Pontifícia Universidade Católica do Rio de Janeiro

Departamento de Economia

Monografia de Final de Curso

Impact Evaluation of the Free Trade Area of the City of Bonfim Using the Synthetic Control Method

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Rio de Janeiro, Brasil

Novembro, 2021

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Declaro que o presente trabalho é de minha autoria e que não recorri para realizá-lo nenhuma forma de ajuda externa, exceto quando autorizado pelo professor tutor.

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As opiniões expressas neste trabalho são de responsabilidade única e exclusiva do autor.

Acknowledgements

To my parents, José and Rosana, for their love and continuous support.

To my brother, Danilo, for his kindness, friendship and help in finding an adequate quote.

To my grandparents, Alfredo, Shirlei, Moysés and Judith, for their constant care and love.

I thank Habonim Dror for its fundamental role in my development.

I am grateful to all the members of the Climate Policy Initiative for helping me discover my interest in research. I especially thank Rhayana for her valuable insights.

To my supervisor Amanda, for the support, patience and great advice.

But as the king desired greatly to show himself gracious to the nation to which the queen belonged, he released all the peoples under his dominion from the payment of taxes and imposts. - Louis Ginzberg (Legends of the Jews)

Abstract

I evaluate the economic impact of the Free Trade Area of Bonfim by applying the Synthetic Control Method on city-level data from the twenty-first century. Results reveal that this policy had a positive effect on Bonfim's Agriculture Added Value per capita, but no impact is identified on other sectors. Future studies are necessary to evaluate the cost-effectiveness of this policy.

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1 Introduction

The Free Trade Areas (FTAs) were created in cities in the border strip of the North Region of Brazil, inspired by the 1967 Free Trade Zone of Manaus (FTZM) model. Their goal is to develop the municipalities they are located in, by generating jobs, stimulating foreign trade and boosting the commercial sector.

In order to achieve this, firms located in the FTAs are granted multiple fiscal incentives, that totalized, only in the commerce and services sectors, R$ 374 million in 2019, according to internal revenue services (Receita Federal (2017)).

Despite the high cost of this policy, no impact evaluations concerning the FTAs were undertaken. Therefore, this article estimates the causal effect of the establishment of the FTA of Bonfim, created in 2008, over the city's Gross Domestic Product (GDP) per capita, Services Added Value per capita, Agriculture Added Value per capita and Industry Added Value per capita.

The estimation is made by using the Synthetic Control Method, proposed by Abadie and Gardeazabal (2003) and expanded by Abadie et al. (2010), Abadie et al. (2015). The synthetic version of Bonfim is built by considering only cities from the North Region located in the border strip (thus, potential candidates for becoming FTAs), besides the existing FTAs. Therefore, it serves as an approximation of the counterfactual, i.e., how would Bonfim's variables of interest have evolved had the FTA never been established. Inference is conducted as proposed by the creators of the synthetic control method. Two robustness checks are also implemented.

The results of this analysis show that the creation of the FTA of Bonfim had a positive impact on the Agriculture Added Value per capita, but there is no evidence of impact on the GDP per capita and Services Added Value per capita. The estimated effect on Industry Added Value per capita was not robust, which could be explained by the simultaneous creation of the FTA of Bonfim and the FTA of Boa Vista.

This article is organized as follows: section 2 presents the literature review; section 3 describes the motivation of the present article; section 4 presents the institutional description and the available fiscal incentives for the FTAs; section 5 describes the Synthetic Control Method; section 6 presents the descriptive statistics obtained regarding Bonfim and its synthetic counterfactual; section 7 describes the results of the application of this methodology and the placebo tests; section 8 presents the two robustness checks and, finally, section 9 concludes.

2 Literature Review

The international literature regarding place-based policies is vast and ambiguous. The specific areas these policies take place in usually present a specific deficit in comparison to the rest of the country, or a market failure (which would prevent the optimal performance of these places) (Glaeser and Gottlieb, 2008).

