some part of MATOPIBA – acronym formed by the first letters of 4 Brazilian states: Maranhão, Tocantins, Piauí e Bahia. Therefore, it can be noted that the funds have been demanded in states where the agricultural production was already developed and well-established (LEAL, 2016; GIANETTI, 2017). According to Gianetti (2017), in regions with high agricultural aptitude, the investments of ABC program contributes less to environmental than if they would allocated to regions with low agricultural aptitude. Thus, it is important to seek a way to foster the adoption of ABC Program funds in regions that present lower agricultural aptitudes.

On the other hand, in most of the northeast of Brazil, the funds have not been demanded by farmers. This conclusion is in line with the conclusion of Leal (2016) that

concluded that the amount of funds have not been demanded by rural producers in locations that present higher potential of GHG emissions reduction, and consequently, have a higher need of technological improvements. The Northeast is one of the Brazilian regions with the lowest agricultural productivity rate.

A way to observe the agricultural productivity of a municipality is to analyze the animal stocking rate. In general, it is expected that regions with more animal unit per hectare are more productive than those that presents lower animal stocking rates (DIAS-FILHO, 2011). The Figure 5 shows the mean of animal stocking rate in Brazilian municipalities from 2003 to 2017.

Figure 5 – Average Animal Stocking Rate (AU/ha) – 2003-2017



Source: Elaborated by the author. Data from IBGE (2018) and LAPIG (2019).

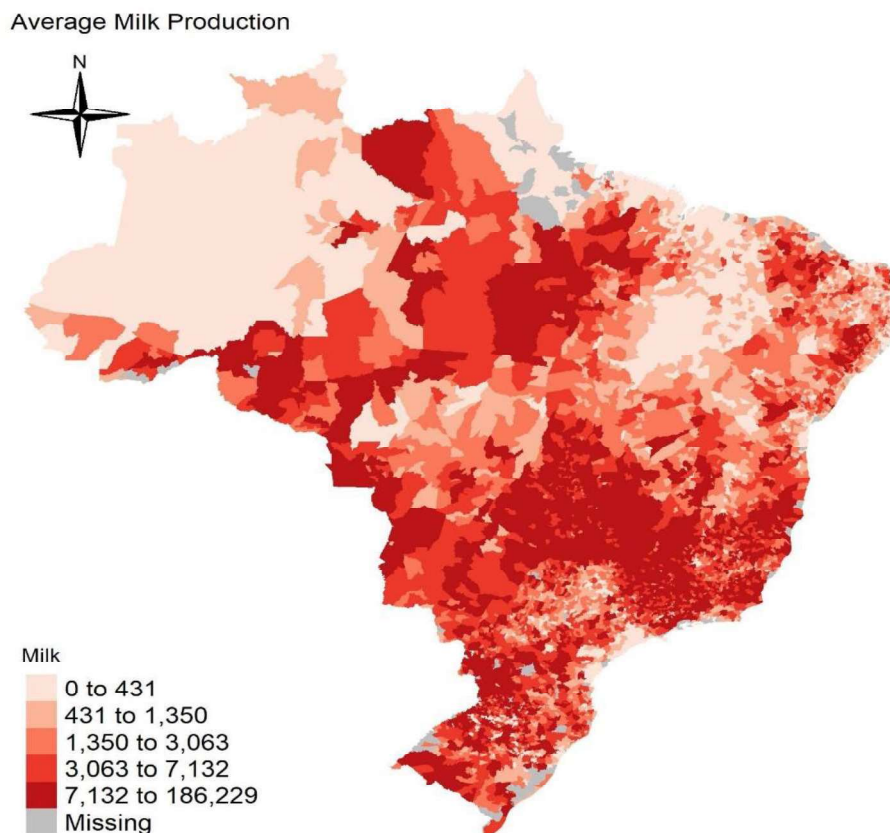
According to Figure 2, it is clear that the Northeastern Brazil appears to contain the municipalities with lowest animal stocking rates. Besides of the Northeast Region, most of Minas Gerais' municipalities present low rates. In spite of that, these locations did not receive a relevant amount of credit for recovery of degraded pasture, which

could lead to an increase in the animal stocking rate, and therefore, an increase in land productivity (DIAS-FILHO, 2011).

In addition, the Southern Brazil appears to be the region with the higher average of animal stocking rate, specially the Western Santa Catarina and Western Paraná. The Northern Pará and Roraima presented high animal stocking rates as well. The most of the municipalities in Midwest region had median animal stocking rates, even though it was the region that received the largest amount of credit. Thus, by simultaneously analyzing the Figures 1 and 2, it is noted that the distribution of credit is not as effectiveness as the expected by the ABC Program's goals.

Finally, the Figure 6 exposes the mean of milk production in Brazilian Municipalities between 2003 and 2017.

Figure 6 – Average Milk Production (1,000L) – 2003-2017



Source: Elaborated by the author. Data from IBGE (2018).

It can be seen that the states of Minas Gerais and Goiás contain a lot of municipalities with high milk production. Moreover, Pará, Rondônia and Mato Grosso

do Sul contained some municipalities as ones of the largest milk producers. Plus, the Southern Brazil appears to had some municipalities with an expressive milk production, and it becomes more relevant when it is analyzed the territorial size of the most of the municipalities from the South region.

In contrast, Brazil northeast semi-arid presented low quantities of milk produced. It can be explained partially by the fact that this region is not propitious to the cattle raising. In addition, the State of Amazonas did not appear to produce milk. The most reasonable explanation is that Amazonas is subordinated to a set of agricultural production restrictions due to the conservation of the Amazon rainforest.

In summary, this present research is in line with the findings of Leal (2016) and Gianetti (2017): the authors presented that the distribution of the ABC credit was strongly correlated to the agricultural production of the municipality. In the Figure 4, it can be seem that the distribution of the funds of the ABC Program's recovery of degraded pastures subprogram appeared to be related with milk production of the municipalities. On the other hand, the investments have not been directed to municipalities with low animal stocking rate. According to Figure 4 and Figure 5, even though the most of the municipalities with lowest animal stocking rates are located in the Northeast of Brazil, the investments were more demanded in the Midwestern Brazil. Thus, it appears that the credit for recovery of degraded pasture has not been demanded in the municipalities that need to increase their land productivity (LEAL, 2016; GIANETTI, 2017).

4.2 Entropy balancing

Firstly, Table 3 shows the three moments of the treatment group and control group before reweighing, whereas the Table 4 exposes the three moments of the same variables after entropy balancing. We decided to balance the variables in three moments because it generates a more robust matching of the groups. In this case, control units are reweighted to satisfy the balance constraints that the 1st, 2nd and 3rd moments match the corresponding moments of the treated units (HAINMUELLER; XU, 2013).

Table 3 – Mean, Variance and Skewness – treated and control group without balancing – 2003 - 2013

Variables (unit)	Treated			Control		
	Mean	Variance	Skewness	Mean	Variance	Skewness
Animal Stocking Rate (AU/ha)	1.671	2.151	4.327	2.284	6.681	2.327
Milk Production (1,000 L)	9,431	2.13E+08	4.303	3,607	3.52E+07	4.847
GDP (R\$1,000)	450,939	4.33E+12	14.86	382,784	6.15E+12	32.88
Agricultural GDP (% related to GDP)	26.55	260.5	0.5229	21.6	233.6	0.7547
Maximum Temperature (°C)	29.86	8.029	-0.5826	29.09	10.03	-0.1992
Minimum Temperature (°C)	18.5	7.252	-0.2139	18.5	10.67	-0.07662
Solar Radiation (W/m ²)	17.99	1.497	-0.04776	18.32	3.356	0.1963
Humidity (%)	71.73	30.87	-0.09166	72.94	40.28	-0.6893
Wind (m/s)	1.294	0.1401	1.003	1.653	0.2942	0.4572

Source: elaborated by the author.

