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Essays on Public Policies in the Brazilian Northeast

Renata de Melo Caldas

Tese de Doutorado

Recife
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Abstract

This dissertation evaluates three different public policies implemented in Brazil with the main objective of reducing regional inequalities and improving life conditions of the poorest region of the country, the Northeast.

In the first chapter, I analyze the impact of the Constitutional Financing Program (FNE) on income and employment at municipality level. Data are from the Brazilian demographic censuses and FNE dataset, provided by the Bank of Northeast, for 2000 and 2010. There is a discussion about the inclusion of new municipalities in semi arid delimitation in Brazil. The main argument is that these municipalities would benefit from the FNE, which has better benefits for those inside semi arid area, such as smaller interest rates and longer financing terms and limits. Using difference-in-differences estimation, I analyze the relationship of microcredit program on income or employment, using the Census 2000 as the baseline and the Census 2010 as the post-treatment period. I do not find a relationship of microcredit program on income or employment, and one possible reason for this is the fact that new municipalities are not taking more funding from FNE.

The second chapter evaluates the effectiveness of a public irrigation project implemented in *Litoral do Camocim e Acaraú* micro-region, at Ceará state, in the Northeast region of Brazil. The dataset is based on individual Censuses data of 2000 and 2010, capturing pre and post period of an irrigation project's implementation in the region, which happened in 2001. Although the literature points to a positive relationship between irrigation and income, I find, in general, a negative and significant impact of irrigation on main wages, total wages and productivity. One of the reasons for this unexpected result is that workers may switch to agricultural sector and become family farmers, who produce for their own consumption. In this way, even though they do not have higher wages, they may be better off in terms of consumption and nutrition. When analyzing the impact on specific products produced at *Baixo Acaraú* irrigated area, the coefficients are positive and significant at 1%.

Finally, the third and last chapter analyzes the impact of intergovernmental transfers on inter and intra-regional inequalities in Brazil. Taking advantage of the discontinuities of the Municipalities Participation Fund (FPM) – an important intergovernmental transfer – this paper uses a regression discontinuity design to identify the causal impact of FPM transfers on regional economic growth rates. I find that an increase in FPM transfer impacts positively on economic growth rate of the poorest region of the country (Northeast) and has no significant impact on the richest region (Southeast), which indicates a decrease in the inter-regional inequality. Nonetheless, I find that the improvements on growth rates achieved by the Brazilian Northeast are driven by the richest municipalities. These results suggest that even though intergovernmental transfers help poor regions catching up intra regional inequalities may increase.

Keywords: Applied Econometrics, Brazilian Northeast, Impact Evaluation, Intergovernmental Tranfers, Irrigation, Microcredit

Resumo

Esta tese avalia três diferentes políticas públicas implementadas no Brasil com o principal objetivo de reduzir as desigualdades regionais e melhorar as condições de vida e indicadores socioeconômicos da região mais pobre do país, o Nordeste.

O primeiro capítulo analisa os impactos do Fundo Constitucional de Financiamento do Nordeste (FNE) sobre renda e emprego a nível municipal. A base de dados foi obtida em parte dos Censos Demográficos, fornecidos pelo Instituto Brasileiro de Geografia e Estatística, e em parte do Banco do Nordeste, para os anos de 2000 e 2010. Existe uma discussão na literatura sobre a inclusão de novos municípios na região do semiárido brasileiro, após a mudança nos seus critérios de elegibilidade. O principal argumento é que esses novos municípios do semiárido beneficiar-se-iam mais do FNE do que antes, uma vez que municípios do semiárido possuem benefícios extras como menores taxas de juros e maiores prazos de financiamentos. Utilizando o método diferença-em-diferenças, não foram encontrados efeitos do programa de microcrédito sobre renda ou emprego dos municípios tratados. Uma possível explicação para isto é o fato de os novos municípios não aproveitarem dos benefícios extras e não pegarem mais empréstimos pelo programa.

O segundo capítulo avalia a eficiência dos projetos públicos de irrigação instalados pelas agências de desenvolvimento na região Nordeste desde a década de 1970. Foi utilizado o caso do Projeto Baixo Acaraú, localizados na microrregião do Litoral do Camocim e Acaraú, no estado do Ceará. A base de dados utiliza informações individuais obtidas nos Censos Demográficos de 2000 e 2010, capturando os períodos pré e pós-tratamento, dado que o projeto de irrigação teve sua primeira etapa concluída em 2001. Embora a literatura aponte para uma relação positiva entre irrigação e renda, este artigo encontra, em geral, um impacto negativo e significante sobre o salário principal, todos os salários e a produtividade. Uma das razões para este resultado inesperado é que trabalhadores podem ter passado a trabalhar no setor agrícola após a implementação do perímetro irrigado, e terem se tornado produtores familiares, que produzem para o auto-consumo. Desta forma, embora eles não tenham tido impacto positivo sobre sua renda, eles podem estar melhores em termos de consumo e nutrição. Quando analisado o impacto sobre produtos específicos produzidos na área irrigada do Baixo Acaraú, os coeficientes são positivos e significantes a 1%.

Por fim, o terceiro e último capítulo analisa o impacto das transferências intergovernamentais sobre as desigualdades inter e intra regionais no Brasil. Aproveitando-se das descontinuidades no repasse do Fundo de Participação dos Municípios (FPM), este artigo utiliza o método de regressão descontínua para identificar o impacto causal das tranferências do FPM sobre a taxa de crescimento econômico dos municípios brasileiros. Foram utilizados dados das transferências do ano de 2010 e a taxa de crescimento econômico foi calculada entre os anos 2011 e 2013, baseado em dados obtidos no Ipeadata. Dentre os resultados, identificou-se que um aumento nas transferências do FPM impacta positivamente no crescimento econômico na região mais pobre do país (Nordeste) e que não tem impacto sobre a região mais rica (Sudeste), o que sugere uma diminuição na desigualdade inter regional do Brasil, que é uma das mais elevadas do mundo. No entanto, as melhorias no crescimento econômico na região Nordeste foram guiadas pelos municípios mais ricos. Este resultado sugere que, embora as tranferências intergovernamentais ajudem as regiões pobres a crescerem, a desigualdade inter-regional deve aumentar.

Palavras-chave: Econometria Aplicada, Nordeste Brasileiro, Avaliação de Impacto, Transferências Intergovernamentais, Irrigação, Microcrédito

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CHAPTER 1

Impacts of Microcredit Programs on Employment and Income in the Brazilian Semiarid Area

1.1 Introduction

There is a huge body in Brazilian literature which shows how adverse the living conditions in the semi arid region are, specially related to socioeconomic aspects. Some assign a big share of the backwardness of this region to local climate and soil conditions whereas there is a huge dependence on the semi arid area by the agricultural sector. For this reason, the Brazilian Government delimited geographically the semi arid region as a group of municipalities with more adverse climate condition, such that they can focus some public policies to develop this area specifically. Before 2004, the only criterion which defined semi arid area used to be precipitation. After that, using a study by Inter-ministerial Work Group for Redefinition of the Northeastern Semi Arid and Drought Polygon Areas, two new criteria have been established: aridity index and drought risk.

Among all policies established by Federal Government supporting the semi arid area, the Northeast Financing Constitutional Fund (*Fundo Constitucional de Financiamento do Nordeste* - FNE[1]) is the most important. The main concern of this microcredit program is to offer financing to investment projects focusing on the Northeast's development, besides the north of Minas Gerais and Espírito Santo states[2]. The primary objective of this policy is to contribute with the reduction of regional inequality in Brazil, which is one of the highest in the world (Gomes, 2002).

The worldwide literature on microcredit is very developed, but there is still no consensus about the effectiveness of these programs. Many papers analyze microcredit programs' impacts using Bangladesh as a case study (Roodman and Morduch, 2009; Pitt and Khandker, 1998; Morduch, 1998; Khandker, 2005). Pitt and Khandker (1998), for example, using a

[1]Most of the acronyms is written in Portuguese.

[2]Although Minas Gerais and Espírito Santo states belong to the Southeast region, they are areas supported by the Superintendency for the Development of the Northeast (*Superintendência de Desenvolvimento do Nordeste* - SUDENE) because of the adverse socio-economic-climate characteristics, which are very similar to the Northeast region.

quasi-experimental survey, found that the effects of the program in Bangladesh on labor supply, schooling, household expenditures and assets are bigger when the credit is provided to women. Morduch (1998), however, using the same dataset to analyze the same microcredit program for Bangladesh during 1991-92, found the opposite result. The main argument was based on selection bias. Roodman and Morduch (2009) also indicated no impact on microcredit policy even ten years later. Impact evaluation of microfinance programs, according to Morduch (1998), is complicated because of the non-randomness of the program placement and the clients' participation, which generate bias in the estimation. This is one of the reasons Banerjee et al. (2015) highlighted that there is no consensus in the literature on the impacts of microcredit on society.

In Brazil, the literature on microcredit policies in less developed areas, such as in the semi arid area, is still scarce. Some papers, such as Rodrigues and Guilhoto (1998) and Gonçalves et al. (2014), analyzed the microcredit policy in Brazil and found a positive and significant effect of FNE on economic outcomes, although Rodrigues and Guilhoto (1998) believe these effects could be even bigger if loans had been allocated more efficiently. However, Silva et al. (2007) did not find any effect of the program on employment and income between 1995 and 2000. Therefore, in this paper I use the expansion of the semi arid border as a quasi natural experiment to analyze the strategy of reduction in the intra regional inequality using FNE policy. The outcomes of interest are measured by per capita income and employment rate. I assume municipalities which are just outside the semi arid boundary (first order neighbors) may have very similar characteristics to their neighbors inside boundary, such as climate and socioeconomic conditions.

I use data at municipality level, collected from different sources, such as the Brazilian Demographic Censuses of 2000 and 2010, from the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE) and FNE database provided by the Brazilian Northeastern Bank (*Banco do Nordeste do Brasil* - BNB) which is the microfinance agency that lends public money to the population. Some other information about semi arid region's characteristics can be found in the Information Management System of the Brazilian Semi Arid Area (*Sistema de Gestão da Informação e do Conhecimento do Semiárido Brasileiro* - SIGSAB) collected by the National Semi Arid Institute (*Instituto Nacional do Semiárido* - INSA) with information about drought incidence, isohyets, among other climate and soil variables.

The empirical strategy used is a difference-in-differences (DD) estimation, using the Census 2000 as the baseline, pre-treatment, and the 2010 as the post-treatment. The treatment here is the inclusion of 102 municipalities in the semi arid area, that happened in the year of 2005, which is considered the treated group. The main finding shows that being inside the semi arid area has no effect on per capita income or employment rate. In fact, FNE could be an important instrument of decreasing regional inequalities, as has been showed by Rodrigues and Guilhoto (1998) and Gonçalves et al. (2014), but the strategy of reducing intra-regional inequality is still not efficient.

Besides this introduction, this paper is divided in four more sections. The second section deals with a general characterization of Brazilian semi arid area, highlighting the criteria established by the Brazilian Federal Government to identify which municipalities should be part of this area and the public investment programs for development of the Northeast and semi arid lands, specifically the Constitutional Fund for Development of the Northeast. The following section presents the dataset and methodology used to identify the causal effect of eligibility criteria on employment and income levels at semi arid municipalities. Finally, the main results and the conclusion will be discussed.

1.2 Case Study: Northeast of Brazil

According to the document of the new delimitation of Brazilian semi arid area (Secretaria de Políticas de Desenvolvimento Regional, 2005), this region was initially defined based on Law n. 7,827, of December the 27^{th} of 1989, as an area under the responsibility of the SUDENE[3], and which the annual precipitation level could not exceed 800mm. In 2005, with the creation of the Inter-ministerial Work Group for Redefinition of the Northeastern Semi Arid and Drought Polygon Areas (*Grupo de Trabalho Interministerial para Redelimitação do Semiárido Nordestino e do Polígono das Secas* - GTI), two other criteria to select the municipalities in semi arid area were stablished. Thus, to be part of the Brazilian semi arid area, municipalities must have at least one of the three following criteria, starting in 2005 (Brasil, 2005):

1. Annual rainfall equal or less than 800 mm;
2. Aridity index less than 0.5 (calculation is based on water balance which measure the ratio of rainfall and potential evapotranspiration, between the period of 1961 and 1990; and
3. Drought risk higher than 60%, based on calculations between 1970 and 1990.

Table 1.1 present the number of municipalities in each state was included in the semiarid region by eligibility criteria. As one can see, column “Total” does not represent the sumation

[3] SUDENE is an institution created in 1959 with the objective of developing socio-economically the Northeastern region, by modernizing the transportation, electricity and sewage systems, and investing in Federal Universities in the region. This institution was dismantled in 2001 after the big depression in the 1980’s, but it was recreated in 2007.

Table 1.1: Municipalities attended criteria

State	Rainfall	Aridity Index	Drought risk	Total
Piauí	0	15	13	18
Ceará	0	2	14	16
Rio Grande do Norte	2	4	7	7
Pernambuco	0	0	4	4
Alagoas	0	0	3	3
Sergipe	0	0	1	1
Bahia	0	0	8	8
Minas Gerais	9	0	45	45
Total	11	21	95	102

Note: Column “Total” does not represent the summation of the other columns because to be elegible to the semiarid area they need to attend to at least one of the criteria. Therefore, some municipalities attend to more than one criteria and they are accounted in more than one column.

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Figure 1.1 shows the semi arid area before the year 2005 and the municipalities included after this date. From 1989 to 2004, only 1,031 municipalities used to belong to the semi arid area and they are represented in the Figure 1.1 by the blue areas. After the changes in the law in 2005, another 104 were included, and they are represented by the red areas. One can observe some red spots in the middle of the semi arid area. These municipalities are located in the Piauí state and they were already part of semi arid region before 2005, but they were divided from their original municipality, so they were excluded from the treated group, which is composed by only 102 municipalities. Currently, the semi arid area has a total of 1,135 municipalities, covering all Northeastern states (except Maranhão) and the northern part of Minas Gerais state.

Nowadays, some researchers discuss about the validity of the delimitation criteria established in 2005 (Lemos, 2014). The main argument is whether the data set used to calculate is too old for the current climate change scenery. For the aridity index, the GTI used data from 1961 to 1990 and for the risk of drought from 1970 to 1990. Especially in the last years, with the intensification of climate changes, some argue that the values of these criteria are not valid anymore. Lemos (2014), for example, discusses about the Maranhão case study, the only northeastern state which does not have any municipality in the semi arid area. According to the author, who recalculated the indexes for more recent data, at least fifteen municipalities from this state should be part of the semi arid delimitation.

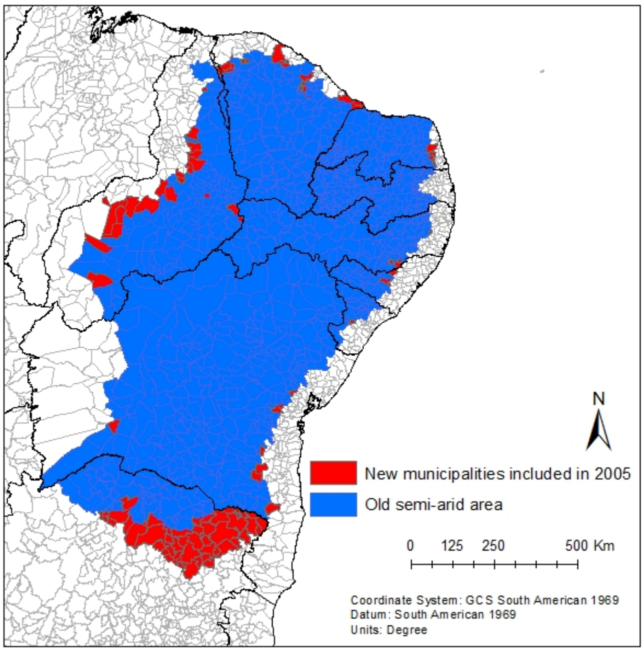


Figure 1.1: Brazilian semi arid municipalities before and after the change in eligibility criteria, in 2005

Source: Author's elaboration.

In the Brazilian Federal Constitution of 1988, the Federal Government created a regional policy agenda called National Policies for Regional Development (PNDR) whose objective is to develop not only the semi arid area, but some other disadvantaged regions, such as the Legal Amazon area. The main instruments of this program are the Constitutional Funds for Development of the Northeast, North and Midwest (FNE, FNO and FCO, respectively). These funds require that 3% of two taxes (income tax and industrialized products tax) should be transferred to these areas as loans for people who wish to be entrepreneurs, of which 1.8% of the fund should be transferred to SUDENE area (Northeast region and the northern part of Minas Gerais state), and the remaining portion is divided between FNO (0.6%) and FCO (0.6%).

FNE gives priority to productive sectors, small farmers and micro-companies and the preference is given to environment preservation projects and those that focus on creation of new dynamic polos. Besides, the interest rates to small farmers and micro-companies are smaller than the ones for bigger companies. For example, interest rates for individual entrepreneurs and micro-companies are about 6.75% per year, but 8.25%, 9.50% and 10.0% per year for small, medium and big companies, respectively (CNI, Confederação Nacional da Indústria, 2013). The terms and limits for financing are also different depending on the size of the company.