The effects of place-based policies – especially enterprise zones – in social and economic indicators such as employment and GDP per capita are not always easy to detect. It is an even bigger challenge to investigate long-run effects or to isolate specific features of the policies that may be effective or disruptive, let alone identifying to whom the eventual gains go to (Neumark and Simpson, 2015).

On the one hand, Kline and Moretti (2014a) present positive effects on one of the biggest American place-based policies, the Tennessee Valley Authority, over national manufacturing productivity. Kline and Moretti (2014b) study the Federal Empowerment Zones in the USA and find, using the differences-in-differences estimator, that the policy was responsible for increasing the local employment rate, as well as the local average wage. Ham et al. (2011) measure the impact of State Enterprise Zones, Federal Empowerment Zones and Federal Enterprise Community programs in the United States of America (USA) and find positive effects on employment, poverty rate and the fraction with wage and salary income.

On the other hand, Elvery (2009) evaluates the impact of the enterprise zones in California and Florida on employment probabilities of its residents and finds no evidence to support that case. Gobillon et al. (2012) analyze a French enterprise zone that conceded wage-tax exemption for firms that hired 20% or more of their labor force from zone residents and show that the effect on employment was small and significant only in the short run.

In Brazil, the most important place-based policy is the Free Trade Zone of Manaus – in terms of amount of tax exemptions granted, area and durability. Since the Free Trade Areas were created as an expansion, with some adaptations, of the FTZM model, it is important to acknowledge the literature about the FTZM. The many studies concerning the effects of the FTZM on creating jobs, protecting the environment and its cost-effectiveness show ambiguous results.

In regard to the environmental impact of the FTZM, Rivas and Mota (2009) evaluate that deforestation in the state of Amazonas could be up to 77.2% higher without the existence of the Industrial Pole of Manaus (the industrial sector of the FTZM). Costa et al. (2016), utilizing comparative analysis, on the other hand, do not identify any effect of the FTZM over deforestation.

In regards to the energy sector, Assunção et al. (2020) point out that, despite the tax exemptions, the evolution of FTZM's productive and energetic efficiency does not

outstand the national evolution of the same indicators. This means that the FTZM's fiscal incentives were not translated into an efficiency growth in the state of Amazonas.

The effects of the FTZM on employment and production are analyzed by Oliveira (2011), Miranda (2013) and Possebom (2017).

Oliveira (2011) considers the FTZM responsible for a significant growth on Amazonas' GDP per capita and that the costs of the fiscal incentives were offset by the benefits generated to the state of Amazonas. Miranda (2013), in contrast, evaluates that FTZM's impact over the development of the region is low, and that the level of the jobs created thanks to the policy are below expectations, considering the large amount of fiscal incentives.

More recently, Possebom (2017) executes an impact evaluation of the FTZM during the 20th century, using the Synthetic Control Method. He identifies positive effects of the FTZM on GDP per capita, Services Total Production per capita and negative effects on Agriculture Total Production per capita.

There are no impact evaluations of the Brazilian FTAs (neither separately nor aggregated).

3 Motivation

This article is heavily inspired by Possebom (2017)'s impact evaluation of the FTZM. The author utilizes the synthetic control estimator to evaluate the impact of the policy on socioeconomic indicators throughout the 20th century.

Possebom (2017) was the first to apply this methodology to evaluate FTZM's consequences on the region. Previously, the policy's impact on Manaus' development had not been so thoroughly studied via quantitative methods.

Although Possebom (2017) is able to identify FTZM's impact over Manaus socioeconomic indicators, the construction of the synthetic control estimator, in this case, presents some limitations.

One of the limitations of his work is that, during this period, many municipalities were created or divided. Since this would compromise the construction of a valid synthetic control estimator, the author used Minimum Comparable Areas (MCAs) – that aggregate different cities to simulate the local economies if the cities' frontiers remained stable.

The use of MCAs reduces the precision of his findings, since the real treatment group was not only – in his case – Manaus, but 29 cities, aggregated as one MCA.

Since the present article relies on data from the 21st century, when fewer cities were created or divided, it is not necessary to use the MCAs.[1] This offers more precision to the results.