Table generated on Stata. "ebalance" code. All variables are balanced on the 1st, 2nd and 3rd orders.

The data presented in Table 3 show that, before entropy balancing, the mean, variance and skewness were different in the treated and control group variables. For instance, the mean of milk production in the treatment group was about 1.61 times higher than the mean of milk production in the control group, while the variance of milk production was 5.05 times higher in treatment group than in control group. The variance of animal stocking rate in the treatment group was about 3 times lower than in the control group, and the mean was 0.26 times lower in the treatment group compared with the control group. Thus, it is clear that the groups were notoriously different before entropy balancing, including the values of the mean and variance of the model-dependent variables - milk production and animal stocking rate.

In addition, it can be noted that the GDP, and the percentage of the Agricultural GDP on GDP, were higher in the treated group. Thus, it may lead us to conclude that the municipalities that received ABC credit is more linked to agricultural production than the ones that did not receive ABC credit (LEAL, 2016; GIANETTI, 2017). Regarding the climate variables, the treated municipalities presented higher mean of maximum temperature. On the other hand, the solar radiation, the humidity and the wind presented lower values in the treated group than in the control group. Finally, the minimum temperature presented similar means between the groups.

Table 4 – Mean, Variance and Skewness – treated and control group with balancing – 2003-2013

Variables	Treated			Control		
	Mean	Variance	Skewness	Mean	Variance	Skewness
Stocking Rate (AU/ha)	1.671	2.151	4.327	1.671	2.151	4.327
Milk Production (1,000 L)	9,431	2.13E+08	4,303	9,431	2.13E+08	4.303
GDP (R\$1,000)	450,939	4.33E+12	14.86	450,938	4.33E+12	14.86
Agricultural GDP (% related to GDP)	26.55	260.5	0.5229	26.55	260.5	0.5229
Maximum Temperature (°C)	29.86	8.029	-0.5826	29.86	8.029	-0.5826
Minimum Temperature (°C)	18.5	7.252	-0.2139	18.5	7.252	-0.2139
Solar Radiation (W/m ²)	17.99	1.497	-0.04776	17.99	1.497	-0.04776
Humidity (%)	71.73	30.87	-0.09166	71.73	30.87	-0.09166
Wind (m/s)	1.294	0.1401	1.003	1.294	0.1401	1.003

Source: elaborated by the author.

Table generated on Stata. "ebalance" code. All variables are balanced on the 1st, 2nd and 3rd orders.

After entropy balancing (Table 4), it is noted that the animal stocking rate (and milk production) mean, variance and skewness are equal between treatment and control groups. Also, the mean, variance and skewness of all control variables are the same between treatment and control groups. Therefore, we can see that the entropy balancing was able to approximate the variables values of the treatment and control group.

In order to provide more information to support the robustness of the entropy balancing, Figure 7 and Figure 8 present the kernel densities of, respectively, Milk Production and its logarithm in the treatment and control groups, before and after balancing.

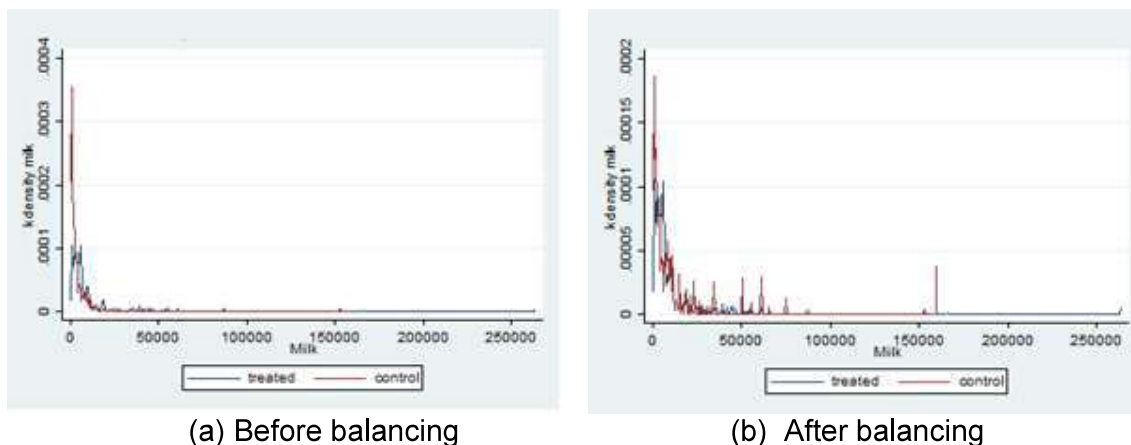


Figure 7 - Milk - Kernel density – 1st, 2nd and 3rd order balancing – before and after balancing

Source: elaborated by the author. Graphics generated on Stata. “ebalance” code.

Comparing the two graphics, we can note that after the entropy balancing the densities of the treatment and control groups is more overlapping, especially in the area where milk production is less than 50000. However, it does not appear well weighted. It is important to analyze options to find a more robust balancing.

Then, the Figure 8 presents the Kernel density of the natural logarithm of milk production.

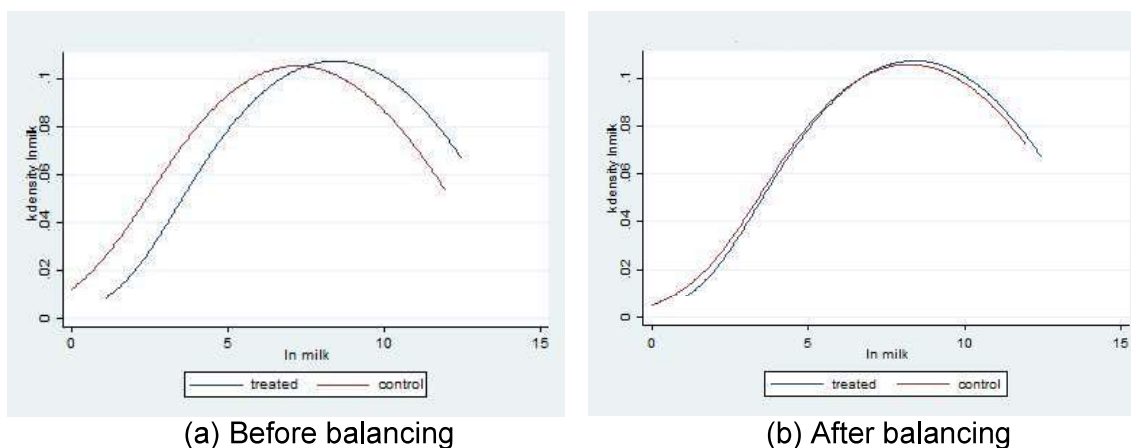


Figure 8 – Natural Logarithm of Milk Production - Kernel density – 1st, 2nd and 3rd orders balancing – before and after.

Source: elaborated by the author. Graphics generated on Stata. “ebalance” code.

By examining Figure 8, it is clear that, after the balancing, the series converge. Before balancing, the higher the value of the natural logarithm of milk production, the greater the probability that the kernel density of the treated group would be greater than the kernel density of the control group. On the other hand, after balancing, the

series are virtually overlapping. Given this, the logarithm of milk production will be used in the diff-in-diff regression.