Furthermore, there are some other benefits to financing municipalities inside the semi arid area. For instance, 50% of the resource should be transfered to projects in this area. Moreover, FNE offers a timely payment benefit of 15% on interest rate of projects payed up to the due date. If this project is inside semi arid area, however, the discount increases to 25%. Regarding the financing terms, municipalities have up to twelve years with up to four years of grace period, and if they are inside the semi arid area they can receive up to fifteen years of financing terms and up to five years of grace period (CNI, Confederação Nacional da Indústria, 2013). Thus, it is expected an increase in economic outcomes for the new semi arid municipalities after the expansion of semi arid border.

Some studies, such as Almeida et al. (2006, 2007), Rodrigues and Guilhoto (1998) and Macedo and Mattos (2008), have analyzed the structure of FNE and highlight that the loans to less developed municipalities are not given the priority which is given to those municipalities that already have a dynamic economy, like the state capitals. The policy reaches the main objective of reducing regional inequality but, at the same time, it is contributing to an increase of the intra-regional disparities. This paper contributes mainly with the literature on regional inequalities and, in a second plan, with the literature on microcredit in Brazil, using the semi arid area as a case study. The empirical strategy is described in the following section.

1.3 Empirical Strategy

This section describes the data source and the empirical strategy chosen to analyze the differences between municipalities' income and employment for those close to the semi arid boundary.

1.3.1 Data

The data sources are the Brazilian demographic Census of 2000, as the baseline, when the new border of the Brazilian semi arid area had not been published yet, and the Census 2010, collected after the inclusion of 102 municipalities in the semi arid area. I also use data on general characteristics provided by IBGE, such as human development, population, etc., and information about the number of projects and the total amount of loans which were provided by BNB. Finally, information on drought incidence, isohyets, among others variables of climate, topography and soil were collected from SIGSAB, provided by INSA.

We used only individuals between 16 and 65 years old because they are the economically active population. Also, I use data from all Northeastern states plus Minas Gerais. For the employment variable, I consider the people who had been working in a remunerated job during the week of survey or s/he was no working in a remunerated job during the week of survey but s/he was temporarily away from work. FNE rate is a share of the total amount of FNE per month divided by total income from all sources for individuals between 16 and 65 years old. To deflate FNE values, I use price index (INPC) collected from IPEAdata, and accessed in July, the 2^{nd} of 2015.

Tables 1.2 and 1.3 show summary statistics of variables for the main sample, which is composed by the treat group (new municipalities in the semiarid area) and control group (first order municipalities around semiarid area, also called "Outside 1") for years 2000 and 2010, respectively. The variable considered to measure employment rate had an increase of 7.5% and the income per capita increased from 287.30 *reais* in 2000 to 410.20 *reais* in 2010 (42.8%). The education level increased from 0.742 to 1.073, respectively, as well as the average age increased from 27.5 to 31 years between 2000 and 2010. The education level under 1 (one) presented in 2000 represents the average for municipality is up to three years of schooling (*primário incompleto*), while education level greater than 1 and smaller than 2 represents individuals who have between 4 and 7 years of schooling (*fundamental incompleto*) on average. Tables 1.10 and 1.11 in the appendix show summary statistics for the expanded dataset – using the same treated group but "Outside 2" as the control group for years 2000 and 2010, respectively. In this new control group, used as a robustness check, I considered not only the semiarid first order neighbors but also the second order neighbors.

Percentage of rural population decreased from 46.1% in 2000 to 40.6% in 2010, likely after the movement of population from the countryside to big cities looking for new opportunities. IFDM, an annual human development measure, increased from 0.457 to 0.605, where 1 is the highest development level. The number of microcredit (FNE) projects had an increase of 577% in 10 years, from 30 to 203 projects. The amount transferred by these projects increased from 452,521 *reais* to 2,817,270 *reais* (equivalent to an increase of 522%) between 2000 and 2010, in *reais* of 2010. FNE resources come from not only a percentage of Income Tax and Industrialized Product Tax, but also from the interest rate of the previous loans and the remaining resource not used in the previous years. This is one of the reasons the available amount of FNE grows at an increasing rate. Finally, the access to housing services, such as piped water, sewage and electricity have increased 22.7%, 25.8% and 17.2%, respectively.

Table 1.4 presents means and difference of means for the whole Northeast and for a restricted sample composed by first neighbor municipalities (those in the first border inside and outside semi arid area), between the years 2000 and 2010. Analyzing the complete sample for

Table 1.2: Summary statistics 1 (2000)

Variable	Mean	(Std. Dev.)	N
Treated municipalities	0.336	(0.473)	304
Employment rate	0.331	(0.068)	304
Total income per capita	216.702	(74.877)	304
Education	0.65	(0.168)	304
Age	26.671	(1.458)	304
% Rural Pop	0.498	(0.189)	302
% Female Pop	0.496	(0.012)	304
IFDM	0.419	(0.07)	304
FNE projects	25.954	(74.852)	239
FNE deflated	378.336	(1062.783)	239
FNE deflated pc	0.108	(0.208)	239
FNE rate	0.095	(0.203)	239
Piped water	0.638	(0.187)	304
Sewage	0.657	(0.191)	304
Bathroom	0.484	(0.188)	304
Electricity	0.784	(0.167)	304

Note: In this table, I consider only the new municipalities in the semiarid area after 2005 (treated group) and the first order municipalities around semiarid area (control group, also called outside 1) in the year 2000.

Table 1.3: Summary statistics 2 (2010)

Variable	Mean	(Std. Dev.)	N
Treated municipalities	0.334	(0.473)	305
Employment rate	0.348	(0.072)	305
Total income per capita	330.91	(91.349)	305
Education	1.012	(0.17)	305
Age	30.275	(1.663)	305
% Rural Pop	0.447	(0.187)	305
% Female Pop	0.498	(0.012)	305
IFDM	0.581	(0.059)	302
FNE projects	214.807	(249.562)	305
FNE deflated	2550.932	(10667.521)	305
FNE deflated pc	0.578	(1.556)	305
FNE rate	0.177	(0.509)	305
Piped water	0.831	(0.126)	305
Sewage	0.877	(0.113)	305
Bathroom	0.79	(0.13)	305
Electricity	0.959	(0.058)	305

Note: In this table, I consider only the new municipalities in the semiarid area after 2005 (treated group) and the first order municipalities around semiarid area (control group, also called outside 1) in the year 2010.

Table 1.4: Mean differences between 2000 and 2010 samples

	Northeast 2000		Border 2000		Northeast 2010		Border 2010	
Variables	Mean	Diff	Mean	Diff	Mean	Diff	Mean	Diff
FNE Rate	0.13	0.01	0.12	0.04	0.17	-0.06	0.24	0.11
		(0.01)		(0.03)		(0.04)		(0.12)
Income PC	212.57	-12.12	211.40	-1.54	328.08	-18.26	326.74	0.94
		(4.15)**		(8.03)		(5.25)***		(10.29)
IFDM	0.41	-0.01	0.41	0.01	0.58	0.01	0.58	0.01
		(0.00)**		(0.01)		(0.00)**		(0.01)
Education	0.63	-0.02	0.62	-0.00	1.00	-0.03	1.00	-0.01
		(0.01)		(0.02)		(0.01)***		(0.02)
Employment rate	0.32	-0.03	0.33	-0.01	0.34	-0.01	0.34	0.00
		(0.00)***		(0.01)		(0.00)*		(0.01)

Note: This table presents the mean and mean difference for both 2000 and 2010 for four variables: FNE rate, Income PC, IFDM and Education. The table is divided in four groups, where Northeast refers to all the northeastern municipalities and Border refers to municipalities in the boundary inside and outside the semi arid area. “Diff” is the difference of the mean between municipalities inside and outside the semi arid area, where negative sign indicates that the semi arid area has lower levels and positive sign indicates the opposite. Numbers in parenthesis are standard errors.

the Northeast in 2000, I observed that income per capita, IFDM and employment rate were statistically different between municipalities inside and outside the semi arid area. The negative sign in the difference coefficient means that municipalities inside the semi arid area had lower levels of income per capita, human development and employment rate, as expected. In 2010, these differences are still significant and the signs are the same, except for IFDM, which is now positive but very close to zero.

The variable FNE rate, which represents the share of FNE lent by the BNB per month and the total income of individuals, were not different between municipalities’ outcomes inside and outside semi arid area. The sign of this difference is positive in 2000, which means these loans used to be bigger for municipalities inside the semi arid area. In 2010, there is still no difference, but the sign is now negative, meaning that municipalities outside the semi arid borrow, on average, higher amounts than those inside the semi arid area.

The analysis for the whole Northeast does not take into consideration that there is a selection bias of municipalities inside and outside the semi arid area. Thus, I specify a sample which reduces this bias comparing municipalities very similar in the baseline. In this restricted sample, which I call “Border” in Table 1.4, I observed no difference between the means of semi arid (treated) and non-semi arid (control) observations for all of the five variables specified in the table for the years of 2000 and 2010 individually. In 2000, the negative sign in the difference’s coefficients shows that Income PC, Education and Employment rate were smaller in the semi arid municipalities, although this difference was very small. Concerning the “Border” group in 2010, I was expecting a significant difference between treated and control municipalities. However, there is still no difference in terms of means of FNE per capita, Income PC, IFDM, Education and Employment rate. This result could be evidence that being inside the semi arid area had no effect on socio economic outcomes. In other words, possibly federal policies to reduce intra regional inequalities are not being efficient in this area.

1.3.2 Identification Strategy – Difference-in-Differences

To measure the causal effect of the new delimitation of the Brazilian semi arid area on municipalities’ economic outcomes, this paper uses a difference-in-differences approach. The first difference is calculated between the outcome from the treated group (those which were qualified to be part of semi arid area in 2005) and the control group (the municipalities adjacent to the outside border of semi arid area, also called first neighbors municipalities). The second difference is taken between the different periods (2000 and 2010), based on the results of the first difference, as shown in the following equation:

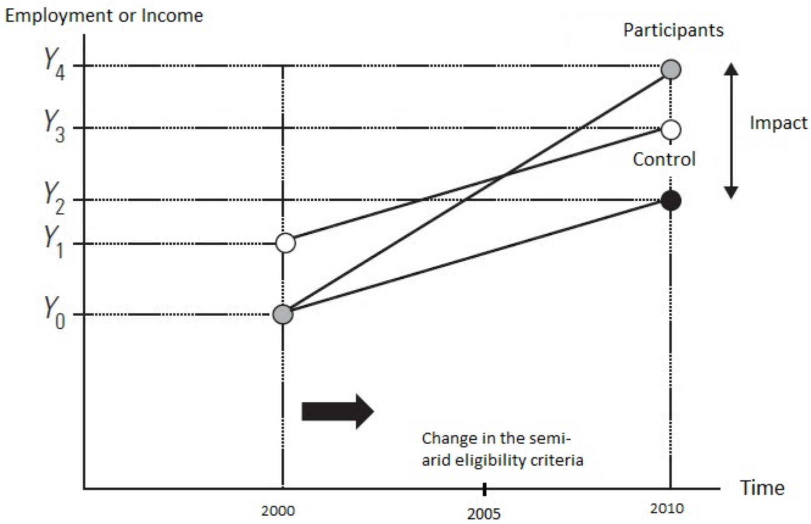
$$DD = E(Y_1^T - Y_0^T | T_1 = 1) - E(Y_1^C - Y_0^C | T_1 = 0),$$

where the first part of the right side of the equation shows the difference of means of the dependent variable (Y) from treated group (T) between 2000 and 2010. The second part is analogous for the control group (C). In this paper, the control group was established as municipalities in the outside semi arid border (first neighbors), since they have similar characteristics to those which entered in the semi arid in 2005 (treated). Besides that, some other tests were made to corroborate the results, such as to use the second border outside semi arid area (second neighbors). The estimated equation is the following:

$$Y_{it} = \alpha + \beta T_{i1} t + \rho T_{i1} + \gamma t + \varepsilon_{it},$$

where $\beta = DD$. Figure 1.2, which is adapted from Khandker et al. (2010), shows graphically how difference-in-differences’ methodology works. In the figure, suppose the control group has the mean outcome bigger than the treatment group in 2000. However, the treatment group has a larger growth shown by the higher inclination of the line. Therefore, the total impact is the the one presented in the figure. This is a general figure to show how the analysis works. Figures 1.4 and 1.5 in the appendix show the same graph but using the variables of FNE rate and per capita income using the same dataset as used in the analysis of this paper.

Figure 1.2: Difference-in-differences approach



Source: Khandker et al. (2010). Adapted.

Figure 1.3 presents Brazilian municipalities which touch the semi arid boundary from outside, which is called here the semi arid first neighbors. As discussed before, these municipalities do not receive the extra benefits from FNE, although they have similar climate and socioeconomic characteristics as those which receive them because they are in the semi arid area. They are used in this paper as the main control group.

1.4 Evaluation of Governmental Microcredit Policy

To estimate the impact of microcredit policy in the Brazilian semi arid area, I use a difference-in-differences estimation, which is controlled by time and municipal characteristics fixed effects. The treatment group consists of municipalities that were not part of the semi arid area in the baseline, but, after the change in the eligibility criteria in 2005, they were included. Thus, they were not part of this area in 2000, but became part of it in 2010. The control group are those called first neighbor municipalities because they are adjacent to the boundary of this area, and it is composed of 203 municipalities. Both control and treated groups' distribution among the Brazilian states are presented in Table 1.5.

Minas Gerais (MG) is the state with the highest number of municipalities in the treated group (45), which represents 44.12%. It is followed by Piauí and Ceará, with 18 and 16 municipalities, representing 17.65% and 15.69%, respectively, Bahia (7.84%), Rio Grande do Norte

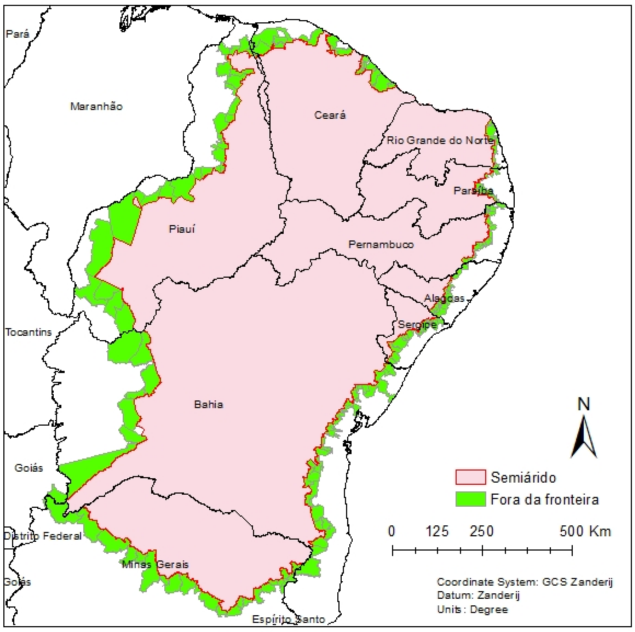


Figure 1.3: Semi-arid first-neighbors municipalities

Source: Authors' elaboration.

Table 1.5: Distribution of treatment and control groups by states (number of municipalities)

UF name	Outside 1	Semi arid	Total
AL	18	3	21
BA	47	8	55
CE	21	16	37
MA	0	0	0
MG	23	45	68
PB	18	0	18
PE	20	4	24
PI	29	18	47
RN	10	7	17
SE	17	1	18
Total	203	102	305

Note: Author's elaboration.

(6.86%), Pernambuco (3.92%), Alagoas (2.94%) and, finally, Sergipe (0.98%) and Paraíba (0.0%). The last state did not have any municipality included in semi arid area after 2005, but it has non-semi arid municipalities adjacent to the boundary, which means this state does have some municipalities in the control group. In fact, 8.87% of the control group, or 18 municipalities, are from Paraíba. Maranhão is the only northeastern state that does not have any municipality either inside and outside boundary close to the semi arid area.

Table 1.6 shows difference-in-differences estimates for five different variables without using any control. This table presents the mean and standard deviation (in parenthesis) in case the municipality is in the treated or control groups both for 2000 and 2010, and also shows the mean difference between the two years and between treatment and control, represented by variables Diff and Difference, respectively, with the standard errors presented in parenthesis. Finally, taking the difference of the differences, there is the final coefficient for the estimation. In parenthesis, there are the standard errors for the DD coefficient.

The first variable analyzed is per capita income in *reais* of 2010 and considering only individuals between 16 and 65 years old. As expected, means in 2000 are smaller than 2010, and municipalities inside the semi arid area are lightly poorer than the ones in the border in 2000 and lightly richer in 2010. Although DD coefficient is positive, which indicates that the difference of average of income per capita in semi arid municipalities between 2000 and 2010 is bigger than the same difference for municipalities in the border, the standard error shows this difference is not statistically significant.

The second variable is FNE rate. The share of FNE by total income has increased from 2000 and 2010, both for treatment and control groups. The difference between treated and control in 2000 and 2010 is negative, which means municipalities in the border used to get more funding from FNE than the other group, both before and after they get treated. DD estimator is positive but non-significant, which means belonging to the semi arid area does not have any effect on FNE application of these municipalities.

Without using any controls, the main result I find in this table is that the difference-in-differences estimators are not significant. This indicates municipalities included in semi arid area after 2005 are not better off comparing to municipalities in the outside border of semi arid area. However, I highlight that there are many other important variables that can impact income and employment of municipalities, apart from the fact of being inside the semi arid area, for instance, educational levels. The next tables show DD estimation for income and employment rate using controls variables (Tables 1.7 and 1.8, respectively).