Another advantage of building a synthetic control estimator for the FTAs, in comparison to the FTZM, is that Manaus is a very singular city in the Northern Region, both in terms of its population size and industrial production. The cities chosen to become FTAs, on the other hand, are generally much more representative of the typical Northern city, presenting a lower population size and density and a more representative agriculture sector.

Considering that the FTAs were created based on FTZM's model, by evaluating the first's impact, the results could be used as evidence on the debate regarding not only the FTAs' expenses and continuity, but also FTZM's.

While both the FTA of Boa Vista and the FTA of Bonfim were created in 2008, the city of Boa Vista is neither a typical exemple of an FTA nor of a North Region city located in the border strip. In fact, the FTA of Boa Vista is the only FTA established in a capital city, its population size and density is way higher and its agriculture sector way less relevant than the control group's average.

Bonfim, on the other hand, is much more similar to the cities located in the border strip of the North Region. Therefore, this study only evaluates the impact of the FTA of Bonfim.

[1] Between 1940 and 2000, more than 3900 cities were created in Brazil, in comparison to less than 100 during the 21st century.

4 Institutional Description

The Free Trade Areas (FTAs) were established in specific cities in Northern Brazil, alongside international borders, as an effort to develop their economies and commercial sector, create jobs and stimulate foreign trade. These areas are granted a number of fiscal incentives, based on the 1967's model of the Free Trade Zone of Manaus (FTZM).

Since the implantation of the first FTA, in the city of Tabatinga (AM), in 1990, six more were created. The two most recent ones were established in 2008, in the state of Roraima: the FTA of Boa Vista (RR) and the FTA of Bonfim (RR), whose data is specifically analyzed in this article.

Both Boa Vista and Bonfim are located in the state of Roraima, 110.6 kilometers apart from each other, near the borders of Guiana and Venezuela. The city of Lethem, in Guiana, has been an FTA for decades, and is only 10 kilometers away from Bonfim. Therefore, by creating the FTAs of Boa Vista and (especially) Bonfim, the goal was to reverse the foreign trade flow, and start exporting to Guiana.

Before 2008, Roraima's FTAs were planned to be located in Bonfim and Pacaraima but, in 2008, the FTAs were established in Bonfim and Boa Vista. According to Superintendência da Zona Franca de Manaus (2014), since Boa Vista is much wealthier and has a better infrastructure in place and an overall more dynamic economy than Bonfim, the FTA of Bonfim became a less attractive option for investors as compared to Boa Vista.

The tax benefits granted to the firms in the FTAs is practically the same for all the seven FTAs, as well as the prerequisites for receiving such incentives.

The potential fiscal incentives that the firms operating in the FTAs may be eligible for are displayed in Table 1.

It is not simple to estimate the expenses regarding the FTAs. Brazil's Federal Revenue Service releases only aggregated tributary expenses of the FTAs for the Import Tax and Tax on Industrialized Products. The other taxes are either state income taxes (such as ICMS) or are displayed aggregated with FTZM.

In any case, the total tributary expenses granted to the FTAs, considering only commerce and services, was over R$ 374 million in 2019. Most of this amount came from the Tax on Industrialized Products, according to internal revenue services (Receita Federal (2017)).

Table 1: Summary of the Fiscal Incentives Available in the Foreign Trade Areas

Tax	Incentive Description
Import Tax	Exemption when destined to the internal market, consumption or exportation.
Tax on Industrialized Products	Exemption when importing or buying nationally, if the product is destined to the internal market or consumption or exportation. Exemption when the product is destined to anywhere in Brazil, if more than 50% of the product's raw material has regional origin (since 2015).
Export Tax	Exemption.
Profit Participation Program and Civil Servants' Investment Program contributions (PIS-PASEP)	Exemption when buying nationally. Reduction when selling nationally (the amount depends on the product, place, and tax regime).
Social Security Financing Contribution (COFINS)	Exemption when buying nationally. Reduction when selling nationally (the amount depends on the product, place, and tax regime).
Value-added tax on sales and services (ICMS)	Exemption.