Finally, Figure 9 shows the kernel densities of the animal stocking rate before and after entropy balancing. Note that after balancing, the series are virtually overlapped.

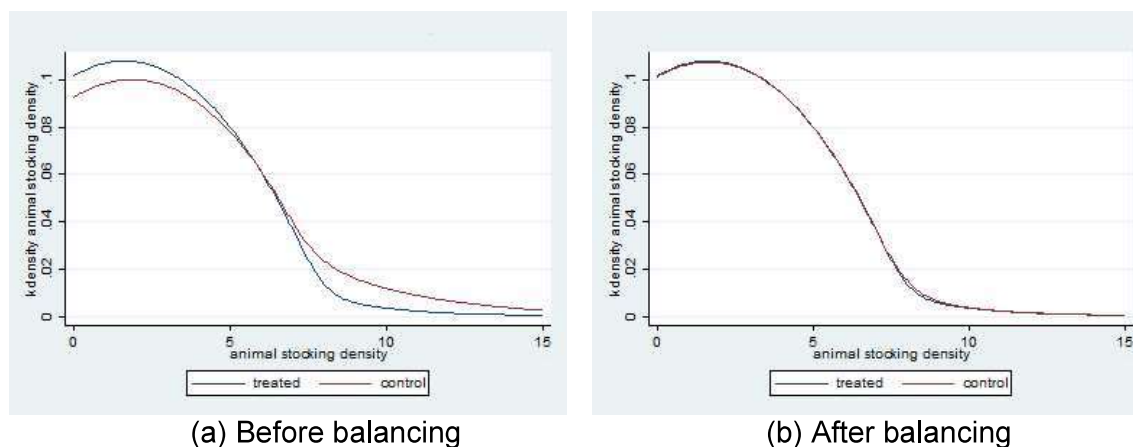


Figure 9 – Animal Stocking Rate - Kernel density – 1st, 2nd and 3rd orders balancing – before and after.

Source: elaborated by the author. Graphics generated on Stata. “ebalance” code.

Therefore, based on the results, we can observe that the entropy balancing made the kernel densities – both for logarithm of milk production and animal stocking rate- practically identical between treated and control groups. For that, it seems that the weights given by the balancing are correct, and so, it can be used in the diff-in-diff estimations, whose results will be presented in the following subsections. The kernel densities of the explanatory variables are contained in Appendix A.

Briefly, the results of entropy balancing showed that, before the program, the group were different, especially in agricultural value added to GDP (%) and GDP. This finding provides evidence that the municipalities that demanded the ABC’s recovery of degraded pastures funds already presented an agricultural system more developed than those municipalities that have not demanded the credit (LEAL, 2016; GIANETTI, 2017).

4.3 Milk Production

The Table 5 contains the results of the diff-in-diff method for the logarithm of milk production.

Table 5 – Estimation of equation 2 – logarithm of milk production – 2003-2017.

Variables	Specifications				
	(1)	(2)	(3)	(4)	(5)
d_1	.0696*** (.017)	.0646*** (.018)	.0624*** (.018)	.0478** (.020)	.0452** (.019)
d_2	.0736** (.030)	.0652** (.031)	.0593* (.031)	.0407 (.034)	.0411 (.033)
d_3	.0118 (.054)	-.0063 (.056)	-.0252 (.055)	-.0369 (.056)	-.0324 (.053)
constant	7.3141*** (.007)	-10.9219** (6.443)	.3046 (7.063)	-.5907 (7.196)	24.6084*** (8.957)
trend_{it}	No	Yes	Yes	Yes	Yes
climate variables	No	No	Yes	Yes	Yes
economic variables	No	No	No	Yes	Yes
entropy balancing	No	No	No	No	Yes
R²	0.9320	0.9321	0.9324	0.9333	0.9330

Source: elaborated by the author. Municipality and time fixed-effects included. Error adjusted for 5,324 clusters of municipality. d_1 , d_2 and d_3 equal 1 when treated municipalities received ABC Program credit for the first, second and third time, respectively. **trend_{it}** is the interaction between municipality and year. Standard errors in parentheses. n=77,415.

***: if p-value<0.01; **: if p-value<0.05; *: if p-value<0.1.

According to the results in Table 5, the effect in the years that the municipalities were first treated (d_1) was positive and statistically significant for all models, even when the sample are balanced by entropy matching and the model includes all control variables. In the specification **(1)**, which do not include control variables nor municipality-specific trend, the d_1 coefficient was equal to .0696, which means that receiving credit from ABC Program for the first time is correlated with a 6.96% increase in milk production in treated municipalities. When the variable of municipality-specific trend is included in the model - specification **(2)** -, the coefficient varies to .0646 – about 7.74% lower than that coefficient estimated in specification **(1)**. Thus, the introduction of municipality-specific trends had little effect on the estimates of the coefficient of d_1 .

Therefore, it can be inferred that in absence of the ABC Program credit, milk production in municipality i deviate from common year by following the linear trend captured by the coefficient of $trend_{it}$ (ANGRIST; PISCHKE, 2005).

The coefficient of d_1 reduces to .0624 in specification **(3)**, when climate variables are included. By including economic variables – specification **(4)** –, the coefficient has a meaningful reduction – from .0624 to .0478. However, it is important to note that the coefficient remains positive and statistically significant. Finally, with balanced sample - specification **(5)** –, the coefficient is reduced slightly to .0452 with a standard error of .019. Therefore, after all specifications, the results in Table 4 show that there is a positive relationship between ABC Program credit and milk production in the years that the municipalities were treated for the first time. The specification **(5)**, which is the most robust specification, presents that receiving funds from ABC Program in at least one time increase the milk production by 4.52%.

On the other hand, in the years that the municipality were treated for the second time (d_2) the coefficients were not statistically significant in specifications **(3)**, **(4)** and **(5)**. Besides, in the periods that the treated municipalities received credit for the third time (d_3), the coefficients were not statistically significant in any specification.

In addition, it is important to verify if the effect varied between the percentiles. Two questions can arise: (i) the effect was positive and statistically significant in different percentiles of milk production? (ii) was the ABC Program credit more effective in the higher percentiles of milk production, or it was more effective in municipalities in lower percentiles of milk production? The Table 6 seeks to answer these questions. As we aimed to respond if there are differences between the percentiles, it is valid to include the confidence interval of the parameters.

Table 6 – Estimation of equation 4 – logarithm of milk production – 2003-2017.

Variables	Percentiles		
	.25	.50	.75
d_1	.0555** (.024)	.0474** (.021)	.0403** (.019)
95% CI (d_1)	(.0082--.1028)	(.0072--.0876)	(.0037--.0769)
d_2	.0449 (.039)	.0405 (.034)	.03653 (.032)
95% CI (d_2)	(-.0321--.1220)	(-.0257--.1067)	(-.0271--.1001)
d_3	-.0262 (.059)	-.0375 (.054)	-.0474 (.060)
95% CI (d_3)	(-.1426--.0902)	(-.1427--.0677)	(-.1642--.0695)

Source: elaborated by the author. All controls included. Error adjusted with a bootstrap of 1000 replications based on 5,324 clusters of municipality. d_1 , d_2 and d_3 equal 1 when treated municipalities received ABC Program credit for the first, second and third time, respectively. Standard errors in parentheses. n=77,415. ***: if p-value<0.01; **: if p-value<0.05; *: if p-value<0.1.