Table 1.7 shows the effect of being inside the semi arid region on income per capita using two different control groups, called Outside 1 and Outside 2. These groups represent first and

Table 1.6: Diff in Diff without controls

	Income per capita			Education		
	2000	2010	Diff	2000	2010	Diff
New	5.334	5.790	-0.456	0.660	1.012	-0.351
	(0.267)	(0.168)	(0.031)***	(0.132)	(0.132)	(0.018)***
Border	5.335	5.765	-0.430	0.644	1.012	-0.368
	(0.291)	(0.252)	(0.027)***	(0.184)	(0.186)	(0.018)***
Difference	-0.001	0.026	0.027	0.016	-0.000	-0.016
	(0.034)	(0.028)	(0.044)	(0.168)	(0.021)	(0.029)
	FNE Rate			Employment		
	2000	2010	Diff	2000	2010	Diff
New	0.068	0.174	-0.106	0.332	0.355	-0.023
	(0.089)	(0.600)	(0.067)	(0.073)	(0.066)	(0.010)*
Border	0.108	0.178	-0.070	0.331	0.344	-0.013
	(0.241)	(0.458)	(0.040)	(0.065)	(0.075)	(0.007)
Difference	-0.040	-0.004	0.036	0.001	0.011	0.011
	(0.028)	(0.062)	(0.074)	(0.068)	(0.009)	(0.012)
	IFDM					
	2000	2010	Diff			
New	0.421	0.588	-0.167			
	(0.068)	(0.045)	(0.008)***			
Border	0.417	0.578	-0.160			
	(0.071)	(0.064)	(0.007)***			
Difference	0.004	0.010	0.007			
	(0.008)	(0.007)	(0.011)			

Note: "New" represents the treated group and "Boder" represents the control group. Sample used in this table is composed of municipalities that have entered the semi arid area after change in the eligibility criteria in 2005 (102 municipalities) and those in the first border outside the semi arid area (202 municipalities). Numbers in parenthesis are standard deviation for means and standard errors for differences.

second borders outside the semi arid area, respectively. The second border is an expansion of the first one, representing all municipalities in the first border and including the ones in the second border as well. The main coefficient is "$New * Year$", which is the interaction between variables treated and year, representing the DD result. Columns 1 and 5 were estimated without controls and without using state dummies. Columns 2 and 6 include state dummies but do not use controls. Therefore, coefficients of "$New * Year$" in column 2 are the same as shown in Table 1.6. Columns 3 and 7 include a variable of education in the estimations, and columns 4 and 8 include some other variables of population characteristics (percentage of female and rural population) and public services (piped water, sewage and electricity).

As one can see, "$New * Year$" is not significant for any one of the eight models presented in the table, either using Outside 1 or Outside 2 borders, which indicates that entering the semi arid area does not affect income per capita of municipalities. Similar results can be found on Table 1.8, which presents the difference-in-differences estimations of being inside the semi arid area on employment rate. In the next section, I present two different robustness checks: fixed effects and lagged dependent variables.

1.5 Fixed effects and Lagged dependent variables analysis

To give robustness to the results, I estimate the difference on income per capita and employment rate using two different strategies. The first one is a fixed effects estimation, which controls for the tendency of each municipality, and the second one is a lagged dependent variable analysis.

Tables 1.12, 1.13 and 1.14 in the appendix present the results for fixed effects estimation for the variables of Income per capita, employment rate and FNE rate, respectively, and Tables 1.15, 1.16 and 1.17 present the lagged dependent variables analysis for the same outcomes. The estimation analysis for both fixed effects and lagged dependent are made for the Outside 1 and Outside 2 borders.

In all of the estimations, both using fixed effects or lagged dependent variables analysis, the results were the same: entering the semi arid area does not affect income per capita or employment rate of the municipalities. This could be because municipalities are not taking advantage of credit benefits after the change in their classification. In other words, belonging to the semi arid area does not have any effect of FNE demand. However, I am not taking inferences about the efficiency of the FNE. The most important result found here is that the strategy of reducing intra regional inequality has not been efficient.

Table 1.7: Effects on Income per capita: Diff in Diff with controls

	Outside 1				Outside 2			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
New	-0.001	-0.036	-0.024	-0.018	-0.031	-0.071*	-0.047*	-0.050*
	(0.031)	(0.031)	(0.023)	(0.021)	(0.030)	(0.029)	(0.022)	(0.020)
Year	0.430***	0.429***	0.025	0.121***	0.432***	0.432***	0.034	0.128***
	(0.026)	(0.024)	(0.025)	(0.026)	(0.019)	(0.018)	(0.019)	(0.021)
New*Year	0.027	0.027	0.057	0.032	0.024	0.024	0.050	0.038
	(0.044)	(0.041)	(0.031)	(0.027)	(0.042)	(0.039)	(0.029)	(0.027)
lneduc			0.855***	0.491***			0.848***	0.512***
			(0.038)	(0.050)			(0.029)	(0.040)
% Female Pop				3.836***				3.500***
				(0.689)				(0.583)
% Rural Pop				-0.211***				-0.232***
				(0.047)				(0.040)
Piped water				-0.147*				-0.096
				(0.066)				(0.057)
Sewage				0.549***				0.521***
				(0.097)				(0.076)
Electricity				-0.152				-0.283***
				(0.087)				(0.072)
Constant	5.335***	5.206***	5.714***	3.655***	5.365***	5.352***	5.755***	4.001***
	(0.018)	(0.029)	(0.031)	(0.357)	(0.013)	(0.080)	(0.061)	(0.305)
State dummies	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	609	609	609	607	1018	1018	1018	1015
Adjusted R^2	0.421	0.495	0.723	0.773	0.394	0.474	0.712	0.755

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: I have considered only individuals between 16 and 65 years old. Numbers in parenthesis are the standard errors.

Table 1.8: Effects on Employment rate: Diff in Diff with controls

	Outside 1				Outside 2			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
New	0.001	-0.002	-0.000	0.001	-0.007	-0.014	-0.012	-0.011
	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)
Year	0.013	0.013*	-0.027**	-0.014	0.015**	0.016***	-0.018**	-0.004
	(0.007)	(0.006)	(0.009)	(0.010)	(0.005)	(0.004)	(0.006)	(0.007)
New*Year	0.011	0.011	0.013	0.006	0.008	0.008	0.010	0.005
	(0.012)	(0.011)	(0.011)	(0.010)	(0.011)	(0.010)	(0.010)	(0.009)
lneduc			0.084***	0.003			0.072***	-0.000
			(0.013)	(0.018)			(0.010)	(0.014)
% Female Pop				0.432				0.282
				(0.253)				(0.199)
% Rural Pop				-0.056**				-0.069***
				(0.017)				(0.014)
Piped water				-0.065**				-0.061**
				(0.024)				(0.020)
Sewage				0.194***				0.163***
				(0.036)				(0.026)
Electricity				-0.035				-0.044
				(0.032)				(0.025)
Constant	0.331***	0.291***	0.341***	0.086	0.338***	0.289***	0.323***	0.175
	(0.005)	(0.008)	(0.011)	(0.131)	(0.003)	(0.020)	(0.020)	(0.104)
State dummies	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	609	609	609	607	1018	1018	1018	1015
Adjusted R^2	0.012	0.201	0.250	0.319	0.013	0.178	0.220	0.286

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: I have considered only individuals between 16 and 65 years old. Numbers in parenthesis are standard errors.

Table 1.9: Effects on FNE: Diff in Diff with controls

	Outside 1				Outside 2			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
New	-0.040	-0.029	-0.029	-0.040	-0.057	-0.034	-0.034	-0.024
	(0.055)	(0.060)	(0.060)	(0.060)	(0.092)	(0.097)	(0.097)	(0.097)
Year	0.070	0.072	0.044	-0.045	0.113^{*}	0.113^{*}	0.115	0.014
	(0.043)	(0.043)	(0.063)	(0.074)	(0.056)	(0.056)	(0.082)	(0.097)
New*Year	0.036	0.031	0.034	0.067	-0.007	-0.008	-0.008	0.036
	(0.074)	(0.074)	(0.074)	(0.074)	(0.122)	(0.122)	(0.123)	(0.122)
lneduc			0.058	0.366^{**}			-0.005	0.528^{**}
			(0.095)	(0.139)			(0.129)	(0.187)
% Female Pop				-6.935^{***}				-11.396^{***}
				(1.894)				(2.681)
% Rural Pop				0.092				0.060
				(0.127)				(0.180)
Piped water				0.220				0.420
				(0.181)				(0.267)
Sewage				-0.066				-0.492
				(0.270)				(0.360)
Electricity				-0.419				-0.557
				(0.240)				(0.338)
Constant	0.108^{***}	0.207^{***}	0.242^{**}	4.002^{***}	0.125^{**}	0.061	0.059	6.286^{***}
	(0.032)	(0.054)	(0.078)	(0.988)	(0.042)	(0.261)	(0.269)	(1.404)
State dummies	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	544	544	544	542	895	895	895	892
Adjusted R^2	0.006	0.013	0.012	0.044	0.003	0.008	0.006	0.039

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The variable FNE rate represents the share of FNE value lent by the BNB per month and the total income of individuals.

1.6 Conclusion

The arguments that have been used for many local governments to justify the inclusion of new municipalities in the semi arid area is the big advantage given to them through microcredit policies to escape the poverty trap. They are mainly referring to FNE extra benefits for those municipalities inside the semi arid area: smaller interest rates, bigger terms and better conditions, and longer grace periods (timely payment benefits), besides the 50% of the resources that should be transferred to projects inside this region.

This paper analyzed the economic impacts of the inclusion of municipalities in the semi arid region after the reform in the eligibility criteria in 2005. Using a difference-in-differences estimates, I do not find any impact of this change in the eligibility criteria on income per capita and employment rate. One of the reasons can be the fact of new municipalities are not increasing the loans, despite the number of benefits provided to them after the inclusion. This could be the reason why the change in the area delimitation does not have effect. It could happen, in one hand, that potential entrepreneurs in the treated group are not applying for more FNE funding or, in the other hand, they are applying for the program but not receiving the credit from BNB. The last argument is the more reasonable to justify the puzzle in the theory of credit (better benefits, such as smaller interest rates, but no increase in the demand for credit).

Another possible argument for the insignificant result could be the fact of the period of time studied is too short (10 years) to result in any significant effect on income or employment levels. However, it is important to observe I do not want to analyze the effectiveness of this policy, but the strategy of reducing intra regional inequality in the semi arid region, which I find has not been efficient. This topic deserves further studies in the future.

Appendix

Particular cases

- The municipality called *Santarém* (ID 2513653), in the Paraíba state, changed its name on December 27th of 2010 to *Joca Claudino*. To simplify the analysis, I kept the old name of *Santarém*.

- The municipality *Campo de Santana* (ID 2516409), also in the Paraíba state, had this name only from 1996 to 2009. Before and after that period, it was called *Tacima*. However, because the Census 2000 occurred while the municipality was called *Campo de Santana*, I kept this name.

- The municipality *Aroeiras do Itaim* (ID 2200954), at Piauí state, used to be part of Picos (ID 2208007). The two of them were inside the semi arid border after 2010.

- The municipality *Livramento de Nossa Senhora* (ID 2919504), in Bahia state, is also known as *Livramento do Brumado*, since May 14th of 1966, according with state law number 2,325. However, the law was not regulated in a federal level and the IBGE does not recognize the name *Livramento do Brumado* as an official name. Therefore, *Livramento de Nossa Senhora* was considered in this analysis.

- *São Miguel dos Touros* (ID 2412559) is the former name of *São Miguel do Gostoso* municipality, in Rio Grande do Norte state. In this paper, I considered *São Miguel dos Touros* as the official name.

Table 1.10: Summary statistics 1 (2000)

Variable	**Mean**	**(Std. Dev.)**	**N**
Treated municipalities	0.201	(0.401)	508
Employment rate	0.337	(0.065)	508
Total income per capita	222.951	(80.114)	508
Education	0.657	(0.177)	508
Age	26.492	(1.51)	508
% Rural Pop	0.475	(0.194)	505
% Female Pop	0.496	(0.012)	508
IFDM	0.421	(0.072)	508
FNE projects	29.549	(74.141)	386
FNE deflated	405.103	(1017.602)	386
FNE deflated pc	0.134	(0.306)	386
FNE rate	0.113	(0.264)	386
Piped water	0.647	(0.185)	508
Sewage	0.663	(0.201)	508
Bathroom	0.493	(0.192)	508
Electricity	0.795	(0.164)	508

Note: In this table, I consider only the new municipalities in the semiarid area after 2005 (treated group) and the second order municipalities around semiarid area (robustness control group, also called outside 2) in the year 2000.

Table 1.11: Summary statistics 2 (2010)

Variable	Mean	(Std. Dev.)	N
Treated municipalities	0.2	(0.4)	510
Employment rate	0.354	(0.072)	510
Total income per capita	339.974	(101.279)	510
Education	1.021	(0.177)	510
Age	30.046	(1.727)	510
% Rural Pop	0.427	(0.191)	510
% Female Pop	0.498	(0.012)	510
IFDM	0.58	(0.063)	506
FNE projects	191.534	(221.511)	509
FNE deflated	3040.404	(14460.455)	509
FNE deflated pc	0.741	(3.077)	509
FNE rate	0.225	(0.944)	509
Piped water	0.833	(0.122)	510
Sewage	0.876	(0.122)	510
Bathroom	0.791	(0.136)	510
Electricity	0.956	(0.066)	510

Note: In this table, I consider only the new municipalities in the semiarid area after 2005 (treated group) and the second order municipalities around semiarid area (robustness control group, also called outside 2) in the year 2010.

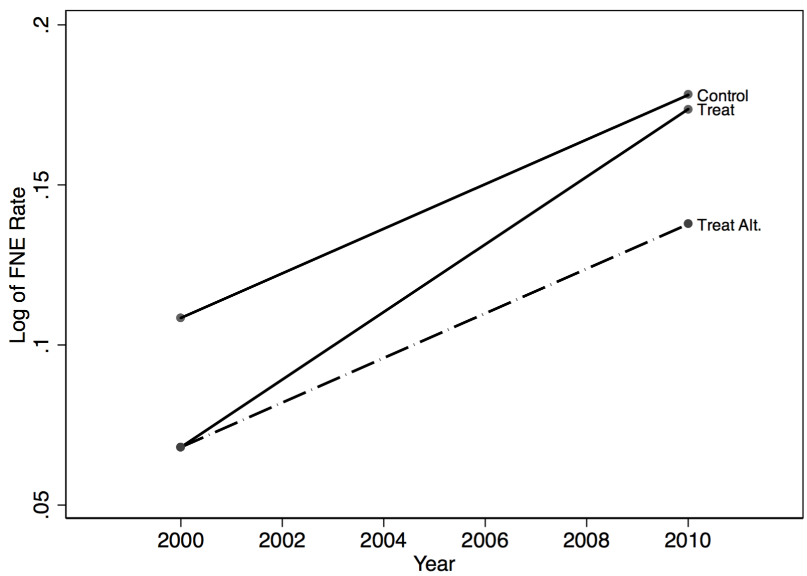


Figure 1.4: Difference-in-differences: log of FNE rate in 2000 and 2010

Source: Author’s elaboration

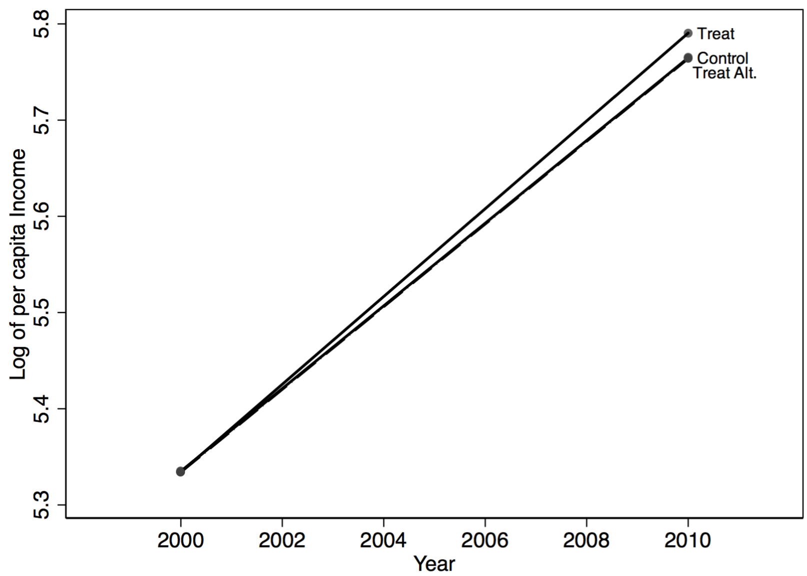


Figure 1.5: Difference-in-differences: log of per capita Income in 2000 and 2010

Source: Author's elaboration

Table 1.12: Robustness Income per capita: Fixed Effects

	Outside 1			Outside 2		
	(1)	(2)	(3)	(4)	(5)	(6)
New	.	.	.	.	.	.
	.	.	.	.	.	.
Year	0.430***	0.320***	0.298***	0.433***	0.313***	0.299***
	(0.012)	(0.032)	(0.043)	(0.009)	(0.024)	(0.032)
New*Year	0.026	0.034	0.023	0.023	0.031	0.022
	(0.021)	(0.020)	(0.031)	(0.019)	(0.019)	(0.028)
lneduc		0.233***	0.155		0.255***	0.158
		(0.063)	(0.117)		(0.048)	(0.085)
% Female Pop			-1.622			-0.647
			(2.452)			(2.018)
% Rural Pop			-0.076			-0.100
			(0.195)			(0.159)
Piped water			-0.058			-0.011
			(0.197)			(0.148)
Sewage			0.421*			0.336*
			(0.183)			(0.133)
Electricity			-0.108			-0.072
			(0.134)			(0.110)
Constant	5.335***	5.443***	6.090***	5.359***	5.475***	5.639***
	(0.007)	(0.030)	(1.251)	(0.005)	(0.022)	(1.033)
Observations	609	609	607	1018	1018	1015
Adjusted R^2	0.738	0.748	0.879	0.732	0.746	0.878

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Ln Income per capita.