5 Synthetic Control Estimator

The methodology applied in this article is the synthetic control estimator, presented by Abadie and Gardeazabal (2003) and further expanded by Abadie et al. (2010) and Abadie et al. (2015).

Suppose that the observed data is composed by $J+1 \in N$ units, during $T \in \mathbb{N}$ time periods. Assume, also, that only unit 1 is affected by a specific treatment, from period $T_0 + 1$ to period T, where $1 \leq T_0 < T$ and $T_0 \in \mathbb{N}$.

Consider $Y^N_{j,t}$ as the potential outcome that would be observed for unit j in period t had it not been treated for $j \in 1, \ldots, J+1$ and $t \in 1, \ldots, T$. Let $Y^I_{j,t}$ be the potential outcome that would be observed for unit j in period t had it been treated from period T_0+1 to T. Therefore, define

$$\alpha_{j,t} = Y^I_{j,t} - Y^N_{j,t} \tag{1}$$

as the treatment effect for unit j in period t, since it represents the difference between the treated and untreated unit's output. By defining $D_{j,t}$ as a dummy variable that equals 1 if unit j receives the treatment and 0 otherwise, we can identify the outcome for unit j in period t as

$$Y_{j,t} = Y^N_{j,t} + \alpha_{j,t} D_{j,t}. \tag{2}$$

Considering that only unit 1 is treated from period $T_0 + 1$ to period T we only need to estimate $(\alpha_{1,T0+1}, \ldots, \alpha_{1,T})$ to determine $Y^N_{j,t}$, since $Y^I_{1,t}$ is observable.

In our case, this process will be applied for Bonfim. The city of interest will be considered unit 1, while the rest of the FTAs will not be considered for the construction of the estimator, since they have all received treatment.

Let $Y_1 = [Y_{1,1}, \ldots, Y_{1,T_0}]$ be the vector of the observed outcome for unit 1 during the pretreatment period and X_1 the vector of the predictors of Y_1. Analogously, let Y_0 be a $(T_0 \times J)$-matrix of controls' outcome data for the pretreatment period and X_0 be a $(K \times J)$-matrix of controls' predictor data, where K is the number of predictors.

Essentially, X_1 and X_0 contain all predictor values, respectively, for the treated and control units. Y_1 and Y_0 contain the outcome for the pretreatment period for the treated and control units, respectively.

Define $W = [w_2, \ldots, w_{J+1}]$ as a $(J \times 1)$-weighting vector, where $w_j \geq 0$ for each $j \in 2, \ldots, J+1$ and $\sum_{j=2}^{J+1} w_j = 1$. This means w_j is the relative importance of control unit j in the construction of the synthetic control estimator of the treated unit.

In order to create the best possible synthetic control to unit 1, it is crucial to minimize the mean squared prediction error during the pretreatment period. This would reflect on the creation of a synthetic control whose predictors and outcome are as close as possible to unit 1's during the pretreatment period. Therefore, it would be suitable as a counterfactual for the treated unit during the treatment period, since it would be an estimation of what

unit 1's outcome would have been had it not been treated.

Therefore, we must choose $\hat{W}(V)$ where

$$\hat{W}(V) := \underset{\mathbf{W} \in w}{\arg\min}\, X_1 - X_0 W' V (X_1 - X_0 W) \tag{3}$$

and V is the $(K \times K)$-set of all positive defined diagonal matrices.

It is clear that $\hat{W}(V)$ depends on V. Abadie et al. (2010) suggests using $\hat{V}$, considering

$$\hat{V} := \underset{\mathbf{V} \in v}{\arg\min}\, (Y_1 - Y_0 \hat{W}(V))'(Y_1 - Y_0 \hat{W}(V)). \tag{4}$$

$\hat{V}$ forces unit 1's synthetic control to be as similar as possible to unit 1 before treatment.