Firstly, it can be seen that neither the coefficients of d_2 nor d_1 's were statistically significant in any percentile. On the other hand, the coefficients of d_1 were positive and statistically significant in all percentiles presented in the Table 6.

Regarding the coefficients of d_1 , the coefficient appears to reduce in higher percentiles, and so, one could conclude that the Program has benefited less the higher producers of milk than the lowest ones. However, it would be hasty to have this conclusion. In fact, the confidence interval of all percentiles are overlapped, which means that the coefficients are statistically equal. In the percentile 25, the confidence interval of d_1 varies from .0082 to .1028; in the percentile 50, the interval varies between .0072 and .0876; finally, in the percentile 75, the interval varies from .0037 to .0769.

However, even though the estimations can provide the information that the coefficients in different percentiles were not different each other, it is not right to conclude that the absolute effect was the same among the quantiles. Since the milk production is in logarithm, and d_1 , d_2 and d_3 are dummies, the coefficients represent the percentage change of the milk production. Thus, despite the statistical equality of the coefficients in the three percentiles, the absolute change of milk production could

be different. On the other hand, the results give signs that the ABC Program credit was not a mechanism of inequality, since the proportion of the effect was statistically equal.

In conclusion, the municipalities that received the credit for at least one year increased their milk production. The median value of the effect is greater in the low percentiles when compared with the higher percentiles. The values vary from an 5.55% increase in the .25 percentile to 4.03% in the .75 percentile. On the other hand, the values are not statistically different since the confidence intervals of d_1 are overlapped in the three percentiles. Finally, the second and third-time treatments (d_2 and d_3) did not present statistically-significant coefficients.

The Table 7 shows the results of the estimation of equation 3, which takes into account the effect of the ABC Program credit in the years after the treatment year.

Table 7 – Estimation of equation 3 – logarithm of milk production – 2003-2017.

Variables	Specifications				
	(1)	(2)	(3)	(4)	(5)
dd_1	.0654*** (.019)	.0591*** (.019)	.0540*** (.020)	.0394* (.021)	.0378* (.021)
dd_2	-.0042 (.027)	-.0089 (.027)	-.0123 (.028)	-.0208 (.027)	-.0151 (.026)
dd_3	-.0446 (.047)	-.0550 (.048)	-.0636 (.048)	-.0619 (.047)	-.0580 (.046)
<i>constant</i>	7.3505*** (.007)	-11.6975* (6.467)	.4238 (7.086)	-.4923 (7.210)	24.6921*** (9.329)
$trend_{it}$	No	Yes	Yes	Yes	Yes
<i>climate variables</i>	No	No	Yes	Yes	Yes
<i>economic variables</i>	No	No	No	Yes	Yes
<i>entropy balancing</i>	No	No	No	No	Yes
R^2	0.9320	0.9321	0.9324	0.9333	0.9330

Source: elaborated by the author. Municipality and time fixed-effects included. Error adjusted for 5,324 clusters of municipality. Errors in the specification (5) were adjusted with a bootstrap of 1,000 replications. dd_1 , dd_2 and dd_3 equal 1 when treated municipalities received ABC Program credit for the first, second and third time, respectively, and in all the following years. $trend_{it}$ is the interaction between municipality and year. Climate variables refer to the deviation of maximum temperature, minimum temperature, humidity, wind and solar radiation. Economic variables refer to Natural Logarithm of GDP, agricultural GDP added value on GDP (%), amount of ABC Program funds and amount of other programs funds. Robust standard errors in parentheses. $n=77,415$.

***: if p-value<0.01; **: if p-value<0.05; *: if p-value<0.1;

Briefly, the coefficients of dd_1 were positive and statistically significant in all specifications. In contrast, the coefficients of dd_2 and dd_3 were negative and were not statistically significant in all specifications.

In the model without control variables and municipality-specific trends, the coefficient of dd_1 was equal to .0654, and dropped to .0591 when the municipality-specific trends were included. However, the difference between the coefficients is small. So, as with the coefficients estimated in Table 5, there does not seem to be

relevant influence of municipality-specific trends on the precision of the results. It is a good signal, because models that include specific trends are often imprecise (ANGRIST; PISCHKE, 2015).

In the specification **(3)**, when the climate variables were included in the model, the coefficient varied to .0540 and remained statistically significant with a significance level of 1%. When the economic variables were added, the coefficient reduced to .0394 and became statistically significant only with a significance level of 10%. Finally, with balanced sample (specification **5**), the coefficient was equal to .0378. This means that receiving the credit one time was responsible for an average increase of 3.78% in milk production in the year that the treated municipality received the credit and in all following years. The coefficient estimated in specification **(5)** was statistically significant with a significance level of 10%.

When compared with the results of the regression that does not include the periods after the treatment year (Table 5), the coefficients of dd1 are slightly lower than the d1 ones. It may be attributed to the fact that the effect on the year of treatment is higher than in the years after that. Thus, it seems that the credit has higher effect on production in the short-term, which means that the recovery of degraded pasture should be applied whenever possible.

Table 8 presents the coefficients of the equation 5 by percentiles, including the confidence intervals. It takes into account the lasting effect of the credit. Thus, all years after the receiving of credit is considered treatment ones.

Table 8 – Estimation of equation 5 – logarithm of milk production – 2003-2017.

Variables	Percentiles		
	.25	.50	.75
<i>dd</i> ₁	.0590** (.026)	.0384** (.020)	.0202 (.020)
95% CI (<i>dd</i> ₁)	(.0077 -- .1102)	(.0000 -- .0767)	(-.0180 -- .0584)
<i>dd</i> ₂	-.0223 (.034)	-.0207 (.026)	-.0193 (.025)
95% CI (<i>dd</i> ₂)	(-.0890 -- .0444)	(-.0712 -- .0298)	(-.0690 -- .0305)
<i>dd</i> ₃	-.0575 (.048)	-.0621 (.046)	-.0662 (.051)
95% CI (<i>dd</i> ₃)	(-.1512 -- .0362)	(-.1521 -- .0278)	(-.1663 -- .0338)

Source: elaborated by the author. Municipality and time fixed-effects included. All controls included. Error adjusted with a bootstrap of 1,000 replications based on 5,324 clusters of municipality. *dd*₁, *dd*₂ and *dd*₃ equal 1 when treated municipalities received ABC Program credit for the first, second and third time, respectively, and in all the following years.. Standard errors in parentheses. n=77,415. ***: if p-value<0.01; **: if p-value<0.05; *: if p-value<0.1.

According to Table 8, *dd*₂ and *dd*₃ were negative and were not statistically significant in all percentiles. On the other hand, the coefficient of *dd*₁ was positive at 25th, 50th and 75th percentiles, yet it was not statistically significant at 75th percentile.

At 25th percentile, the coefficient of *dd*₁ was .0590, and it was significant at a 5% level. The coefficient dropped to .0384 at the 50th percentile, and remained statistically significant at a 5% level. At the 75th percentile, however, the coefficient dropped to .0202 and was not statistically significant. Thus, this finding provide signs that the ABC credit did not present effect in years post-treatment in municipalities that were in higher percentiles, as both *dd*₁, *dd*₂ and *dd*₃ were not statistically significant at 75th percentile. The main conclusion of Table 8 is that the credit affected positively the municipalities contained at 25th and 50th percentiles in the first-treatment year and in the years after that. However, it is not clear whether there was a positive effect of the credit in municipalities contained at 75th percentile, since the Table 8 shows that the coefficients were not statistically significant.