Table 1.13: Robustness Employment rate: Fixed Effects

	Outside 1			Outside 2		
	(1)	(2)	(3)	(4)	(5)	(6)
New	.	.	.	.	.	.
	.	.	.	.	.	.
Year	0.013**	0.057***	0.053**	0.016***	0.061***	0.060***
	(0.005)	(0.012)	(0.018)	(0.003)	(0.008)	(0.011)
New*Year	0.011	0.007	0.006	0.008	0.005	0.004
	(0.008)	(0.008)	(0.011)	(0.007)	(0.006)	(0.010)
lneduc		-0.093***	-0.063		-0.097***	-0.075*
		(0.024)	(0.051)		(0.016)	(0.033)
% Female Pop			-1.333			-0.869
			(0.937)			(0.726)
% Rural Pop			-0.050			-0.009
			(0.073)			(0.058)
Piped water			-0.099			-0.098
			(0.088)			(0.063)
Sewage			0.078			0.076
			(0.078)			(0.053)
Electricity			-0.043			-0.033
			(0.051)			(0.038)
Constant	0.331***	0.288***	1.033*	0.337***	0.293***	0.776*
	(0.003)	(0.011)	(0.471)	(0.002)	(0.008)	(0.365)
Observations	609	609	607	1018	1018	1015
Adjusted R^2	-0.878	-0.792	0.132	-0.849	-0.734	0.156

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note:We have considered only individuals between 16 and 65 years old. Numbers in parenthesis are standard errors.

Table 1.14: Robustness FNE rate: Fixed Effects

	Outside 1			Outside 2		
	(1)	(2)	(3)	(4)	(5)	(6)
New	.	.	.	.	.	.
	.	.	.	.	.	.
Year	0.084	-0.096	-0.130	0.164**	0.003	0.057
	(0.046)	(0.127)	(0.303)	(0.057)	(0.170)	(0.217)
New*Year	0.052	0.077	0.109	-0.028	-0.009	-0.033
	(0.078)	(0.080)	(0.180)	(0.125)	(0.126)	(0.189)
lneduc		0.372	0.086		0.339	0.188
		(0.245)	(0.432)		(0.337)	(0.436)
% Female Pop			3.295			-15.328
			(8.288)			(13.359)
% Rural Pop			-1.099			-0.707
			(1.720)			(2.753)
Piped water			1.064			0.705
			(1.323)			(1.229)
Sewage			-0.261			-0.892
			(1.027)			(1.020)
Electricity			-0.271			0.519
			(0.391)			(0.860)
Constant	0.084**	0.257*	-1.265	0.086*	0.242	7.830
	(0.027)	(0.117)	(4.621)	(0.037)	(0.158)	(6.796)
Observations	544	544	542	895	895	892
Adjusted R^2	-1.217	-1.205	0.059	-1.271	-1.271	0.033

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.15: Robustness Income per capita: Lagged dependent variables

	Outside 1			Outside 2		
	(1)	(2)	(3)	(4)	(5)	(6)
New*Year	0.026	0.023	0.028	0.012	0.010	0.010
	(0.017)	(0.015)	(0.015)	(0.016)	(0.015)	(0.015)
Lagged Income pc	0.642***	0.479***	0.418***	0.668***	0.509***	0.469***
	(0.028)	(0.033)	(0.034)	(0.021)	(0.026)	(0.028)
lneduc		0.456***	0.431***		0.430***	0.372***
		(0.058)	(0.060)		(0.047)	(0.050)
% Female Pop			2.693***			1.725**
			(0.692)			(0.590)
% Rural Pop			0.017			-0.069
			(0.048)			(0.040)
Piped water			0.195**			0.209***
			(0.065)			(0.058)
Sewage			0.275**			-0.043
			(0.096)			(0.075)
Electricity			-0.739***			-0.269*
			(0.179)			(0.130)
Constant	2.341***	3.211***	2.489***	2.212***	3.065***	2.572***
	(0.149)	(0.176)	(0.359)	(0.115)	(0.142)	(0.303)
Observations	304	304	304	508	508	508
Adjusted R^2	0.636	0.697	0.723	0.658	0.706	0.720

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Ln Income per capita.

Table 1.16: Robustness Employment rate: Lagged dependent variables

	Outside 1			Outside 2		
	(1)	(2)	(3)	(4)	(5)	(6)
New*Year	0.011	0.010	0.012	0.006	0.006	0.005
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Lagged Employment	0.621***	0.499***	0.473***	0.687***	0.584***	0.570***
	(0.050)	(0.047)	(0.045)	(0.039)	(0.036)	(0.035)
lneduc		0.173***	0.136***		0.160***	0.128***
		(0.020)	(0.023)		(0.014)	(0.017)
% Female Pop			-0.398			-0.680**
			(0.288)			(0.222)
% Rural Pop			-0.018			-0.029
			(0.020)			(0.015)
Piped water			-0.014			-0.004
			(0.028)			(0.022)
Sewage			0.177***			0.079**
			(0.040)			(0.028)
Electricity			-0.089			0.060
			(0.076)			(0.049)
Constant	0.138***	0.179***	0.335*	0.122***	0.155***	0.388***
	(0.017)	(0.016)	(0.144)	(0.013)	(0.012)	(0.110)
Observations	304	304	304	508	508	508
Adjusted R^2	0.341	0.472	0.509	0.383	0.510	0.533

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note:We have considered only individuals between 16 and 65 years old. Numbers in parenthesis are standard errors.

Table 1.17: Robustness FNE rate: Lagged dependent variables

	Outside 1			Outside 2		
	(1)	(2)	(3)	(4)	(5)	(6)
New*Year	0.021	0.021	-0.002	0.006	0.006	0.000
	(0.076)	(0.076)	(0.079)	(0.124)	(0.124)	(0.127)
Lagged FNE rate	0.227	0.226	0.090	1.607***	1.607***	1.449***
	(0.177)	(0.178)	(0.182)	(0.191)	(0.192)	(0.200)
lneduc		0.084	0.436		0.012	0.284
		(0.224)	(0.284)		(0.307)	(0.394)
% Female Pop			-4.230			-0.908
			(3.792)			(5.456)
% Rural Pop			-0.016			-0.214
			(0.244)			(0.351)
Piped water			-0.166			0.045
			(0.347)			(0.517)
Sewage			0.108			-0.224
			(0.506)			(0.658)
Electricity			-2.479*			-3.063*
			(1.028)			(1.190)
Constant	0.167***	0.168***	4.735*	0.089	0.089	3.748
	(0.048)	(0.048)	(1.952)	(0.061)	(0.062)	(2.679)
Observations	239	239	239	386	386	386
Adjusted R^2	-0.001	-0.005	0.030	0.152	0.150	0.172

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The variable FNE rate represents the share of FNE value lent by the BNB per month and the total income of individuals.

CHAPTER 2

Economic Effects of Irrigation Policies in Brazilian Developing Areas

2.1 Introduction

The Brazilian Northeast concentrates the poorest population and the worst socioeconomic indicators of the country. This region is also extremely dependent on agriculture, even though climatic conditions make production very challenging. In order to reduce farmers' vulnerability to droughts and make production more profitable, public irrigation projects (PIP, hereafter) have been implemented.

Irrigation investments have been used to mitigate the effects of weather on economy and poverty in semi arid areas. Some studies (Molden et al., 2007; Hussain and Hanjra, 2004, 2003; Smith, 2004) argue that irrigation can directly or indirectly reduce poverty by increasing crop productivity, employment, income rates and the supply of food, decreasing migration rates and improving health and education levels.

In Brazil, many public irrigation projects have been implemented since the 1960's, especially in the Northeast, where half of its territory is composed by a semi arid area. *Baixo Acaraú*, located in Ceará state, is one of these projects and its first stage was concluded in 2001. Although *Baixo Acaraú* project is not located in the semi arid area, the municipalities in which the project belong are located very closed to the border, and present very similar characteristics to semi arid municipalities.

Using difference-in-differences approach, this research identifies the impacts the irrigation system has had on wage indicators and productivity at the individual level on *Baixo Acaraú* area. Although productivity is a variable difficult to measured, in this paper I used the log of the share of main wage by the total number of hours worked on the main job, which is an indicator of hourly wage. The main data source is from the Brazilian Demographic Censuses of 2000, the baseline, and 2010, the post treatment period, provided by the Brazilian Institute of Geography and Statistics (IBGE[1]). Although the literature points to a positive relationship

[1]Most of the acronyms are written in Portuguese.

between irrigation and income, I find, in general, a negative and significant impact of irrigation on main wages, total wages and productivity when considering the total population. One of the reasons for this unexpected result is that workers may switch to agricultural sector and become family farmers, who produce for their own consumption. In this way, even though they do not have higher wages, they may be better off in terms of consumption and nutrition. When I restrict the sample only to workers who produce specific products commonly grown at *Baixo Acaraú* irrigated area, the coefficients are positive and significant at 1%.

Besides this introduction, this research is divided in six more sections. The following section discusses the literature on irrigation investments in Brazil and other developing countries as a strategy of reducing poverty and regional inequalities. Section 3 describes "Baixo Acaraú" irrigation project, while section 4 presents the data and empirical strategy chosen to identify its impacts on wages and productivity. The results are presented in section 5, followed by the robustness checks and the conclusions.

2.2 Irrigation investment in Brazil and other developing countries

According to Arrobas and Enei (2009), the Brazilian experience investing in public irrigation areas is relatively new (1970s) compared to other Latin American countries, such as Mexico, Argentina, etc. Many papers studied the impacts of these projects in developing countries, especially in Africa and Asia. However, the literature about irrigation impacts in Brazil is still scarce. A large share of the papers focusing on Brazil concentrated on in *Petrolina-Juazeiro* irrigated area (see, for instance, Damiani (2004)), which is the most important polo of fruits' production for exportation in Brazil. The two following sections present the literature on irrigation in the world and in Brazil, respectively.

2.2.1 Irrigation in the world

Irrigation used as an input to agricultural production is a very old practice. According to the Irrigation Museum[2], since 6,000 A.C. Egyptians have been using the water from the Nile river for irrigation, and Mesopotamians have been using water from the Tigris and Euphrates rivers. Since then, the techniques have been developed and expanded around the world. In China, the government invested heavily in irrigation infrastructure to develop rural areas from 1950 until 1966. From 1970 to 1990, China's investment in irrigation experienced a period of stagnation

[2] http://www.irrigationmuseum.org/

at times experiencing a decrease in the investment (Thorat and Fan, 2007).

Many studies investigated the effects of irrigation on poverty in Asia (Hussain, 2007) and in some Asian developing countries, such as China (Huang et al., 2005, 2006) and India (Bhattarai and Narayanamoorthy, 2003), and also in Africa (You et al., 2011) and some African countries, such as Ethiopia (Gebregziabher et al., 2009), Malawi (Nkhata, 2014) and Mali (Dillon, 2008), among others. All of these papers found a positive relationship between irrigation and farmers income, and a negative impact on poverty incidence. According to Del Carpio et al. (2011), who studied the impacts of irrigation on poverty in Peru, these relationships are valid both because of the expansion of quantity/quality of fertile cultivated areas and because of the diversification of production in these areas.

2.2.2 Irrigation in Brazil

The beginning of public irrigation investments in Brazil date from the 1960s. Irrigation systems were created as an important instrument for mitigating regional inequalities. They would increase job creation and decrease poverty through an increase in the productivity and wages. Moreover, they would promote a decrease in migration rates from countryside to the capitals and big cities since the rural areas would offer better opportunities for their population (especially small farmers).

According to Damiani (2004), the development agencies (named DNOCS and CODEVASF) created the "irrigation perimeters" by dividing the land into plots, building the irrigation infrastructure, housing and the social infrastructure, such as schools and health posts. After that, they lease the plots to producers, who paid fees for water use and maintenance of the project's infrastructure (Damiani, 2004, p. 112).

Cunha et al. (2013) found that initial returns of irrigated lands are smaller than in rainfed areas, which is explained by the high costs of irrigation. The authors highlighted, however, that this investment is profitable in medium and long terms. In the Brazilian empirical literature about irrigation, there are some papers concerned about the impacts on environment (Rodrigues and Irias, 2004), vulnerability of small producers as a result of climate changes (Cunha et al., 2013) and impacts on land quality (Lopes et al., 2008). In other cases, there are some more specific papers focusing on the impact of irrigation on employment and income, such as Sobel and Costa (2004), which concentrate on the *Pontal no Vale do São Francisco* Project's area, or even about irrigated areas of *Petrolina-Juazeiro* polo (Sampaio and Souza, 2001). *Petrolina-Juazeiro* polo is a very developed region with high technology equipments, which makes this area very particular and important in terms of production for exportation. However, it does not necessarily represent the average of PIP in the Northeast of Brazil, where many of them are located in poor areas and not supported by a high technology industry.

2.3 *Baixo Acaraú* Irrigation Project

The beginning of the project's construction was in 1983, when the Federal Government developed an agenda to promote regional development and economic growth in less developed areas, but only in 2001 the management, operations and infrastructure maintenance have started. According to Jales et al. (2010), the Government developed the public irrigation projects, also called irrigated perimeters, where farmers could buy land with the infrastructure they needed paying also for the water use. In this paper, I analyse the effect of a public irrigation project called *Baixo Acaraú* on economic variables, such as wages and productivity. *Baixo Acaraú*[3] irrigated perimeter is located in the northern area of Ceará state, at the Brazilian Northeast. The distance to Fortaleza, capital of Ceará state, is about 220 km. This is also a strategic point to export products to Europe and North America.

According to DNOCS, the main objective of the irrigated perimeter is to promote increase on employment and income through new technologies, especially on agriculture, attracting entrepreneurs and encouraging social inclusion on agrobusiness. This project has 8,817 hectares implemented and it is composed by three municipalities: Acaraú, Bela Cruz and Marco. Acaraú is the municipality with biggest share of participation (84% of the perimeter is in the Acaraú municipality), followed by Marco (11%) and Bela Cruz (5%). The main source of water comes from the Acaraú river, whose length is around 320 km and area 14,500 km^2, which represents 10% of Ceará state's area. The main products cultivated in this area are pineaple, melon, banana, watermelon, beans and corn.

There was three different steps, where the first one was concluded in 2001 with fifty resettled small farmers, five professionals from the Agricultural Sciences and five entrepreneurs and the total area sold to each group was 392, 96,22 and 900 hectares, respectively, totalizing 1,388.22 hectares in the first step. In the second step, concluded in 2002, 127 small farmers received some area to produce, six professionals from the Agricultural Sciences and six entrepreneurs, where the area for each group was 1,016, 127.13 and 647.65 hectares, respectively. For the third step there is no actual information but only estimatives, and the total area to be distributed in this step is 4,219.63 hectares. In the area in which this irrigation system is estab-

[3]Most of the information in this section was collected from DNOCS website (`http://www.dnocs.gov.br/~dnocs/doc/canais/perimetros_irrigados/ce/baixo_acarau.html`)

lished, micro sprinkler system is responsable for 50% and drip irrigation system is responsable by the other 50%.

Next section presents the methodological strategy to analyze the impact of the irrigation project in Baixo Acaraú perimeter on economic variables, such as wages and productivity.

2.4 Empirical Strategy

2.4.1 Data

Gebregziabher et al. (2009) highlighted that studies based on aggregated data cannot find a link between irrigation and poverty compared with others which use micro data at the individual or family level. Based on these findings, in this paper I use individual census data from 2000 and 2010, provided by IBGE. The studied area is the *Baixo Acaraú* irrigated area, located in Ceará state, in Brazil. The first part of the project was concluded in 2001, when the project provided water for the first time in this area. Therefore, the 2000 Census is used as a baseline and the 2010 Census is used as a post-treatment dataset.

Some other information about PIP was collected from the Information Systems about Public Irrigation Projects (SISPPI) available at the Ministry of Integration website[4], which provides information about municipalities with ongoing projects. Figure 2.1 shows a map of the Brazilian Northeast, including the semi arid border and all of the municipalities with at least one PIP under DNOCS or CODEVASF responsibility[5].

Baixo Acaraú irrigated perimeter is composed by three municipalities (Acaraú, Bela Cruz and Marco), which are considered the treatment group. In other words, the entire population located in one of these three municipalities is considered in the treated group, even if they are not directly benefited by the irrigation process. The information on irrigation use by the population is not available, which makes this the main limitation of this paper. The control group is composed of the other municipalities in the micro-region of *Litoral do Comocim e Acaraú* other than the ones listed in the *Baixo Acaraú* irrigated perimeter. In this way, I identify two groups of municipalities that have similar characteristics but differ on the presence of the irrigation project. The municipalities that belong to the control group are: Granja, Chaval, Barroquinha, Camocim, Martinópole, Jijoca de Jericoacoara, Cruz, Morrinhos and Itarema. Both treated and control groups are presented in Figure 2.2.