Considering

$$\hat{W} := \hat{W}(\hat{V}) = [w_2, \ldots, w_{J+1}], \tag{5}$$

the estimator of $Y_{j,t}^N$ is $\hat{Y}_{j,t}^N$, where

$$\hat{Y}_{j,t}^N = \sum_{j=2}^{J+1} \hat{w}_j Y_{j,t}. \tag{6}$$

Now we are able to obtain

$$\hat{\alpha}_{j,t} = Y_{j,t} - \hat{Y}_{j,t}^N, \tag{7}$$

that represents the vector of treatment effects for $t \in 1, \ldots, T$. When $t > T_0 + 1$, $\hat{\alpha}_{j,t}$ represents the estimates of the parameter of interest.

It is expected $\hat{\alpha}_{j,t}$ to be relatively small during the pretreatment stage, since no intervention occurred to that point. This would represent a well-built synthetic control estimator to unit 1.

After the treatment, $\hat{\alpha}_{j,t}$ should be significantly different from zero, had the treatment had any effect on the parameter of interest. This way, the synthetic control estimator would be an approximation of unit 1's counterfactual, representing the parameter of interest's route had the treatment not occurred.

Abadie et al. (2010) and Abadie et al. (2015) propose to test the significance of $\hat{\alpha}_{j,t}$ for $t > T_0 + 1$ by running placebo tests. To check the null hypothesis (zero effect of the treatment on the parameter of interest), we estimate the synthetic counterfactual for all control units, assuming they all individually received treatment.

Since they were not actually treated, $|\hat{\alpha}_{1,t}|$ should be significantly larger than $\hat{\alpha}_{j,t}$ for $j \in 2, \ldots, J+1$, when $t > T_0 + 1$. If that is the case, we would be able to reject the null hypothesis.

However, Possebom (2017) points out that $|\hat{\alpha}_{1,t}|$ could be abnormally large only for

some time periods, but not all when $t > T_0 + 1$. Since this could compromise the rejection rule, he utilizes the inference method used by Abadie et al. (2015): the Root Mean Squared Prediction Error (RMSPE), defined as

$$RMSPE_{j,\ pretreatment} \coloneqq \sqrt{\sum_{t=1}^{T_0} (\hat{\alpha}_{j,t})^2 / T_0} \tag{8}$$

for the pretreatment period, and

$$RMSPE_{j,\ posttreatment} \coloneqq \sqrt{\sum_{t=T_0+1}^{T} (\hat{\alpha}_{j,t})^2 / T_0} \tag{9}$$

for the posttreatment period.

The RMSPE takes into consideration $\hat{\alpha}_{j,t}$ magnitude or, in other words, the difference between the real outcome and the synthetic counterfactual. Though, as stated by Abadie et al. (2015),"a large postintervention RMSPE is not indicative of a large effect of the intervention if the preintervention RMSPE is also large".

In order to solve this problem, Abadie et al. (2015) divides the posttreatment RMSPE by the pretreatment RMSPE, which is also applied by Possebom (2017). This results in

$$RMSPE_j \coloneqq \sqrt{\frac{\sum_{t=T_0+1}^{T_0} (\hat{\alpha}_{j,t})^2 / T_0}{\sum_{t=1}^{T_0} (\hat{\alpha}_{j,t})^2 / T_0}}. \tag{10}$$

Finally, we are able to obtain, for $j \in 1, \ldots, J+1$,

$$p \coloneqq \frac{\sum_{j=1}^{J+1} \mathbb{1}[RMSPEj \geq RMSPE_1]}{J+1}. \tag{11}$$

If p is less than the chosen significance level, we reject the null hypothesis and, therefore, we will have obtained the treatment effect over the parameter of interest.

6 Data Description

The collected data contains the GDP per capita, Agriculture, Industry and Services Total Added Value per capita and as shares of GDP (Government share is also presented) and Population Density of the Brazilian municipalities, all extracted from the Brazilian Institute of Geography and Statistics, for the year 2002 to 2018.