As in the Table 6, which does not include the years after the treatment year, the Table 8 shows that the median value of the coefficient dd_1 decreases as the percentile gets higher. On the other hand, different from Table 6, the Table 8 does not provide signs that there was a positive effect of the ABC Program on milk production of the municipalities in the .75 percentile.

In general, the results contained in Tables 5, 6, 7 and 8 provided signs that the milk production increased even when the climate and economic variables were included in the model. Also, it seems that the effect was statistically equal between the different percentiles. Thus, it can be concluded that, even though the credit funds have been concentrated in Midwest of Brazil, the effect on the low percentile of milk production was positive and statistically equal to the effect on the 75th percentile, and so, the effect could be higher if the funds were more directed to areas that present lowest land productivities. In addition, fostering the adoption of ABC credit in areas that presented low land productivity would be more beneficial to the environment, since Leal (2016) and Gianetti (2017) showed that the potential of mitigation in areas with more degraded areas is higher than in places that have actually received the credit funds. Finally, the results presented in this subsection did not provide evidence that the second-time and third-time treatments (when the municipality receive the credit for the second and third time) play an important role on milk production.

4.3 Animal Stocking Rate

This subsection presents the effect of ABC Program credit on Animal Stocking rate. The Table 9 shows the results of the Equation 3.

Table 9 – Equation 3 estimation – animal stocking rate – 2003-2017.

Variables	Specifications				
	(1)	(2)	(3)	(4)	(5)
d_1	.1650*** (.023)	.0874*** (.022)	.0755*** (.022)	.0868*** (.023)	-.0424 (.035)
d_2	.1736*** (.027)	.0413 (.033)	.0175 (.031)	.0437 (.034)	-.0773 (.050)
d_3	.1905*** (.033)	-.0908* (.050)	-.1684*** (.048)	-.1302** (.052)	-.1763** (.068)
Constant	1.8836*** (.014)	-296.86*** (13.01)	-245.39*** (12.07)	-237.58*** (11.97)	-90.90*** (7.58)
$trend_{it}$	No	Yes	Yes	Yes	Yes
climate variables	No	No	Yes	Yes	Yes
economic variables	No	No	No	Yes	Yes
entropy balancing	No	No	No	No	Yes
R^2	0.8816	0.8883	0.8896	0.8899	0.8853

Source: elaborated by the author. Municipality and time fixed-effects included. Error adjusted for 5,330 clusters of municipality. Errors in the specification (5) were adjusted with a bootstrap of 1,000 replications. d_1 , d_2 and d_3 equal 1 when treated municipalities received ABC Program credit for the first, second and third time, respectively. $trend_{it}$ is the interaction between municipality and year. Climate variables refer to the deviation of maximum temperature, minimum temperature, humidity, wind and solar radiation. Economic variables refer to logarithm of GDP, agricultural GDP added value on GDP (%), amount of ABC Program funds and amount of other programs funds. Robust standard errors in parentheses. n=77,688. ***: if p-value<0.01; **: if p-value<0.05; *: if p-value<0.1;

According to the results, the coefficients of d_1 were positive and statistically significant with a significance level of 1% in all specifications, except in specification (5). In this specification, the coefficient of d_1 was negative and was not statistically significant.

The coefficient of d_1 equaled .1650 in specification (1), then dropped to .0894 when the municipality-specific trend was included. After the climate variables were included (specification (3)), the coefficient reduced to .0755, and then it increased to .0868 when the economic variables were added to the model. Finally, with balanced

sample data, in specification **(5)**, the coefficient was negative and was not statistically significant. This finding does not provide a robust conclusion to the effect of first-time treatment since the coefficient changed drastically in balanced sample data. So, it means that the difference of the observed characteristics (including the animal stocking rate) of the treated municipalities and the control ones may played an important role on the estimation of the coefficient of d_1 , and then, after the entropy balancing was applied – which takes into account the observed characteristics of the municipalities, and seeks to gives weight to each control ones-, the effect of first-time treatment became statistically null. In addition, it could be seen that the coefficient had already varied a lot when the municipality-specific time trend was added to the model, and so, it is not possible to assure that the coefficient is unbiased (ANGRIST AND PISCHKE, 2015).

The coefficient of d_2 was positive and statistically significant only in the specification **(1)**. In the specifications **(2)**, **(3)** and **(4)** the coefficient of d_2 was positive, but was not statistically significant. Finally, in the specification **(5)**, the coefficient of d_2 was negative and was not statistically significant.

Finally, the coefficient of d_3 was statistically significant in all specifications. However, in the specification **(1)** the d_3 value was positive. After the inclusion of the specific-municipality trend the coefficient has become negative. For that, we should be cautious by analyzing this finding: since the inclusion of the municipality-specific time trend made the coefficient of d_3 varies drastically it could mean that the common trends assumption cannot be relaxed, and so, the differences-in-differences coefficients would be biased (ANGRIST AND PISCHKE, 2015). However, it is important to notice that the coefficient remained negative in the specifications **(3)**, **(4)** and **(5)**. One possible reason for that result is that the recovered pasture area is now being used for cultivate another crop other than milk or cattle-related activities in these municipalities.

It is important to analyze if the negative effect of d_3 remain in all percentiles. The Table 10 presents the results of the estimation of Equation 4.

Table 10 – Equation 4 estimation – animal stocking rate – 2003-2017

Variables	Percentiles		
	.25	.50	.75
d_1	.0625*** (.024)	.0830*** (.023)	.1075*** (.024)
95% CI (d_1)	(.0147 -- .1104)	(.0379 -- .1281)	(.0597 -- .1553)
d_2	.0254 (.034)	.0408 (.033)	.0591* (.035)
95% CI (d_2)	(-.0418 -- .0926)	(-.0267 -- .1082)	(-.0097 -- .1281)
d_3	-.1020** (.041)	-.1257*** (.049)	-.1542** (.062)
95% CI (d_3)	(-.1819 -- -.0220)	(-.2203 -- -.0310)	(-.2764 -- -.0320)

Source: elaborated by the author. Municipality and time fixed-effects included. All controls included. Error adjusted with a bootstrap of 1000 replications based on 5,330 clusters of municipality. dd_1 , dd_2 and dd_3 equal 1 when treated municipalities received ABC Program credit for the first, second and third time, respectively, and in all the following years. Robust standard errors in parentheses. n=77,688. ***: if p-value<0.01; **: if p-value<0.05; *: if p-value<0.1.

Briefly, the results contained in Table 10 shows that the coefficients of d_1 were positive and statistically significant at the 25th, 50th and 75th percentiles. The coefficients of d_2 were positive in all percentiles as well. However, only at 75th percentile the coefficient was statistically significant in a confidence level of 10%. Lastly, the coefficients of d_3 were negative and statistically significant in all percentiles. This result shows that the negative effect of the third-treatment year occur not only in the municipalities that historically are great milk producers, but also in the municipalities located in the low percentiles.

By analyzing the results, it seems that producers increase their cattle in the first-treatment year, while in the third-treatment year they use the recovered pasture to produce another crop. Yet, one another explanation is that the producers are investing in genetically modified animals rather than increase their cattle with common animals. This practice could raise the production of milk, even though the animal stocking rate decreases.

The Table 11 estimates the equation 3. It is estimated an linear regression that take into account that the effect of receiving credit from ABC Plan endures for the years following the treatment year (i.e. year that municipality receive credit).

Table 11 – Estimation of equation 3 – animal stocking rate – 2003-2017.