[4] `http://sisppi.mi.gov.br/`

[5] National Department of Works Against Droughts (DNOCS) and Development Company of São Francisco and Parnaíba Valley (CODEVASF) are the main agencies responsible to support the areas with irrigation projects.

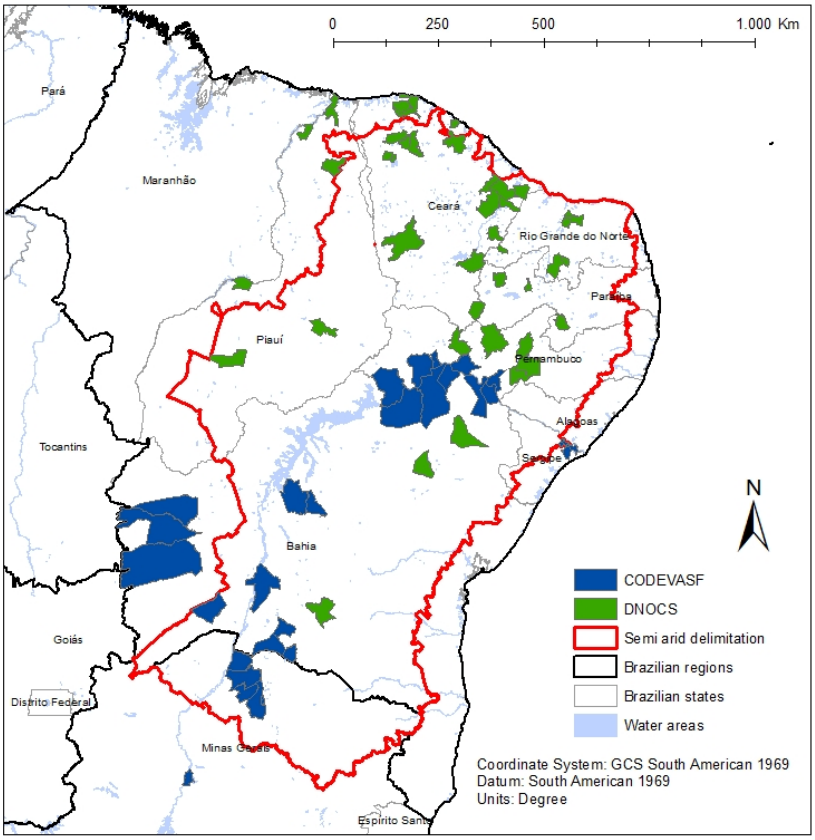


Figure 2.1: Public irrigation projects in Brazil: DNOCS and CODEVASF

Source: Author's elaboration.

2.4.2 Identification Strategy – Difference-in-Differences

The main objective of this paper is to find a causal relationship between irrigation and three different dependent variables: natural logarithm of the main job's wage (*lnwage*) and the log of total job's wages (*lntotalwages*), and the productivity (*lnwagehr*), measured by the log of the share of main wage by total number of hours worked on the main job.

The difference-in-differences method measures the difference between participants and non participants before and after any policy implementation (Khandker et al., 2010). Specifically, this method identifies the expected change of dependent variables (wages and productivity) in the treatment group and the expected change of the same variables in the control group.

Let $t = 0$ be the initial time before treatment and $t = 1$ the period after treatment. Let also Y_t^T and Y_t^C be the outcomes of interest to the treatment and control groups, respectively, in time

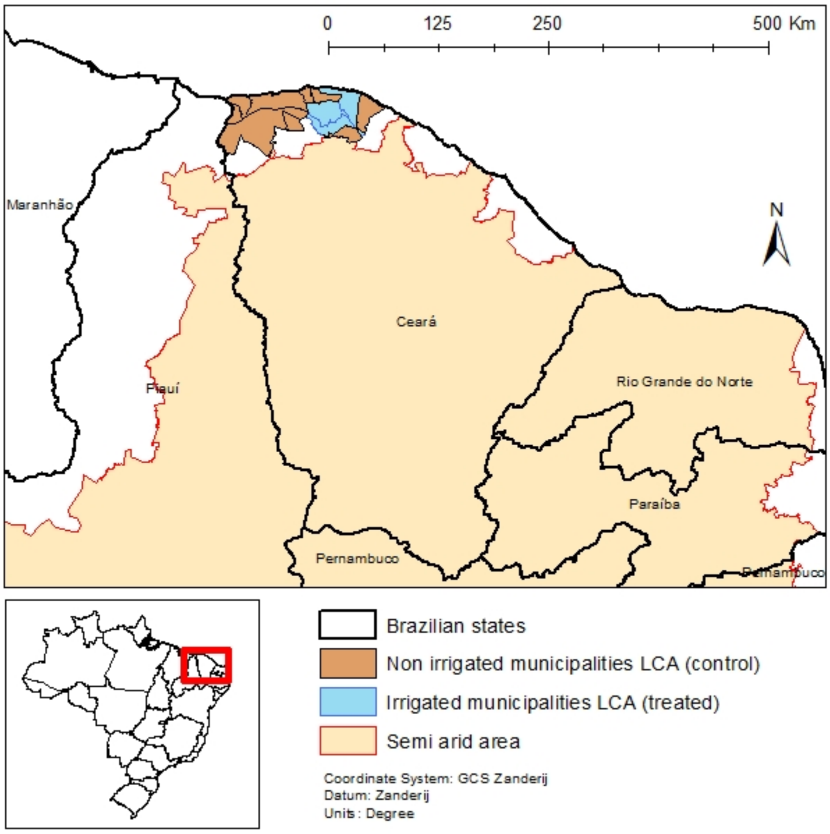


Figure 2.2: Treated and Control group of *Litoral do Camocim e Acaraú* Micro-region (*Baixo Acaraú* Project)

Source: Author's elaboration.

t. Therefore, the estimation by diff-in-diff method will be as following:

$$DD = E(Y_1^T - Y_0^T | T_1 = 1) - E(Y_1^C - Y_0^C | T_1 = 0),$$

in which $T_1 = 1$ means that the municipality is treated while $T_1 = 0$ otherwise.

According to Khandker et al. (2010), estimations by diff-in-diff allow the existence of non-observed differences in the variables of interest between treated and non treated groups without generating bias. These differences in the characteristics between treated and control groups, however, should be time invariant, such that the bias is canceled when making the time difference.

The diff-in-diff is estimated by the equation:

$$Y_{it} = \alpha + \beta T_{i1} t + \rho T_{i1} + \gamma t + \varepsilon_{it},$$

in which β is the average effect of the program. In other words, it is the coefficient of interest. The variables T_{i1} and t are included separately to capture the time effect (t) and the effect of being part of treatment group (T_{i1}).

2.5 Results

Based on previous literature, the main hypothesis of this paper is that public irrigation projects in the Northeast region of Brazil have a positive impact on wages' outcomes and productivity. Table 2.1 lists names of municipalities in the treated (panel A) and control (panel B) groups and also information about the areas (in Km^2) and total population in 2010. Municipalities in both treated and control groups are located in *Litoral do Camocim e Acaraú* micro-region. On average, they are small municipalities both in terms of area and in terms of population.

Table 2.1: Treated and Control groups

PANEL A: Treated Group			
Municipality	**Area** (Km^2)	**Population**	**Population Density**
Acaraú	842.60	57,551	68.302
Bela Cruz	824.40	30,878	37.455
Marco	574.10	24,703	43.029
PANEL B: Control Group			
Municipality	**Area** (Km^2)	**Population**	**Population Density**
Granja	2,698.10	52,645	19.512
Chaval	238.20	12,615	52.960
Barroquinha	383.40	14,476	37.757
Camocim	1,139.20	60,158	52.807
Martinópole	299.00	10,214	34.161
Jijoca de Jericoacoara	204.80	17,002	83.018
Cruz	334.10	22,479	67.282
Morrinhos	415.60	20,700	49.808
Itarema	720.70	37,471	51.993

Note: Author's elaboration. Information on area and Population was based on 2010 Census data set.

Table 2.2 presents the means and difference of means between treatment and control areas in 2000 and 2010 for both independent and control variables. The values in parenthesis are the standard errors of the differences. As one can see, wage and productivity coefficients are slightly higher in treated areas compared to the control ones in 2000, but the difference is not significant between these two groups. In 2010, the means of *lnwage*, *lntotalwages* and *lnwagehr* are higher for non-irrigated areas than for the irrigated ones, and the difference of means is significant at 1%. This essentially means that the different groups used to have statistically equal wages and productivity in 2000 and, in 2010, this difference is significant, with the control group having higher averages than the treatment group.

Regarding the control variables, such as age and proportion of men in the municipality, they are statistically similar between treated and control groups in 2000, and the same happens in 2010. The variable “educ” measure the individual’s level of schooling, indicated by the highest grade attended. Therefore, this variable does not represent the years of schooling of the individuals. In Table 2.2, control areas present higher average of education than the treatment group in both years, but in 2010 this difference is not significant anymore. Finally, concerning percentage of rural areas, treated group presented, in 2000, 48% of rural lands, while control municipalities, 46%, and this difference is statistically significant. In 2010, the difference was still significant, with the treated areas presenting a higher share of their lands as rural areas. These informations are very important to observe that control and treated groups were in fact very similar during pre-treatment period, and the diff-in-diff analysis will measure the effect of the irrigation project implemented after that.

Tables 2.3, 2.4, 2.5, 2.6 and 2.7 show the results for the *Litoral do Camocim e Acaraú* micro-region difference-in-differences estimations. The structure of the results tables is the same for all of them, where I use the whole population between 14 and 60 years old (economically active age) working on at least one remunerated job. The two first columns present the estimations for the log of the main wage (*lnwage*), columns 3 and 4 present the results for the log of the total wages (*lntotalwages*) and the two last columns present the coefficients of estimation for the productivity (*lnwagehr*), measured by the log of the main wage by total number of hours worked in the main job. The difference between the two columns is that in the first column of each group there is no control variables, while in the second estimations of each group I include information on age, percentage of rural population, percentage of men and education.

The variable called “treatyear” states the difference-in-differences (DD) coefficient. For the six models presented in the Table 2.3, the DD coefficients are negative and significant, indicating that the presence of irrigation in the treated group decreases the main wage, total wages and productivity of the total population. Table 2.3 considers workers from all different sectors, even if they are not being directly benefited from the irrigation. This indicates that the results are biased due to the selection problem. It is possible that many of these workers might

Table 2.2: Means and difference of means between irrigated and non-irrigated municipalities

Variables	Irrig 2000 Mean	Non-Irrig 2000 Mean	Diff	Irrig 2010 Mean	Non-Irrig 2010 Mean	Diff
lnwage	4.65	4.62	0.04	5.59	5.70	-0.11
			(0.03)			(0.02)***
lntotalwages	4.66	4.63	0.03	5.61	5.71	-0.11
			(0.03)			(0.02)***
lnwagehr	0.99	0.97	0.02	2.03	2.12	-0.09
			(0.03)			(0.02)***
age	32.50	32.66	-0.16	33.23	33.36	-0.13
			(0.21)			(0.18)
educ	4.80	4.89	-0.09	6.74	6.77	-0.03
			(0.04)*			(0.04)
rural	0.48	0.46	0.03	0.49	0.43	0.06
			(0.01)***			(0.01)***
men	0.51	0.50	0.00	0.51	0.50	0.01
			(0.01)			(0.01)

Note: Author's elaboration. Control group is composed by the non-irrigated municipalities of the micro-region *Litoral do Camocim e Acaraú* listed in Table 2.1.

have preferred to work in jobs indirectly created by irrigation other than in the agriculture sector per se. Other possible reason the negative and significant signs of the coefficients is the strong presence of family production in these areas. When a family produces for its own consumption, this amount is not accounted by GDP, which makes the analysis very challenging. This is one of the reasons why considering income/wages is not a good measure of welfare. Some other variables, such as nutrition or family agricultural prodution, would be a better measure in this case, but they were not available in the dataset.

I reduce the estimation bias restricting the sample only to workers of the agricultural sector[6], as shown in Table 2.4. However, although the bias from using a sample with all sectors of the economy have reduced, there is still the problem of considering wages as a measure of welfare. The results are still similar to the general sample, indicating a decrease in wages and productivity in the presence of irrigation. Therefore, it is reasonable to believe the workers from agricultural sector choose to move to jobs in other sectors or, as explained before, the

[6]Using the National Classification for Economic Activities (CNAE) list, I define agricultural workers as those whose job is categorized in the sectors included in the "Agriculture, livestock, hunting and related services" subsection (*Code* $<$ 2000). The CNAE classification can be found at IBGE website: `ftp://ftp.ibge.gov.br/Censos/Censo_Demografico_2010/Resultados_Gerais_da_Amostra/Microdados/Documentacao.zip`

Table 2.3: DD TOTAL Workers - *Litoral do Camocim e Acaraú*

	(1) lnwage	(2) lnwage	(3) lntotalwages	(4) lntotalwages	(5) lnwagehr	(6) lnwagehr
Treat	0.0147	0.0576*	0.0104	0.0563*	0.0126	0.0416
	(0.60)	(2.12)	(0.42)	(2.06)	(0.51)	(1.49)
Year	0.104***	0.0667***	0.104***	0.0661***	0.113***	0.0755***
	(55.80)	(30.65)	(55.35)	(30.10)	(59.96)	(33.65)
treatyear	-0.110***	-0.104**	-0.108**	-0.103**	-0.0964**	-0.0751*
	(-3.34)	(-3.00)	(-3.23)	(-2.94)	(-2.89)	(-2.09)
Age		0.0202***		0.0207***		0.0215***
		(25.85)		(26.30)		(26.78)
% Rural		-0.507***		-0.508***		-0.411***
		(-30.25)		(-30.07)		(-23.77)
% Men		0.456***		0.459***		0.236***
		(26.79)		(26.73)		(13.42)
Education		0.137***		0.140***		0.130***
		(37.78)		(38.41)		(34.92)
Constant	-203.9***	-130.2***	-204.3***	-128.9***	-224.8***	-151.4***
	(-54.41)	(-29.90)	(-53.97)	(-29.36)	(-59.53)	(-33.72)
Observations	19583	14953	19596	14961	19583	14953
Adjusted R^2	0.179	0.305	0.177	0.305	0.204	0.288

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: In this table, I use the whole population between 14 and 60 years old working on at least one remunerated job.

Table 2.4: DD Agricultural Workers - *Litoral do Camocim e Acaraú*

	(1)	(2)	(3)	(4)	(5)	(6)
	lnwage	lnwage	lntotalwages	lntotalwages	lnwagehr	lnwagehr
Treat	0.138**	0.116*	0.134**	0.116*	0.132**	0.0743
	(3.15)	(2.12)	(3.03)	(2.11)	(2.95)	(1.32)
Year	0.0893***	0.0769***	0.0882***	0.0759***	0.110***	0.0932***
	(24.89)	(17.11)	(24.43)	(16.81)	(29.94)	(20.21)
treatyear	-0.267***	-0.181*	-0.258***	-0.177*	-0.287***	-0.150*
	(-4.49)	(-2.57)	(-4.30)	(-2.50)	(-4.71)	(-2.08)
Age		0.00869***		0.00926***		0.0100***
		(5.62)		(5.96)		(6.30)
% Rural		-0.479***		-0.484***		-0.456***
		(-13.03)		(-13.09)		(-12.08)
% Men		0.295***		0.298***		0.106*
		(5.95)		(5.97)		(2.09)
Education		0.0793***		0.0810***		0.0653***
		(10.60)		(10.78)		(8.50)
Constant	-174.3***	-150.0***	-172.1***	-148.1***	-219.4***	-186.2***
	(-24.23)	(-16.64)	(-23.78)	(-16.35)	(-29.78)	(-20.12)
Observations	4517	3207	4528	3215	4517	3207
Adjusted R^2	0.149	0.215	0.145	0.213	0.206	0.244

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: In this table, I use data for population between 14 and 60 years old working on at least one remunerated job in the agricultural sector (CNAE codes between 01101 and 01999).

decrease in the wage is just a reflex of an increase in the family farmers production for their own consumption.

When considering temporary and permanent crops[7] in the agricultural sector, as shown in Table 2.5, the results are not significant, indicating that the presence of the irrigation project has, in general, no effect on wages and productivity outcomes. Table 2.6 reduces even more the bias generated by the escape of workers to other sectors. This table considers only the Code 01117 in the CNAE list, which identifies the workers who work on "other plants and fruits from permanent crops other than the ones previously specified" (CNAE code 01117)[8]. I chose this

[7]Code of activity bigger than 01101 and smaller than 01117, in the CNAE list.