The pretreatment period is 2002-2008, and the treated municipality is Bonfim. Abadie and Gardeazabal (2003), Abadie et al. (2010) and Abadie et al. (2015)'s methodology is applied in order to construct a synthetic control unit of Bonfim for GDP per capita, Agriculture Added Value per Capita, Industry Added Value per capita and Services Added Value per capita. Bonfim's own pretreatment values, as well as its GDP shares and population density, are used as predictors.

An important caveat, concerning the pretreatment period, is its size. Abadie (2021) points out that a small number of pretreatment periods may result in a spurious close match for the pretreatment period, by taking into consideration short-term shocks, which would be a source of bias. Abadie (2021) suggests that "the severity of this problem can be diminished if powerful predictors of post-intervention values of $Y_{j,t}^{N}$, aside from pre-intervention values of the outcome, are included in X_j, reducing the residual variance and, as a result, the risk of over-fitting". Therefore, the selected predictors are only composed indicators that reflect macroeconomic trends, less subjected to variance caused by short-term local shocks.

The control group is composed of municipalities located in the border strip (up to 150 kilometers from the frontier) of the Brazilian North Region. This is the criteria used by the government to create the FTAs. It is understood that Brazil's North Region's municipalities present very specific socioeconomic and cultural characteristics that differ them from the rest of the country. Additionally, their proximity to the frontier might affect their economies, e.g., in terms of foreign trade, in unique ways.

Since they had also received treatment throughout the 20th century, the other FTAs were excluded from the control group.

By limiting the control group to this smaller and more similar sample, virtually all selected cities could have been candidates to becoming an FTA themselves.

Table 2 reports the pretreatment means of outcome and predictor variables for Bonfim, as well as its four synthetic versions (columns (2)-(5)).

In Table 2, all synthetic control units are well-matched to Bonfim's outcome variables and covariates. This is easily identifiable by the small difference between Table 2's Bonfim (column (1)) and Synthetic Bonfim (columns (2)-(5)), for all variables.

The synthetic control units in Table 2 are able to reproduce Bonfim's variables' values more accurately than the Sample Average. This is true not only to the respective dependent variable each synthetic control unit is forced to match but also to the other

variables. This is an indication that the adopted methodology was well-suited for this scenario.

Since the municipalities from the database are similar to Bonfim (concerning the selected variables), by applying the synthetic control methodology, Bonfim's RMSPE from the pretreatment period is expected to be considerably small. In other words, Bonfim's results tend to be trustworthy.

Table 2: Bonfim's Descriptive Statistics (Pretreatment Average Values)

Variables	Bonfim (1)	Synthetic Bonfim				Sample Average (6)
		GDP pc (2)	SAV pc (3)	AAV pc (4)	IAV pc (5)	
GDP pc (R$ of 2010)	5756.76	5728.86	5144.85	5070.71	5604.99	5350.30
SAV pc (R$ of 2010)	475.58	494.12	478.52	463.29	514.07	1031.59
AAV pc (R$ of 2010)	1185.80	1193.58	1237.73	1187.02	1192.73	1039.83
IAV pc (R$ of 2010)	147.54	337.32	157.50	163.98	170.70	540.12
Population Density (per sq km)	1.35	1.32	1.51	1.71	1.34	3.69
Services Share (%)	8.19	7.24	8.48	8.36	8.32	17.21
Agriculture Share (%)	20.51	20.32	19.33	20.36	20.46	19.59
Industry Share (%)	2.66	3.75	2.72	2.77	2.70	7.17
Government Share (%)	67.09	67.04	67.22	66.50	66.99	51.49

Note: XAV stands for Sector X Added Value per capita, and X Share stands for Sector X's share on the GDP.

7 Results

Figure 1 presents the estimated effects for Bonfim. The course of the four variables of interest (real GDP per capita, Services Added Value per capita, Industry Added Value per capita and Agriculture Added Value per capita) are plotted as a time series.