Variables	Specifications				
	(1)	(2)	(3)	(4)	(5)
dd_1	.2176*** (.027)	.1173*** (.027)	.0927*** (.026)	.0961*** (.028)	-.0470 (.046)
dd_2	-.0268 (.035)	-.0994** (.037)	-.1098*** (.036)	-.0975*** (.037)	-.0831** (.039)
dd_3	-.0310 (.036)	-.0934*** (.047)	-.1405*** (.046)	-.1287*** (.045)	-.0725* (.039)
<i>constant</i>	1.8836*** (.014)	-296.15*** (13.04)	-245.15*** (12.10)	-237.34*** (11.99)	-91.26*** (7.48)
$trend_{it}$	No	Yes	Yes	Yes	Yes
<i>climate variables</i>	No	No	Yes	Yes	Yes
<i>economic variables</i>	No	No	No	Yes	Yes
<i>entropy balancing</i>	No	No	No	No	Yes
R^2	0.9320	0.9321	0.9324	0.9333	0.9330

Source: elaborated by the author. Municipality and time fixed-effects included. Error adjusted for 5,330 clusters of municipality. Errors in the specification (5) were adjusted with a bootstrap of 1,000 replications. dd_1 , dd_2 and dd_3 equal 1 when treated municipalities received ABC Program credit for the first, second and third time, respectively, and in all the following years. $trend_{it}$ is the interaction between municipality and year. Climate variables refer to the deviation of maximum temperature, minimum temperature, humidity, wind and solar radiation. Economic variables refer to Natural Logarithm of GDP, agricultural GDP added value on GDP (%), amount of ABC Program funds and amount of other programs funds. Robust standard errors in parentheses. n=77,688.

***: if p-value<0.01; **: if p-value<0.05; *: if p-value<0.1;

First of all, the coefficients of dd_1 were positive and statistically significant in all specifications, except in the specification (5). In this specification, the coefficient of dd_1 was negative and was not statistically significant. Thus, the result is not as robust as those found in the analysis of milk production. Besides, the coefficient of dd_1 varied

from .2176 to .1173 when the municipality-specific time trend was included. In percentage terms, it has reduced by 46.09%, which can be considered a huge value. Therefore, the coefficient it is not possible to conclude that the coefficient is unbiased.

This same conclusion can be made for the coefficients of dd_2 and dd_3 . In the former, the coefficient varied from -.0268 to -0.0994, which means an increase of 270.90%. The coefficient of dd_3 varied from -.0310 to -.0934, an increase of 201.29%.

Despite the estimators do not appear unbiased, it is important to see the dynamic of the coefficient throughout the percentiles. However, the quantile regression package used to estimate the Table 12 does not allow the inclusion of the weights calculated in entropy balancing.

Table 12 – Estimation of equation 5 – animal stocking rate – 2003-2017.

Variables	Percentiles		
	.25	.50	.75
dd_1	.0654** (.030)	.0912*** (.027)	.1221*** (.028)
95% CI (dd_1)	(.0066 -- .1241)	(.0389 -- .1435)	(.0667 -- .1771)
dd_2	-.1000** (.044)	-.0979** (.038)	-.0954*** (.034)
95% CI (dd_2)	(-.1871 -- -.0129)	(-.1729 -- -.0230)	(-.1629 -- -.0290)
dd_3	-.0806* (.045)	-.1211*** (.042)	-.1695*** (.052)
95% CI (dd_3)	(-.1680 -- .0068)	(-.2041 -- -.0381)	(-.2722 -- -.0668)

Source: elaborated by the author. Municipality and time fixed-effects included. All controls included. Error adjusted with a bootstrap of 1000 replications based on 5,330 clusters of municipality. dd_1 , dd_2 and dd_3 equal 1 when treated municipalities received ABC Program credit for the first, second and third time, respectively, and in all the following years. Robust standard errors in parentheses. n=77,688. ***: if p-value<0.01; **: if p-value<0.05; *: if p-value<0.1;

According to Table 12, the lasting effect of the first-time treatment of ABC credit was positive and statistically significant at all percentiles. On the other hand, dd_2 and dd_3 presented negative and statistically significant coefficients at all percentiles.

In summary, the results were not conclusive about the effect of the ABC Program's recovery of degraded pastures subprogram on the animal stocking rate of

the treated municipalities. It seems that the dynamic of this variable is more correlated with the municipality-specific time trend than with the adoption of the program. It would be important to analyze another variable that could be considered a proxy of degraded pasture area.

5 CONCLUSIONS

This work aimed calculate the effects of ABC Program Credit for pasture recovery on milk production and degraded pasture (through the analysis of stocking rate). As specific objectives, this research aimed to: (i) To describe the distribution of the funds of ABC Program's recovery of degraded pasture subprogram, milk production and animal stocking rate; (ii) to compare and balance the agricultural, climatic and economic variables of the treated and non-treated municipalities before the implementation of the Program; (iii) To measure whether the effect was the same in the different percentiles.

For that, since there are available data for the pre- and post-policy periods, we opted to use the differences-in-differences method. The data.....

The hypothesis is that the Program positively affected the milk production of the treated municipalities, as well as their animal stocking rates. In addition, it was expected that the effect was larger in municipalities that received the credit for more than one period.

In summary, the distribution of the credit for recovering of degraded pasture was concentrated in states located in Midwestern Brazil and the MATOPIBA region. On the other hand, the most of the municipalities that presented lowest animal stocking rates was located in the Northeast of Brazil. Finally, the distribution of milk production is more concentrated in the States of Minas Gerais and Goiás.

Furthermore, it was analyzed the summary of the different components of the municipalities before the program, in order to balance the sample data. The control and treated groups were different before the program, especially regarding the GDP and the Added Agricultural Value on GDP (%). After that, the sample of control units was weighted through the implementation of entropy balancing. After the balancing, it could be noted that the Kernel density of the logarithm of milk production was very similar between the treatment and control groups. This also occurred for the animal stocking rate variable. Plus, it was observed that the mean, variance and skewness of all variables, including the dependent variables and the control ones, were quite similar after the entropy balancing.

Regarding milk production, in general, the results showed that municipalities that received some amount of credit of recovery of degraded pasture area from ABC Program increased their milk production. Also, the results do not provide evidence to the existence of larger effects on municipalities that were treated in more than one

period when compared to those that were treated just once. In addition, the effects remained positive and statistically significant at 25th, 50th and 75th percentiles.

It was also tested whether the effects exist only in the first year, or if they last for years after the first year of treatment. The results provided signs that the effect in the first year of the first treatment is greater to the effect in following years, since the median values of the coefficients were lower in the regressions that include the years after the treatment period. On the other hand, when it was tested if the effect is the same between the quantiles, it was noted that the lasting effect of the first-time treatment was not statistically significant at the 75th percentile, while at the 25th and 50th percentiles it could be noted that the effect was positive and statistically significant. Finally, as in the model that take into account just the period that the city received the treatment as the year of treatment, it was not observed that existed larger effects in municipalities that received credit for more than one year when compared to those that were treated once.

On the other hand, it was not conclusive that the ABC Program affected the animal stocking rate in the first and second-time treatment. However, it seems that the third-time treatment had a negative effect on the animal stocking rate in the treated municipalities. This effect remains in the more robust specifications, and it is present in the 25th, 50th and 75th percentiles. A possible reason for that is that producers are investing in animals with more quality – genetically modified animals – rather than increase the number of cows relevantly. In this case, they are preferring quality over quantity.