[8]The permanent crops previously listed in the CNAE list are: horticulture; cultivation of flowers or ornamental

Table 2.5: DD Temporary and permanent crops - *Litoral do Camocim e Acaraú*

	(1) lnwage	(2) lnwage	(3) lntotalwages	(4) lntotalwages	(5) lnwagehr	(6) lnwagehr
Treat	0.126**	0.0966	0.116**	0.0853	0.134**	0.0751
	(2.84)	(1.70)	(2.58)	(1.50)	(2.92)	(1.29)
Year	0.0672***	0.0662***	0.0653***	0.0645***	0.0881***	0.0820***
	(13.69)	(11.20)	(13.30)	(10.93)	(17.48)	(13.55)
treatyear	-0.104	-0.0164	-0.0926	-0.00950	-0.0624	0.0347
	(-1.34)	(-0.18)	(-1.19)	(-0.10)	(-0.78)	(0.37)
Age		0.00440*		0.00469*		0.00510**
		(2.30)		(2.45)		(2.61)
% Rural		-0.268***		-0.292***		-0.228***
		(-5.03)		(-5.47)		(-4.19)
% Men		0.410***		0.409***		0.180*
		(4.86)		(4.84)		(2.08)
Education		0.0202*		0.0227*		0.00911
		(2.05)		(2.30)		(0.90)
Constant	-130.1***	-128.6***	-126.4***	-125.2***	-175.6***	-163.6***
	(-13.24)	(-10.85)	(-12.85)	(-10.58)	(-17.41)	(-13.49)
Observations	2570	1693	2575	1696	2570	1693
Adjusted R^2	0.103	0.129	0.098	0.127	0.166	0.172

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: In this table, I use data for population between 14 and 60 years old working on at least one remunerated job in the cultivation of temporary or permanent crops (CNAE code between 01101 and 01117).

sub-sector because it includes some other crops produced in this area after irrigation implementation. In fact, for the models 2, 4 and 6, that are the models including the control variables, the coefficients are positive and significant at 5%, 1% and 1%, respectively, indicating that the irrigation presence in the treated areas increases significantly the wages and productivity of workers in this sector.

Similar to the results of Table 2.6 are the results of Table 2.7, which includes only the production of banana (CNAE code 01116) and "other plants and fruits from permanent crops other than the ones previously specified" (CNAE code 01117). Only columns 1 and 3, which

plants; and cultivation of citrus fruits, coffee, cocoa, grapes and banana.

Table 2.6: DD Other products from permanent crops other than those specified in CNAE list - *Litoral do Camocim e Acaraú*

	(1)	(2)	(3)	(4)	(5)	(6)
	lnwage	lnwage	lntotalwages	lntotalwages	lnwagehr	lnwagehr
Treat	0.0188	0.0446	-0.00453	0.0239	-0.0187	-0.0205
	(0.18)	(0.38)	(-0.04)	(0.21)	(-0.19)	(-0.18)
Year	0.0556***	0.0465***	0.0546***	0.0438***	0.0787***	0.0661***
	(4.84)	(3.63)	(4.77)	(3.47)	(7.21)	(5.25)
treatyear	0.241	0.507*	0.256	0.510**	0.328	0.586**
	(1.36)	(2.57)	(1.44)	(2.63)	(1.94)	(3.03)
Age		0.00614		0.00837*		0.00626
		(1.56)		(2.16)		(1.62)
% Rural		-0.542**		-0.669***		-0.458*
		(-2.94)		(-3.69)		(-2.53)
% Men		0.407		0.357		0.140
		(1.60)		(1.42)		(0.56)
Education		0.0221		0.0345		0.00993
		(1.06)		(1.68)		(0.48)
Constant	-106.7***	-88.87***	-104.6***	-83.33**	-156.6***	-131.4***
	(-4.64)	(-3.45)	(-4.56)	(-3.29)	(-7.17)	(-5.20)
Observations	479	362	479	362	479	362
Adjusted R^2	0.105	0.162	0.104	0.179	0.207	0.236

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: In this table, I use data for population between 14 and 60 years old working on at least one remunerated job in the agricultural sector (CNAE code equal to 01117).

Table 2.7: DD Banana + Other products from permanent crops other than those specified in the "Atividade CNAE_DOM 2.0 2010.xls" file - *Litoral do Camocim e Acaraú*

	(1)	(2)	(3)	(4)	(5)	(6)
	lnwage	lnwage	lntotalwages	lntotalwages	lnwagehr	lnwagehr
Treat	0.0386	0.0455	0.0160	0.0241	0.00981	-0.0195
	(0.38)	(0.40)	(0.16)	(0.21)	(0.10)	(-0.17)
Year	0.0567***	0.0463***	0.0558***	0.0436***	0.0809***	0.0660***
	(4.98)	(3.65)	(4.92)	(3.49)	(7.49)	(5.31)
treatyear	0.299	0.575**	0.313	0.579**	0.324*	0.597**
	(1.73)	(3.02)	(1.81)	(3.09)	(1.97)	(3.21)
Age		0.00609		0.00833*		0.00623
		(1.58)		(2.19)		(1.65)
% Rural		-0.528**		-0.648***		-0.448**
		(-3.01)		(-3.75)		(-2.62)
% Men		0.432		0.382		0.144
		(1.71)		(1.53)		(0.58)
Education		0.0233		0.0356		0.00999
		(1.13)		(1.76)		(0.50)
Constant	-109.0***	-88.48***	-107.1***	-83.00**	-161.1***	-131.1***
	(-4.78)	(-3.47)	(-4.71)	(-3.31)	(-7.44)	(-5.26)
Observations	493	373	493	373	493	373
Adjusted R^2	0.123	0.186	0.122	0.201	0.220	0.250

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: I use data for population between 14 and 60 years old working on at least one remunerated job cultivating banana (Code 01116) or other fruits or plants from permanent crops other than those specified in the CNAE list (Code 01117).

analyze the effects on main wage and total wages without controls, presented non-significant coefficients, indicating no impact of irrigation on wages. Columns 2, 4, 5 and 6 presented positive and significant impacts of irrigation on wages and productivity, suggesting that an improvement in irrigation in this area increases wages and productivity of workers who produce banana and other permanent crops. This is an extra analysis to give robustness to the findings of the previous table.

2.6 Robustness analysis

According to Khandker et al. (2010), when one does not have a random experiment, it is better to create a randomization. In other words, based on a probability model, generating a counterfactual as similar as possible to the treated group, using observable characteristics, will allow me to address the problem of non-randomization. It is very hard, however, to find municipalities which have exactly the same characteristics. Therefore, using Propensity Score Matching (PSM), I match treated and non-treated groups based on their most similar propensity scores. In this paper I use similar characteristics to identify the counterfactual group in 2000, when the irrigation project had not started. I chose the municipalities among all municipalities within Ceará state whose propensity scores were close to the propensity scores of municipalities in the treatment group. Table 2.8 present the variables used to calculate the PSM.

The robustness analysis is composed by a combination of PSM and difference-in-differences strategies. The idea is to use PSM only to identify the new control group at municipality level. After that, I use difference-in-differences at individual level, same as I did in the previous analysis, to estimate the causal effect. The control group was selected based on propensity scores and it is composed by the municipalities presented in Panel B of Table 2.9, where three municipalities (out of six) are the same as the control group in the previous analysis. Panel A is the same as the one shown in Table 2.1 using difference-in-differences among the municipalities of the *Litoral do Camocim e Acaraú* micro-region.

Table 2.10 presents the means and difference of means for treated (irrigated) and control (non-irrigated) groups. Wages and productivity used to be significantly larger in treated areas in 2000 (before treatment began), but are significantly smaller in the post-treatment period (2010). Some other variables, such as age and percentage of men in the municipality, have difference of means not statistically significant, both before and after treatment.

Tables 2.11, 2.12, 2.13, 2.14 and 2.15 present the results for the difference-in-differences

Table 2.8: Treated and Control groups using PSM selection

Description	Label
Permanent crops area in 2000	areacolhperm2000
Total crops area in 2000	areaplanttotal2000
Total production in 2000	prodtotal2000
Percentage of urban population in 2000	urb2000
Percentage of women in 2000	women2000
Total population in 2000	pop2000
Temperature during the Fall	tempFall
Precipitation during the Fall	precipFall
Municipality altitude	altitude
Share of production value of beans (in R$ 1,000) on GDP	valuefeijaogdp
Share of production value of cassava (in R$ 1,000) on GDP	valuemandiocagdp
Share of production value of corn (in R$ 1,000) on GDP	valuemilhogdp
Share of production value of banana (in R$ 1,000) on GDP	valuebananagdp
Share of production value of cashew nut (in R$ 1,000) on GDP	valuecastanhagdp
Share of production value of guava (in R$ 1,000) on GDP	valuecocodabaiagdp

Note: Author's elaboration. Data collected from Ipeadata website (`http://ipeadata.gov.br/`)

Table 2.9: Treated and Control groups using PSM selection

PANEL A: Treated Group			
Municipality	Area (Km^2)	Population	Population Density
Acaraú	842.60	57,551	68.302
Bela Cruz	824.40	30,878	37.455
Marco	574.10	24,703	43.029
PANEL B: Control Group			
Municipality	Area (Km^2)	Population	Population Density
Aurora	889,90	24.566	27.605
Cruz	334.10	22,479	67.282
Granja	2,698.10	52,645	19.512
Morrinhos	415.60	20,700	49.808
Paracuru	296,20	31.636	106.81
Trairi	925,70	51.422	55.549

Note: Author's elaboration. Information on area and Population was based on 2010 Census data set.

Table 2.10: Means and difference of means between irrigated and non-irrigated municipalities

Variables	Irrig 2000 Mean	Non-Irrig 2000 Mean	Diff	Irrig 2010 Mean	Non-Irrig 2010 Mean	Diff
lnwage	4.65	4.54	0.11	5.59	5.65	-0.06
			(0.03)***			(0.03)*
lntotalwages	4.66	4.55	0.11	5.61	5.67	-0.06
			(0.03)***			(0.03)*
lnwagehr	0.99	0.93	0.07	2.03	2.15	-0.12
			(0.03)*			(0.03)***
age	32.50	32.81	-0.31	33.23	33.54	-0.31
			(0.22)			(0.19)
educ	4.80	4.68	0.12	6.74	6.78	-0.04
			(0.04)**			(0.05)
rural	0.48	0.57	-0.08	0.49	0.52	-0.03
			(0.01)***			(0.01)***
men	0.51	0.51	-0.00	0.51	0.51	0.00
			(0.01)			(0.01)

Note: Author's elaboration. Data from Demographic Censuses of 2000 and 2010. Control groups was selected based on propensity score estimations.

estimation using the propensity score control group. The sequence of tables is similar to the analysis of the micro-region of *Litoral do Camocim e Acaraú* in the previous section. Starting with Tables 2.11 and 2.12 for the total number of workers and agricultural workers, respectively, the results are negative and significant, which means irrigation access decreased the wages and productivity of the region. One possible reason for this, as explained in the previous analysis, is the influence of other sectors of the economy or, more plausibly, the increase of family farmers who produce for their own consumption. In Table 2.12, in order of analize the influence on the agricultural wages, I have selected all sectors from the code 01101 to 01999, which is a subdivision of the CNAE list, and includes the production of "Agriculture, livestock, hunting and related services". Therefore, it is possible that this sector moved to other non-irrigated areas, such as textile industry.

Tables of total workers and agricultural workers were ommited from this paper due to the number of pages' restriction, but they are available under request. Table 2.13 presents the results for temporary and permanent crops using the control group selected by PSM. When including the control variables in the analysis, the coefficient of interest is non-significant, which means that the presence of irrigation does not affect workers' wages or productivity. Tables 2.14 and 2.15 present the results using "Other plants and fruits from permanent crops other than the ones previously specified" (Code 01117) and Table 2.15 also includes production of Bananas (Code 01116). Both tables present positive and nonsignificant results, which means irrigation has no impact on main or total wages. The exception is the productivity outcome, which is positive and significant at 5%, indicating that the presence of irrigation increased the productivity of workers who work on banana cultivation and other permanent crops. Overall, the robustness checks show that the results using PSM are similar to the findings generated previously by differences-in-differences estimations in *Litoral do Camocim e Acaraú* micro-region.

2.7 Conclusions

This paper analyzes the impact of a public irrigation project called Baixo Acaraú, located in the northwest part of the Ceará state, on wages and productivity outcomes. The construction of this project started in the 1970's, but the water from irrigation started to be used in 2001. Therefore, I have used individual Census data from 2000 as the baseline and 2010 as the post-treatment data, considering the workers in the municipalities of Acaraú, Bela Cruz and Marco as the treated group and the other municipalities in the same micro-region of *Litoral do Camocim e Acaraú* (Granja, Chaval, Barroquinha, Camocim, Martinópole, Jijoca de Jericoacoara, Cruz, Morrinhos and Itarema) as the control group.

In general, the results indicate a negative and significant impact of irrigation when considering the total workers or only those in the agricultural sector (including in the last one the livestock sector). This analysis, however, is biased because it considers other sectors other than the ones improved with the irrigation access. When considering the crops produced in those areas, one can see a positive and significant increase of the wages (main job and total jobs) and productivity, measured by log of the share of the main wages over the total number of hours worked in the main job. In other words, this paper shows that irrigation projects increase wages and productivity of workers in the crops that benefited from irrigation, but not the general income of the municipality. Therefore, it is very important to consider these factors when proposing to use irrigation as a strategy of regional development.

The strongest explanation for the negative impact found in the analysis for the total workers and agricultural workers is the fact of many of producers benefited from irrigation are family farmers, whose production is absorbed by the family members. They do not account the production as wage or income, making any measure of money a not precise variable to quantify welfare. Since food consumption is strongly related to healthy status, one possibility to be

Table 2.11: DD Total Workers - PSCORE

	(1)	(2)	(3)	(4)	(5)	(6)
	lnwage	lnwage	lntotalwages	lntotalwages	lnwagehr	lnwagehr
Treat	0.106***	0.0622*	0.103***	0.0615*	0.0569*	0.00903
	(3.90)	(2.12)	(3.76)	(2.08)	(2.09)	(0.30)
Year	0.111***	0.0676***	0.111***	0.0669***	0.122***	0.0798***
	(50.01)	(26.58)	(49.67)	(26.11)	(54.84)	(30.34)
treatyear	-0.178***	-0.112**	-0.176***	-0.110**	-0.188***	-0.108**
	(-4.86)	(-2.97)	(-4.76)	(-2.90)	(-5.11)	(-2.77)
Age		0.0198***		0.0202***		0.0206***
		(22.67)		(23.01)		(22.75)
% Rural		-0.555***		-0.559***		-0.436***
		(-30.20)		(-30.15)		(-22.93)
% Men		0.483***		0.485***		0.268***
		(25.35)		(25.24)		(13.60)
Education		0.136***		0.139***		0.126***
		(33.40)		(33.90)		(29.89)
Constant	-217.5***	-131.9***	-218.0***	-130.6***	-243.1***	-159.9***
	(-48.86)	(-25.94)	(-48.53)	(-25.48)	(-54.49)	(-30.39)
Observations	14680	11451	14688	11455	14680	11451
Adjusted R^2	0.194	0.336	0.192	0.336	0.225	0.313

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: In this table, I use the whole population between 14 and 60 years old working on at least one remunerated job.

Table 2.12: DD Agricultural Workers - PSCORE

	(1) lnwage	(2) lnwage	(3) lntotalwages	(4) lntotalwages	(5) lnwagehr	(6) lnwagehr
Treat	0.121**	0.0332	0.120**	0.0348	0.0910	-0.0266
	(2.64)	(0.58)	(2.60)	(0.60)	(1.92)	(-0.44)
Year	0.0886***	0.0785***	0.0890***	0.0784***	0.114***	0.0993***
	(23.60)	(16.80)	(23.54)	(16.66)	(29.54)	(20.36)
treatyear	-0.261***	-0.164*	-0.266***	-0.169*	-0.332***	-0.185*
	(-4.18)	(-2.23)	(-4.23)	(-2.28)	(-5.16)	(-2.41)
Age		0.00856***		0.00908***		0.00944***
		(5.20)		(5.47)		(5.49)
% Rural		-0.458***		-0.463***		-0.413***
		(-11.20)		(-11.23)		(-9.67)
% Men		0.357***		0.358***		0.145**
		(6.68)		(6.65)		(2.59)
Education		0.0581***		0.0599***		0.0487***
		(7.30)		(7.49)		(5.87)
Constant	-173.0***	-153.2***	-173.7***	-153.0***	-228.4***	-198.2***
	(-22.98)	(-16.35)	(-22.92)	(-16.21)	(-29.38)	(-20.26)
Observations	4007	2876	4009	2878	4007	2876
Adjusted R^2	0.151	0.202	0.150	0.201	0.218	0.236

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: In this table, I use data for population between 14 and 60 years old working on at least one remunerated job in the agricultural sector (CNAE codes between 01101 and 01999).

Table 2.13: DD Temporary and permanent crops - PSCORE

	(1) lnwage	(2) lnwage	(3) lntotalwages	(4) lntotalwages	(5) lnwagehr	(6) lnwagehr
Treat	0.113*	0.0676	0.105*	0.0572	0.0948	0.0201
	(2.37)	(1.11)	(2.20)	(0.94)	(1.93)	(0.32)
Year	0.0775***	0.0774***	0.0771***	0.0767***	0.102***	0.0959***
	(16.66)	(13.63)	(16.55)	(13.53)	(21.36)	(16.30)
treatyear	-0.208**	-0.151	-0.210**	-0.152	-0.205*	-0.124
	(-2.61)	(-1.60)	(-2.63)	(-1.62)	(-2.49)	(-1.27)
Age		0.00767***		0.00756***		0.00713***
		(3.81)		(3.75)		(3.41)
% Rural		-0.242***		-0.253***		-0.193**
		(-4.08)		(-4.27)		(-3.14)
% Men		0.390***		0.388***		0.186*
		(4.58)		(4.56)		(2.11)
Education		0.0299**		0.0308**		0.0247*
		(2.93)		(3.01)		(2.33)
Constant	-150.8***	-151.0***	-149.9***	-149.6***	-204.0***	-191.5***
	(-16.18)	(-13.27)	(-16.07)	(-13.17)	(-21.27)	(-16.23)
Observations	2419	1627	2420	1628	2419	1627
Adjusted R^2	0.128	0.157	0.126	0.156	0.201	0.204

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: In this table, I use data for population between 14 and 60 years old working on at least one remunerated job in the cultivation of temporary or permanent crops (CNAE code between 01101 and 01117).

Table 2.14: DD Other products from permanent crops other than those specified in CNAE list - PSCORE

	(1)	(2)	(3)	(4)	(5)	(6)
	lnwage	lnwage	lntotalwages	lntotalwages	lnwagehr	lnwagehr
Treat	0.0934	0.0775	0.0891	0.0731	0.0817	0.0401
	(0.80)	(0.60)	(0.77)	(0.56)	(0.79)	(0.34)
Year	0.0744***	0.0746***	0.0753***	0.0748***	0.0936***	0.0887***
	(5.57)	(5.20)	(5.63)	(5.20)	(7.88)	(6.75)
treatyear	0.0533	0.251	0.0481	0.247	0.179	0.395*
	(0.28)	(1.19)	(0.25)	(1.16)	(1.04)	(2.04)
Age		0.00443		0.00497		0.00238
		(0.97)		(1.09)		(0.57)
% Rural		-0.310		-0.303		-0.230
		(-1.26)		(-1.23)		(-1.03)
% Men		0.457		0.389		0.234
		(1.67)		(1.42)		(0.93)
Education		0.0383		0.0415		0.0332
		(1.73)		(1.87)		(1.63)
Constant	-144.4***	-145.3***	-146.3***	-145.7***	-186.5***	-176.9***
	(-5.40)	(-5.05)	(-5.45)	(-5.04)	(-7.83)	(-6.70)
Observations	361	294	361	294	361	294
Adjusted R^2	0.145	0.197	0.146	0.198	0.280	0.308

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: In this table, I use data for population between 14 and 60 years old working on at least one remunerated job in the agricultural sector (CNAE code equal to 01117).

Table 2.15: DD Banana + Other products other than those specified in the "Atividade CNAE_DOM 2.0 2010.xls" file - PSCORE

	(1)	(2)	(3)	(4)	(5)	(6)
	lnwage	lnwage	lntotalwages	lntotalwages	lnwagehr	lnwagehr
Treat	0.0825	0.0730	0.0785	0.0698	0.0521	0.00602
	(0.73)	(0.58)	(0.69)	(0.55)	(0.52)	(0.05)
Year	0.0724***	0.0735***	0.0734***	0.0738***	0.0901***	0.0846***
	(5.53)	(5.28)	(5.59)	(5.28)	(7.71)	(6.58)
treatyear	0.142	0.323	0.136	0.317	0.233	0.438*
	(0.76)	(1.59)	(0.72)	(1.56)	(1.39)	(2.34)
Age		0.00453		0.00507		0.00196
		(1.04)		(1.16)		(0.49)
% Rural		-0.308		-0.299		-0.247
		(-1.41)		(-1.37)		(-1.22)
% Men		0.487		0.425		0.215
		(1.91)		(1.66)		(0.91)
Education		0.0380		0.0412		0.0308
		(1.76)		(1.90)		(1.54)
Constant	-140.5***	-143.1***	-142.5***	-143.8***	-179.4***	-168.7***
	(-5.36)	(-5.12)	(-5.41)	(-5.12)	(-7.66)	(-6.53)
Observations	376	307	376	307	376	307
Adjusted R^2	0.159	0.220	0.160	0.220	0.282	0.310

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: I use data for population between 14 and 60 years old working on at least one remunerated job cultivating banana (CNAE code 01116) or other fruits or plants from permanent crops other than those specified in the CNAE list (CNAE code 01117).

analyzed in a future research is the impact of irrigation on nutrition.

However, when analyzing the general gains of irrigation in terms of municipality, I cannot say there is a positive impact. This result is not similar to those found in the international literature. Many irrigated areas, such as Petrolina-Juazeiro located in the Pernambuco and Bahia states, are examples of success in terms of both economic and social aspects. However, this sucess is not representative of the impact of other public irrigation projects in the Northeast. It is essential, therefore, to rethink the necessity of developing these less developed regions in Brazil and focusing on more efficient ways to promote economic and social growth for this population.

CHAPTER 3

The Effects of Intergovernmental Transfers on Inter and Intra Regional Inequalities: Evidence for Brazil

3.1 Introduction

In the last decades, cash transfer programs have been used as an important instrument to reduce income concentration in Brazil (Barros et al., 2006; Soares et al., 2006, 2009, 2010). There is a solid literature on the influence of conditional cash transfers (CCT), such as *Bolsa Família* Program, on income inequality. Hoffmann (2006), for instance, found that CCT decrease income inequality in 28% in Brazil and in 66% in the Northeast region between 1998 and 2004. Barros et al. (2006) estimated that 36% of the decrease in the income inequality between 2001 and 2004 in Brazil had happened because of the increase in the "income from other sources", which includes government transfers (*Bolsa Família*).

However, there are other transfers which are transferred from Federal to Local Government (state and municipalities) aiming to contribute to local development, since states and municipalities have a better knowledge of their necessities than the Central Government, and they could allocate more efficiently the received resources. Established by the tax reform of 1967, the State Participation Fund (FPE) and Municipalities Participation Fund (FPM) have the main objective of reducing regional inequalities. Differently from Conditional Cash Transfers, where money is directly transferred to the individuals, FPM and FPE are transferred to local governments. Many researchers have studied in the last years the impacts of FPM on many different outcomes and they found positive effects on local public spending and education (Kosec, 2013; Litschig and Morrison, 2013) and negative impacts on poverty (Litschig and Morrison, 2013), positive effect on corruption and a negative effect on the average education of candidates for mayor (Brollo et al., 2013).

The municipality funds are financed by 22.5% of the revenue of Income Tax and Industrialized Products Tax of the previous year. Besides, from the amount transferred for each municipality, 20% is automatically invested in the educational system, and at least 15% must be spent in the health system (Mattos and Ribeiro, 2015). The remaining can be spent in anything considered priority for each municipality, which is decided by the city council.

According to Paes and Siqueira (2008), the main contribution of this fund is decreasing regional inequality in Brazil, characterized as one of the highest in the world (Cossio and Carvalho, 2001). In fact, FPM, by construction, must reduce regional inequalities because it transfers income from more to less developed areas[1]. However, Gomes and Mac Dowell (2000) and Politi and Matto (2013) argued that FPM transfers are bigger, using per capita terms, for smaller municipalities (less than 10.000 inhabitants), which not necessarily means these are the poorest municipalities of the country.

When calculating theoretical transfers, it is necessary to identify coefficients for municipality population and the inverse of the states' income. In this way, poorest states have higher income coefficients. Although the northeastern states of Brazil have the highest income coefficients of the country (determined by the wealth of the state), the number of inhabitants is crucial to determine the transfer value. The Brazilian semi arid area is considered the poorest sub-region of the country and that where transfers flow is higher comparative to municipalities' revenue collected with taxes. Baião (2013) showed that, on average, a municipality budget in Brazil is composed by 64% of intergovernmental transfers, 20% of tax collection and 16% from other sources, such as economic activities at the industrial, agricultural or service sectors. In some parts of the Northeast region, for instance in the semi arid area, the share of the intergovernmental transfers on the total revenue is even bigger, reaching sometimes more than 90% of total revenue.

Although the share of FPM on municipalities revenue in Brazilian municipalities is very high, the literature on their impacts on income and welfare is still lacking. It is very important to study more deeply how these funds are transferred to population because they are responsible for financing the biggest share of public services in developing countries (Litschig and Morrison, 2013), such as Brazil. Therefore, the first objective of this paper is to analyze the impacts of FPM on regional inequality in Brazil and, secondly, identify the impact of these transfers on intra-regional inequalities, measured in both cases by the municipality economic growth rate. Similar analyses were developed for the EU Regional Policy and they found a positive impact of the structural funds on economic growth (Becker et al., 2010; Pellegrini et al., 2013). Kyriacou et al. (2015) study the effects of fiscal decentralization on regional disparities in 24 OECD countries over the period from 1984 to 2006 and found that fiscal decentralization

[1]Based on FPM calculation, the amount is directly transferred to the municipality's inhabitant and indirectly to the state's GDP. In other words, the GDP's coefficients are bigger for municipalities in poorer states, particularly located in the Northeast region of the country.

promotes regional convergence in high government quality settings, but in countries with poor governance it increases regional disparities.

The data set was collected by the Brazilian Finance (FINBRA) website, provided by National Treasure, and by the Demographic Census of 2010, provided by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE). Therefore, to analyze the causal effect of transfers on regional inequalities, this paper uses the same methodology firstly used by Brollo et al. (2013) to analyze FPM impacts, which is the fuzzy regression discontinuity approach, whose instrument is the discontinuity among each population threshold. It is possible to measure the impact of an increase of a municipality revenue on economic growth rate, considering that municipalities very close to the threshold have very similar characteristics. Growth rate was measured by the growth of municipalities' GDP per capita between 2011 and 2013.

The results show an overall positive impact of FPM transfers on economic growth rate in Brazil driven by a positive impact on the Northeast region. The other regions do not present significant impact on their growth rates. Considering that the Northeast is the poorest region of the county and that the Southeast is the richest one, we conclude FPM is contributing to reduce inter-regional inequalities. When the impacts on intra-regional inequalities are analyzed, we observed a positive and significant impact on the economic growth rate of the 50% richest municipalities in the Northeast, whereas there is no impact for the 50% poorest municipalities in this region, which indicates an increase in the intra-regional inequality in the Northeast.

Besides this introduction, the paper is divided in four more sections. The second section reviews FPM and the fiscal federalism in Brazil. The following section describes the dataset and methodology used in this paper. Section 4 presents the results and Section 5 the main conclusions of the paper.

3.2 FPM and Fiscal Federalism in Brazil

In Brazil, the biggest share of the municipalities revenue comes from intergovernmental transfers (Shah, 2006), which are constitutional and without counterpart funds. According to Cossio and Carvalho (2001), intergovernmental transfers are very popular in developing countries, such as Brazil, and their main objective is to equalize the tax collection inequalities, which is the main source of differences of public services offered by local governments. The poorest regions, which is the Northeast region in the Brazilian case, are more in need of public services and infrastructure, when compared to richer and more developed regions, such as the Southeast.

According to Secretaria do Tesouro Nacional (2012), the Constitutional Amendment n. 18, from January the 12^{th} of 1965, determined that 20% of Income Tax (IR) and Industrialized Product Taxes (IPI) must be transferred to states (10%), via FPE, and for municipalities (10%), via FPM. These percentages changed along the years and, in 1992, the value transferred to FPM increased to 22.5% of IR and IPI's collection from the previous years and this percentage is the same nowadays.

From the total amount transferred to municipalities, 20% is automatically transferred to the educational system. The Constitutional Amendment of September, the 12^{th} of 1996 created the Fund for Maintenance and Development of Elementary Education (FUNDEF), whose financial support comes from the FPM quota transferred automatically to the educational system. In December, the 19^{th} of 2006, another amendment was created to susbstitute FUNDEF by FUNDEB, which is still in place nowadays. Litschig and Morrison (2013) studied the impacts of FPM on education and they found there is a positive impact on municipalities' schooling and literacy rates. Although Kosec (2013) also finds a positive impact of an exogonous increase in the municipalities' revenue on educational outcomes (such as public schools enrollment rates), the author also finds that more unequal and higher-income municipalities are less likely to spend in the educational system and to improve public school enrollment. Instead, they are more likely to invest in public infrastructure, such as parks and roads.

FPM allocation criteria are directly related to the size of municipality's population and inversely related to the state's GDP. From the whole amount of transfer, 10% must be distributed among states' capitals and 90% for the remaining municipalities, which is segmented between "interior" municipalities, (which receive 86.4% of the total amount) and "reserve" municipalities (which receive 3.6% of the total amount transferred as a complementary quota besides the "interior" quota). The "reserve" municipalities receive this extra transfer because they are highly populated (population above 156,216 inhabitants). These rules were established in the Brazilian Constitution, where municipalities more (less) populated and which belong to poorer (richer) states receive a bigger (smaller) share of the transfer.

As highlighted by Gasparini and Ramos (2004), the population criterion is the main determinant of the 86.4% of the FPM amount. Thus, Table 3.6 presents population thresholds and their respectives coefficients, which are useful to calculate the theoretical transfers. According to Gasparini and Ramos (2004), smaller municipalities (those which less than 5,000 habitantes) are the ones which receive more per capita transfers in all macro-regions, except Southeast. This encouraged the creation of new and small municipalities along the last decades. Gomes and Mac Dowell (2000) showed that 52% out of 1,405 municipalities created between 1984 and 1997 in Brazil had less than 5,000 inhabitants.

Information on population for each municipality and on per capita income of each state is informed by IBGE to Federal Court of Audit (Tribunal de Contas da União – TCU) before October the 31^{st} of the previous year. Tables 3.5 to 3.8 in the Appendix present coeffients used to calculate the theoretical transfers. More details about the metodology to calculate the transfers to capitals, interior and reserve municipalities can be found in Secretaria do Tesouro Nacional (2012).

3.3 Empirical Strategy

3.3.1 Data

Data of FPM transfers are available at the Brazilian Finance database (*Finanças do Brasil* – FINBRA), provided by the National Treasure for 2010 and data for population and other variables were collected at Ipeadata website and Demographic Census data of 2010.

According to FPM mechanisms, municipalities are divided in populational brackets which determine transfers coefficients, as one can see in Table 3.6. This coefficient is an increasing function of the municipality population size, where a municipality above certain cut-off receives higher transfer comparing to the ones bellow it, keeping the level of their state's income constant. Figure 3.1 shows how transfers are distributed along the municipalities, with clear "jumps" in each thresholds of inhabitants. Besides, because each state receives a different percentage of the transfer (related to their wealth), two cities in the same populational threshold should receive the same amount of transfer only if they are in the same state. Let the populational coefficient of municipality m be called λ_m and FPM_s the volume of transfer to state s, so the FPM volume transferred to municipality m in the state s is given by:

$$FPM_m^s = \frac{FPM_s \lambda_m}{\sum_{m \in s} \lambda_m}.$$

As one can see in Table 3.6, the difference between first and second thresholds is 3,396 inhabitants, and the difference between the sixth and seventh is 6,791. Therefore, to keep the simetry of the analysis, we included in the sample municipalities with 3,396 inhabitants bellow the first cut-off and 6,791 above the seventh cut-off, which is the last cut-off used in the estimations. We used only cities bellow the seventh threshold because the other brackets with higher population size were not many and the analysis for those cut-offs would not be accurate.

However, regression discontinuity analysis requires that only municipalities close to the cut-offs may be considered in the estimations, because the method assumes that observations right

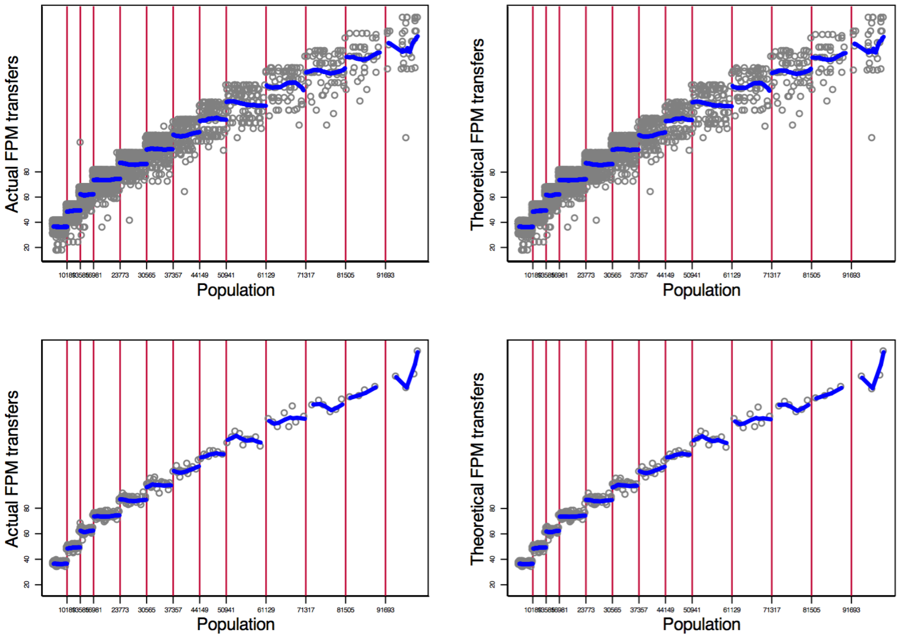


Figure 3.1: FPM distribution along the population, Brazil

Source: Author's elaboration. Data from FINBRA, 2010.

before and right after the discontinuities may have similar characteristics, differing only by the fact that a municipality with bigger population size receives more transfers than another one less populated. Therefore, we considered only municipalities in the mid point of each interval before and after each threshold. For example, for the analysis in the first cut-off, we considered municipalities whose population size is in between 8,490 and 11,886 inhabitants, while in the last threshold analyzed the population size is in between 40,753 and 47,544. Thus, the final sample size is composed by the Brazilian municipalities whose number of inhabitants is in between 8,490 and 47,544, which is represented by 2,673 municipalities. The same analysis is made for each one of the macro-regions such that the number of cities used in the analysis is not the actual number of cities in the whole region. Table 3.1 shows exatcly the number of observation in each threshold by macro-region for the seven brackets used in the estimations, considering only the municipalities in the mid point of the threshold before and the mid point of the threshold after. As one can see, when each threshold was estimated individually, only Northeast and Southeast regions had enough number of observation. Northeast is the region with higher number of municipalities and Southeast is the most populated.