Regarding to the Program ABC itself, it has been a challenge to this policy to achieve farmer adoption. In all the years of the program period, the total amount supplied was higher than the total amount demanded (OBSERVATORIO ABC, 2017a). Therefore, it is clear that the Program has not succeeded to reach individuals who would need resources to implement conservationist practices on their farms. Additionally, according to some specialists, bureaucracy and misinformation seem to be obstacles to the adoption of the farmers (SANTOS, 2019).

Thus, it is important to examine ways to reduce the obstacles to adoption of the Program ABC by farmers. It would be very important borrow the credit funds to those who are motivated to implement conservationist practices, but cannot afford it. The results showed that the ABC credit has a positive impact on milk production, and this type of information could help policymakers to convince those that are reluctant to take

out loan that the pasture recovery is beneficial both to the environment and agricultural production.

This research is limited by the fact that there is not a database that provide information about the time series of the degraded pasture area of the municipalities. For that, it was utilized data about animal stocking rate. However, it is not assured that analyzing this variable in absolute value is a strong proxy for degraded pasture. Therefore, it would be relevant to work collectively with LAPIG to produce a time series of degraded pasture utilizing the methodology to calculate the degraded pasture area that LAPIG already used for the year of 2017. In addition, this research is limited in analyzing the local effect of the Program. Given the availability of data, the analysis was made in a municipality-level. However, it would be more robust if the analysis was made in specific areas that received the credit.

Finally, it is important to analyze the effect of the ABC Program as the government spends funds to its implementation. Since resources are limited, the government should examine whether it is worth to keep investing in the ABC Program. Therefore, for future researches, it is recommended to analyze the economic viability of the ABC Program's recovery of degraded pasture subprogram, utilizing the coefficients of the effects on the milk production calculated in this research. In addition, it is recommended to analyze the effects of this subprogram in the GHG emissions. For that, it would be important to capture the effect in the specific locations that have received the credit, and compare to those areas that have not received. For example, it would be relevant to utilize data from GPS to calculate the effect of the program in specific locations that received the credit.

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Appendix

Appendix A – Kernel densities of the explanatory variables

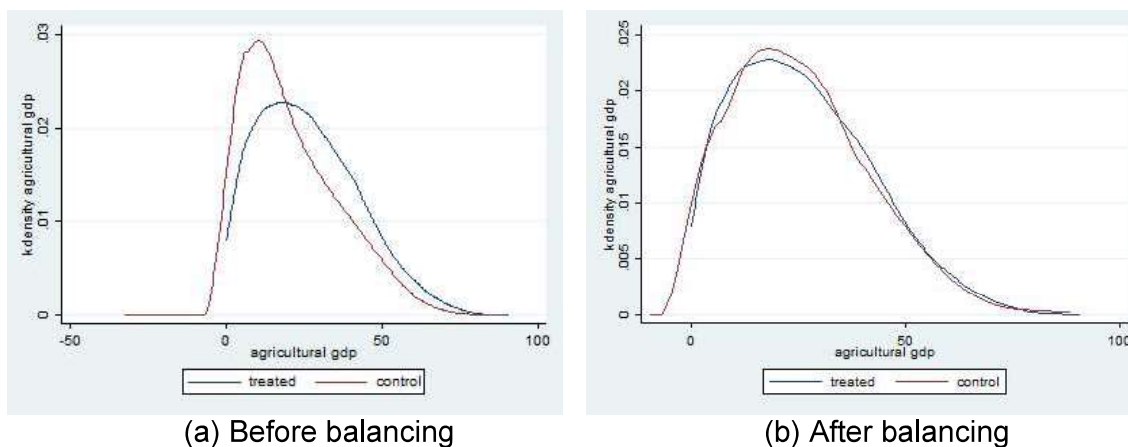


Figure A-1 – Added value of agriculture on GDP - Kernel density – 1st, 2nd and 3rd orders balancing – before and after.
Graphics generated on Stata. “ebalance” code.

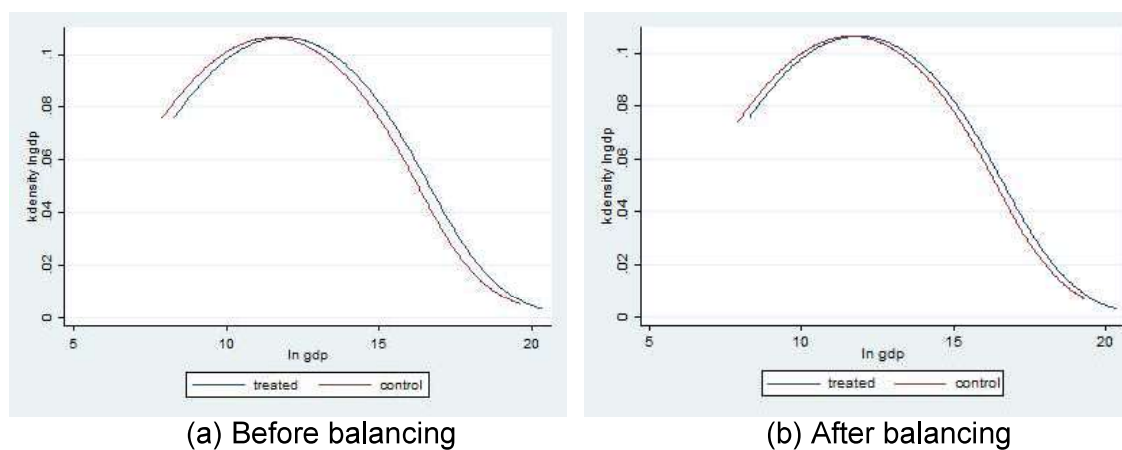


Figure A-2 – Natural Logarithm of GDP - Kernel density – 1st, 2nd and 3rd orders balancing – before and after.
Graphics generated on Stata. “ebalance” code.

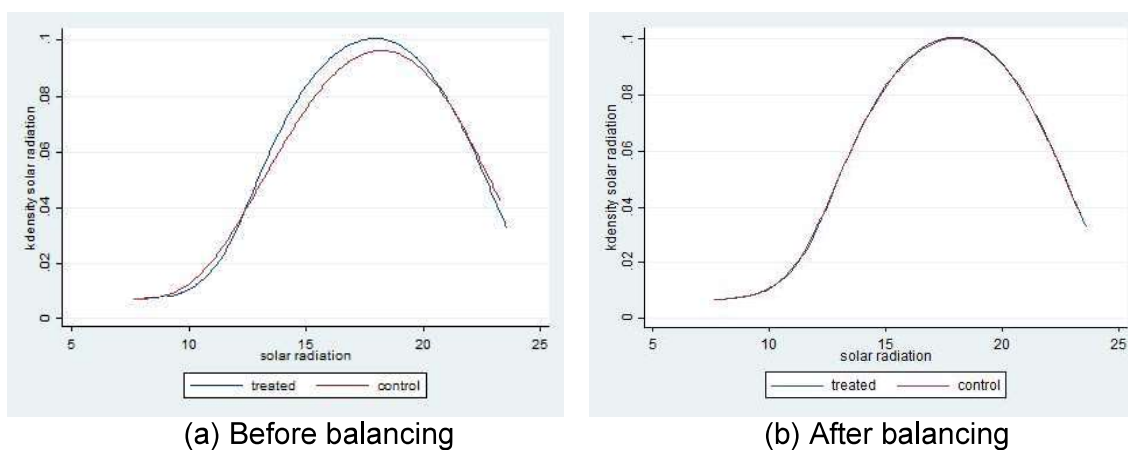


Figura A-3 – Solar radiation - Kernel density – 1st, 2nd and 3rd orders balancing – before and after.