The outcome variable used in the analysis is the economic growth rate, calculated based on municipalities' per capita GDP for the years 2011 to 2013. The ideia is to identify if transfers

Table 3.1: Number of observation in each threshold

Threshold	Brazil	North	Northeast	Southeast	South	Midwest
Threshold 1	644	46	220	194	129	55
Threshold 2	510	42	228	121	82	37
Threshold 3	361	31	157	97	54	22
Threshold 4	444	39	197	121	62	29
Threshold 5	262	34	106	65	38	19
Threshold 6	161	16	67	45	22	11
Threshold 7	118	13	39	42	16	8

Source: Author's elaboration.

received in 2010 had effect on economic growth of the following years. The first analysis observes whether an increase in FPM has effect on inter-regional inequality by macro-region and by threshold. The second analysis, about intra-regional impacts, I considered only municipalities in the poorest and richest regions of the country: Northeast and Southeast, respectively. For this later analysis, the FPM impacts were observed for the 50% poorest municipalities and the 50% richest ones.

3.3.2 Identification Strategy - Regression Discontinuity

According to Khandker et al. (2010), participation rules in a public policy are considered exogenous identification instruments for participant and non-participant groups. In this paper, the upper bound of each population cut-off is the exogenous variation in which we are interested. The choice of these cut-offs was defined exogenously by the Brazilian Constitution. Therefore, it is possible to identify the effect of this policy on inter and intra-regional inequalities, measured by the economic growth rate of those municipalities around the cut-offs.

The idea of comparing municipalities above and below a certain cut-off came up from the fact that municipalities close to the threshold have similar characteristics, which make them comparable and useful to calculate the average treatment effect (ATE). Formaly, the population variable, p_m, determines the program eligibility[2]. Population is divided by cut-offs p^*, such that if a municipality m is in $p_m \leq p^*$, it will receive a smaller share of transfers, otherwise ($p_m > p^*$) it will be in a higher threshold and will receive a higher amount of transfer.

We use a fuzzy regression discontinuity design (RDD), in which the probability of receiving

[2]To be precise, all municipalities are treated by the policy. The eligibility, in this specific case, is to be alocated in a higher threshold, where it receives more transfers than in the case it was not allocated for this higher threshold.

the treatment is smaller than 1, unlike sharp RDD (Imbens and Lemieux, 2008). This happen, in FPM case, because population is not the only criterion that defines in which interval the municipality is and, therefore, how much it should receive.

Therefore, we calculate the theoretical transfers[3] ($\hat{\tau}$) and compare them to the actual transfers (τ). While the theoretical transfers follow the pattern defined by the policy, actual transfers do not necessarily do, because some municipalities tend to overestimate their population estimatives to receive more transfers. Monastério (2014), for example, argued that there was a distortion of the population size of the small Brazilian municipalities and this may happen due to the distribution of FPM.

The effect of transfers on economic growth can be estimated by:

$$y_m = g(p_m) + \beta \tau_m + \gamma_s + \varepsilon_m,$$

where y_m is the economic growth rate of the municipality m from 2011 and 2013, β is the coefficient we are interested in, $g(.)$ is a high-order polynomial in p_m, γ_s is the state fixed effect, and ε_m is the clustered error term. We use theoretical transfers in the municipality m ($\hat{\tau}_m$) as an instrument for actual transfers in the municipality m (τ_m), where the first stage is given by:

$$\tau_m = g(p_m) + \alpha_\tau \hat{\tau_m} + \gamma_s + u_m,$$

where u_m is the clustered error term. In the next section we present the results for the impacts of FPM on inter and intra-regional inequalities in Brazil.

3.4 Results

The main hypothesis of the paper is that FPM transfers generate a higher economic growth rate for poorer regions, such as North and Northeast, and a negative or no impact in the economic growth of the richer regions, such as the Southeast region. This hypothesis is based on the structure of the transfer itself, where a bigger share of the amount is transferred to municipalities located in poorer states.

Table 3.2 presents the first stage estimations, where theoretical transfers explain actual transfers for Brazil and macro-regions. Besides the overall impact, we also have segregated the analysis of the effect of theoretical transfers on actual trasfers in two different groups: the

[3]Theoretical transfers are those that should be received by municipalities considering the rule of the transfers, based on population estimations provided by IBGE in a previous year.

first three thresholds (municipalities between 8,490 and 18,678 inhabitants) and the last four thresholds (municipalities between 20,377 and 47,544 inhabitants); and for each threshold individually. In all of the models we have included state fixed effects and a third-order polynomial based on the municipalities' population. The number of observations shown in the table represent the sample size of each region described in the column, considering the mid point below the first cut-off and the mid point above the seventh cut-off. To see the number of observation of each threshold for each region, see Table 3.1.

As expected, first stage estimations present coefficients positive and statistically significant at 99% confidence interval for all regions in the overall analysis and for most of the estimations by groups of thresholds. The exception is the North region, which does not present significant coefficents in the individual analysis of the first threshold. The number of observation for North and Midwest regions are very small comparing to the remaining regions, thus one has to be cautious about the interpretation of their results.

In Table 3.3 the estimations for the inter-regional analysis are exposed. As expected, the Northeast region presents a positive and statistically significant coefficient, indicating that an increase in the amount transferred to a municipality increase its economic growth rate. The other four macro-regions present non significant coefficients, which means that an increase of transfers to municipalities in those regions does not increase economic growth. This result, in general, suggests that FPM decreases regional inequality. This findings are in line with the findings of Becker et al. (2010) and Pellegrini et al. (2013) who studied the impacts of the regional funds on economic growth in Europe. Results by groups of thresholds also indicate a positive and significant effect of economic growth of northeastern municipalities, while the analysis for each threshold only present significant impact for the first, fourth and sixth intervals.

Considering that Northeast and Southeast regions have the highest number of municipalities, and that, in general, the Southeast region transfers income for the Northeast region[4], the intra-regional analysis in this paper considers only these two Brazilian macro-regions, and its results are presented in Table 3.4. In this table, the first three columns present estimations for the Northeast region and the last three for the Southeast. Besides the overall effect for each region, presented in columns 1 and 4, the table also shows the effects on the 50% poorest municipalities (50−), and the 50% richiest ones (50+), considering the per capita GDP in 2007. We considered 2007 GDP because it was the year used by the Government to calculate the states' income coefficient for the FPM tranfers in 2010.

[4]The Southeast is the richest macro-region of the country and, therefore, it is responsible for the biggest share of the income taxes and industrialized product taxes collected by the Federal Gorvernment. The Northeast, however, although very populated, is the poorest region of the country. Therefore, in general, one can say that Southeast transfers income to the Northeast region.

Table 3.2: First Stage Estimations - Effects of theoretical on actual transfers

	Brazil	North	Northeast	Southeast	South	Midwest
Overall	0.995***	1.008***	0.994***	1.000***	0.988***	1.000***
	(0.005)	(0.009)	(0.013)	(0.000)	(0.012)	(0.000)
Threshhold 1-3	0.821***	0.603**	0.889***	1.016***	0.880***	0.685***
	(0.033)	(0.188)	(0.034)	(0.017)	(0.034)	(0.072)
Threshold 4-7	0.866***	0.812***	0.898***	0.991***	0.915***	0.768***
	(0.019)	(0.099)	(0.022)	(0.021)	(0.025)	(0.054)
Threshold 1	0.689***	0.378	0.765***	0.950***	0.749***	0.560***
	(0.042)	(0.259)	(0.042)	(0.015)	(0.049)	(0.097)
Threshold 2	0.730***	0.454*	0.853***	0.952***	0.784***	0.567***
	(0.049)	(0.221)	(0.064)	(0.021)	(0.042)	(0.095)
Threshold 3	0.761***	0.635***	0.797***	0.943***	0.807***	0.659***
	(0.026)	(0.123)	(0.033)	(0.025)	(0.038)	(0.073)
Threshold 4	0.788***	0.694***	0.823***	0.946***	0.835***	0.680***
	(0.027)	(0.151)	(0.029)	(0.025)	(0.031)	(0.070)
Threshold 5	0.806***	0.771***	0.856***	0.953***	0.853***	0.725***
	(0.021)	(0.084)	(0.023)	(0.021)	(0.028)	(0.059)
Threshold 6	0.830***	0.736***	0.851***	0.952***	0.837***	0.720***
	(0.021)	(0.096)	(0.027)	(0.023)	(0.032)	(0.058)
Threshold 7	0.836***	0.730***	0.864***	0.960***	0.855***	0.774***
	(0.017)	(0.085)	(0.027)	(0.019)	(0.027)	(0.047)
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Cubic Polynom	Yes	Yes	Yes	Yes	Yes	Yes
N	2673	238	1086	721	428	200

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.3: Inter Regional Inequality

	Brazil	North	Northeast	Southeast	South	Midwest
Overall	0.042	-0.009	0.094*	-0.122	0.078	
	(0.035)	(0.138)	(0.050)	(0.112)	(0.050)	
Threshhold 1-3	-0.012	0.015	0.089*	-0.168	0.017	
	(0.050)	(0.156)	(0.051)	(0.200)	(0.064)	
Threshold 4-7	0.049	-0.058	0.109*	-0.115	0.035	0.087
	(0.031)	(0.112)	(0.060)	(0.083)	(0.044)	(0.068)
Threshold 1	-0.104	-0.027	0.184**	-0.702	0.042	-0.022
	(0.119)	(0.187)	(0.082)	(0.627)	(0.109)	(0.158)
Threshold 2	-0.058	-0.035	-0.138	-0.080	0.014	
	(0.066)	(0.180)	(0.182)	(0.166)	(0.103)	
Threshold 3	-0.039	-0.102	0.062	0.034	0.032	0.014
	(0.058)	(0.210)	(0.081)	(0.137)	(0.086)	(0.129)
Threshold 4	0.007	-0.168	0.171**	-0.253**	0.039	0.129
	(0.046)	(0.122)	(0.083)	(0.121)	(0.059)	(0.117)
Threshold 5	0.043	0.061	0.055	0.047	-0.029	0.092
	(0.047)	(0.172)	(0.084)	(0.140)	(0.066)	(0.104)
Threshold 6	0.010	-0.030	0.099*	-0.266	0.077	0.091
	(0.043)	(0.127)	(0.058)	(0.196)	(0.082)	(0.104)
Threshold 7	0.079	-0.506	0.068	-0.140	0.215**	0.108*
	(0.057)	(0.388)	(0.089)	(0.110)	(0.100)	(0.064)
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Cubic Polynom	Yes	Yes	Yes	Yes	Yes	Yes
N	2673	238	1086	721	428	200

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.4: Intra Regional Inequality

	NE	50-	50+	SE	50-	50+
Overall	0.094*	-0.017	0.192**	-0.122	0.087	-0.369*
	(0.050)	(0.039)	(0.097)	(0.112)	(0.074)	(0.221)
Threshold 1-3	0.089*	-0.071	0.308***	-0.168	-0.002	-0.475
	(0.051)	(0.048)	(0.094)	(0.200)	(0.097)	(0.454)
Threshold 4-7	0.109*	0.029	0.109	-0.115	0.044	-0.262*
	(0.060)	(0.049)	(0.108)	(0.083)	(0.076)	(0.144)
State Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Cubic Polynom	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The coefficients shown in the table indicate that FPM transfers have a positive and statistically significant impact on economic growth rate in the Northeast but not in the Southeast, which is an evidence of decreasing in the regional inequality. Columns NE and SE are the same as showed in the previous table. When considering the distribution of income of the municipalities, one can see FPM transfers do not affect economic growth rate in the poorest municipalities of the Northeast region, but do so for the 50% richiest ones, represented by a positive and 5% statistically significant coeffient of 0.192. In the Southeast, the overall impact on the region is not significant, but when considering rich and poor municipalities separately, one can observe a negative and significant impact of FPM on the 50% richer. Probably those municipalities are the ones which pay more taxes and proportionally receives less transfer. Therefore, for a richer region, FPM decrease intra-regional inequality, but for a poor region, the intra-regional inequality increases. We have not considered in this table the analysis for each threshold individually because of the decrease in the number of observations.

Therefore, using a regression discontinuity strategy, we found an evidence that intergovernmental transfers in fact decrease regional inequality but increase intra-regional inequality of the poor region. This result may suggest the transfers are meeting their goals of reducing inter-regional disparities because poorer municipalities are growing faster than the richier ones.

3.5 Conclusions

This paper analyzes the impact of intergovernmental transfers on inter and intra-regional inequalities in Brazil, measured by the economic growth rate of municipalities in differente macro-regions. Using data of transfers in 2010, provided by the Brazilian Finance, we used a regression discontinuity design to capture the causal effect.

Results presented in this paper suggest that an increase in the FPM transfer impacts positively on economic growth rate of the poorest region of the country (Northeast) and has no significant impact on the richest region (Southeast), which indicates a decrease in the overall inter-regional inequality. Nonetheless, we find that the improvement on growth rates in the Brazilian Northeast is driven by the richest municipalities. This results suggest that even though intergovernmental transfers help poor regions catching up, intra regional inequalities may increase.

This findings are in line with others papers which concentrated in the regional funds in Europe, such as Becker et al. (2010) and Pellegrini et al. (2013), which used an identification strategy similar to that of this paper. Although there is no consensus in the literature, these results are one more piece of evidence that regional funds reduce regional inequalities. However, the positive impact on the economic growth rate of the richest municipalities in the Northeast reveals a government expenditure more efficient in those municipalities, possibly because they invest in more dynamic sectors. The 50% poorest municipalities – the ones for which we did not find any effect of the transfers – may be stuck in a poverty trap.

Appendix

Table 3.5: Share of each state in the total of transfers – “Interior” municipalities, 2014

Region	State	% Participation
North	Acre	0,263
North	Amapá	0,1392
North	Amazonas	1,2452
North	Pará	3,2948
North	Rondônia	0,7464
North	Roraima	0,0851
North	Tocantins	1,2955
Northeast	Alagoas	2,0883
Northeast	Bahia	9,2695
Northeast	Ceará	4,5864
Northeast	Maranhão	3,9715
Northeast	Paraíba	3,1942
Northeast	Pernambuco	4,7952
Northeast	Piauí	2,4015
Northeast	Rio Grande do Norte	2,4324
Northeast	Sergipe	1,3342
Midwest	Goiás	3,7318
Midwest	Mato Grosso	1,8949
Midwest	Mato Grosso do Sul	1,5004
Southeast	Espírito Santo	1,7595
Southeast	Minas Gerais	14,1846
Southeast	Rio de Janeiro	2,7379
Southeast	São Paulo	14,262
South	Paraná	7,2857
South	Rio Grande do Sul	7,3011
South	Santa Catarina	4,1997

Source: Lei Complementar 62, de 28/12/1989 c/c Resolução-TCU 242/1990.

Table 3.6: FPM coefficients by population threshold – “Interior” municipalities

Population	Coefficient	Population	Coefficient
Up to 10,188	0.6	From 61,129 to 71,316	2.4
From 10,189 to 13,584	0.8	From 71,317 to 81,504	2.6
From 13,585 to 16,980	1.0	From 81,505 to 91,692	2.8
From 16,981 to 23,772	1.2	From 91,693 to 101,880	3.0
From 23,773 to 30,564	1.4	From 101,881 to 115,464	3.2
From 30,565 to 37,356	1.6	From 115,465 to 129,048	3.4
From 37,357 to 44,148	1.8	From 129,049 to 142,632	3.6
From 44,149 to 50,940	2.0	From 142,633 to 156,216	3.8
From 50,941 to 61,128	2.2	Above 156,216	4.0

Source: Decreto-Lei 1.881, de 27 de agosto de 1981.

Table 3.7: FPM – Per capita income factor

Inverse of the state per capita income index	Factor
Bellow 0,0045	0,4
From 0,0045 to 0,0055	0,5
From 0,0055 to 0,0065	0,6
From 0,0065 to 0,0075	0,7
From 0,0075 to 0,0085	0,8
From 0,0085 to 0,0095	0,9
From 0,0095 to 0,0110	1,0
From 0,0110 to 0,0130	1,2
From 0,0130 to 0,0150	1,4
From 0,0150 to 0,0170	1,6
From 0,0170 to 0,0190	1,8
From 0,0190 to 0,0220	2,0
Above 0,0220	2,5

Source: Lei nº 5.172, de 25/10/66 (Accessed in `http://www.planalto.gov.br/ccivil_03/Leis/L5172.htm`).

Table 3.8: FPM – Population factor

Population threshold	Coefficient
Up to 10.188	0,6
From 10.189 to 13.584	0,8
From 13.585 to 16.980	1,0
From 16.981 to 23.772	1,2
From 23.773 to 30.564	1,4
From 30.565 to 37.356	1,6
From 37.357 to 44.148	1,8
From 44.149 to 50.940	2,0
From 50.941 to 61.128	2,2
From 61.129 to 71.316	2,4
From 71.317 to 81.504	2,6
From 81.505 to 91.692	2,8
From 91.693 to 101.880	3,0
From 101.881 to 115.464	3,2
From 115.465 to 129.048	3,4
From 129.049 to 142.632	3,6
From 142.633 to 156.216	3,8
Above 156.216	4,0

Source: Lei nº 5.172, de 25/10/66 (Accessed in `http://www.planalto.gov.br/ccivil_03/Leis/L5172.htm`).

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