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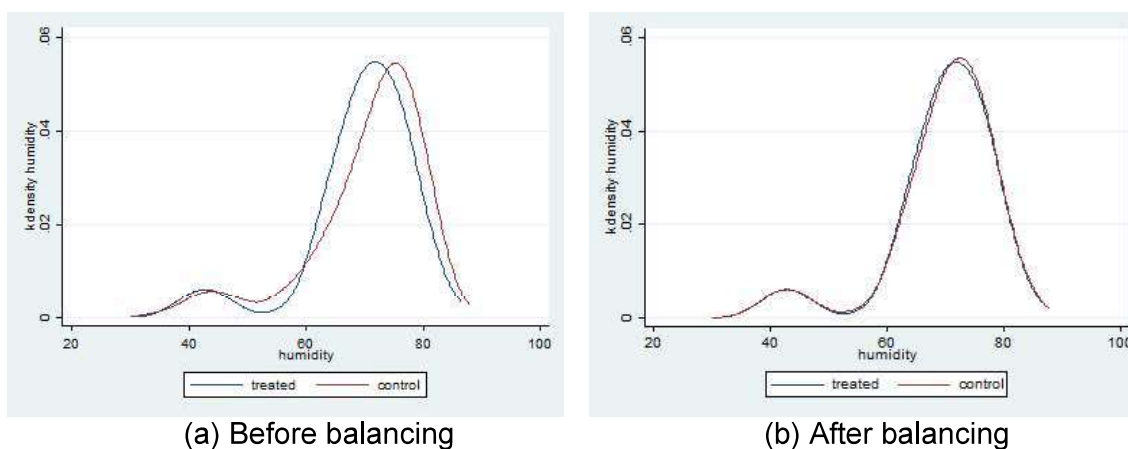
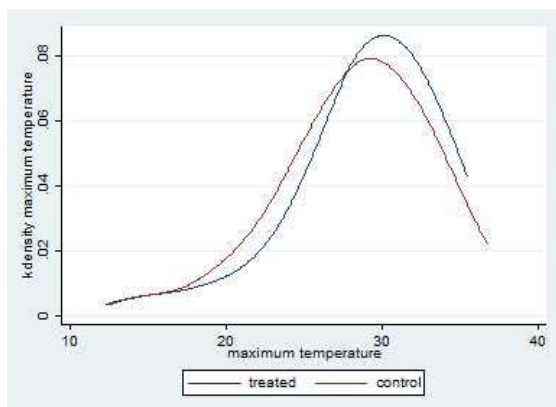
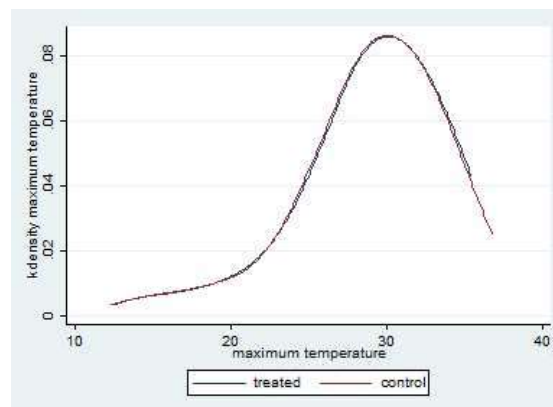


Figura A-4 – Relative humidity of the air - Kernel density – 1st, 2nd and 3rd orders balancing – before and after.

Graphics generated on Stata. “ebalance” code.

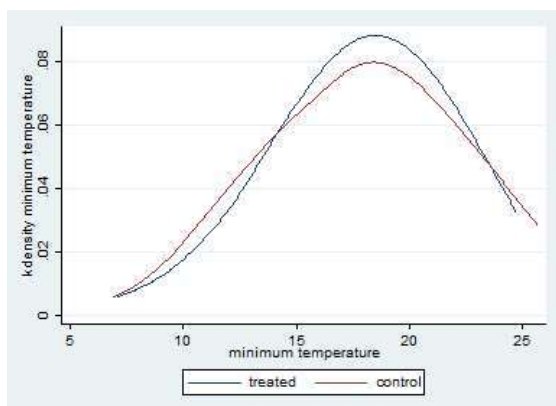


(a) Before balancing

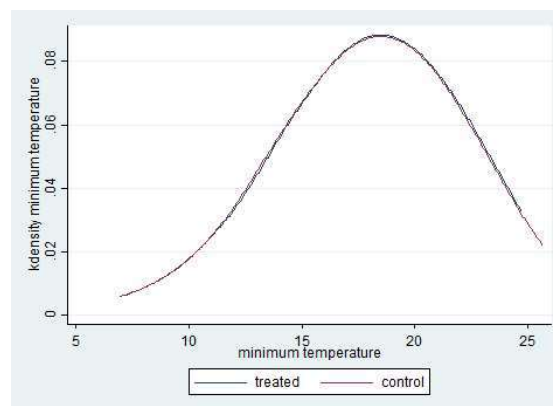


(b) After balancing

Figura A-5 – Maximum temperature - Kernel density – 1st, 2nd and 3rd orders balancing – before and after.
Graphics generated on Stata. “ebalance” code.



(a) Before balancing



(a) After balancing

Figura A-6 – Minimum temperature - Kernel density – 1st, 2nd and 3rd orders balancing – before and after.
Graphics generated on Stata. “ebalance” code.

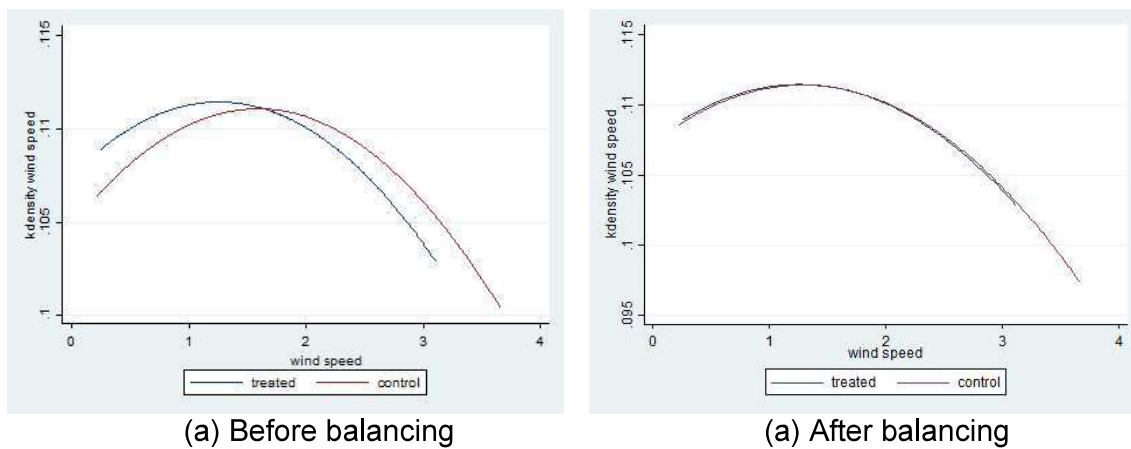


Figura A-7 – Wind speed - Kernel density – 1st, 2nd and 3rd orders balancing – before and after.
Graphics generated on Stata. “ebalance” code.