The dotted vertical lines on the graphs mark the year 2008, when the FTA of Bonfim was created. Therefore, the left part of the graph represents the pretreatment period, when the synthetic control and the actual city are expected to present an evolution as similar as possible. The closer the synthetic control is to the actual city in the left of the graph, the better was the application of the methodology, which translates to more trustworthy results. The area of the graph on the right of the dotted line represents the posttreatment period, where the synthetic control should simulate how the variable of interest would have evolved, from 2008 to 2018, had the FTA never been established. The difference between the synthetic control and the treated unit is, thus, the estimated impact of the creation of the FTA.

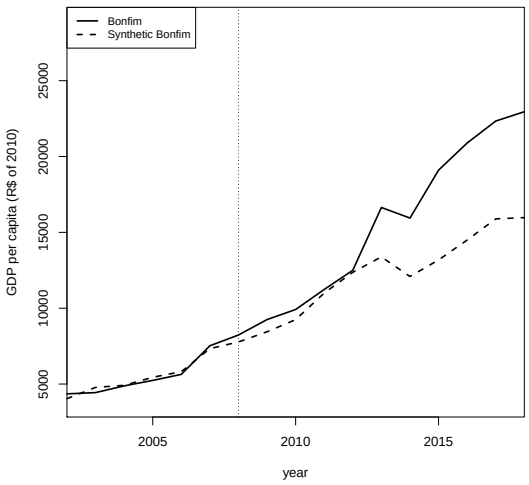
The results indicate that the establishment of the FTAs had a positive impact on the outcome of all variables for Bonfim.

Bonfim's pretreatment RMSPE are relatively small, which means that the synthetic control estimator was able to realistically simulate Bonfim's economic behaviour during the 2002-2008 period.

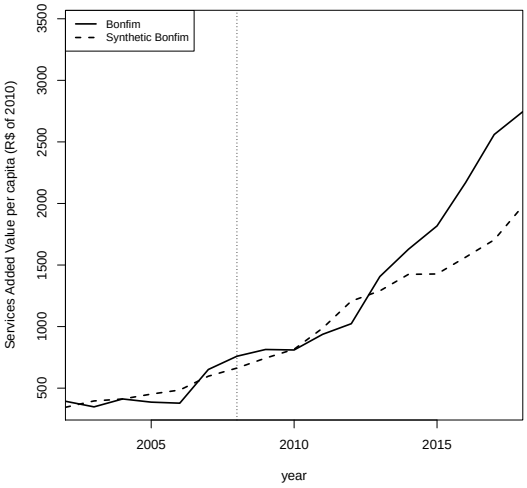
By analysing Figure 1, one could argue that the creation of the FTA of Bonfim had a positive impact on Services and Industry Added Value per capita, as well as Agriculture Added Value per capita and GDP per capita. In terms of economic theory, it is simple to understand why a subsidy policy would benefit a city's economy.

In fact, the reported results show that the establishment of the FTA of Bonfim is responsible for 30.4% of the achieved GDP per capita in 2018. In other words, had this FTA not been created, the realized GDP per capita from 2018 would have been only 69.6% of the actual amount for Bonfim. Regarding the other variables, the FTA of Bonfim was responsible for 27.9% of the Services Added Value per capita, 30.4% of the Industry Added Value per capita and 52.8% of the Agriculture Added Value per capita.

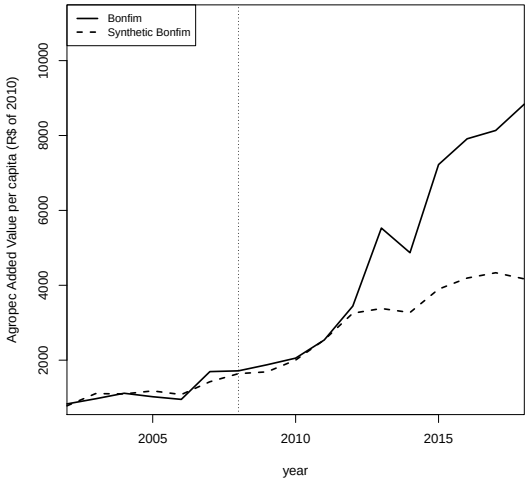
Figure 1: Estimated effects for Bonfim using the Synthetic Control Method



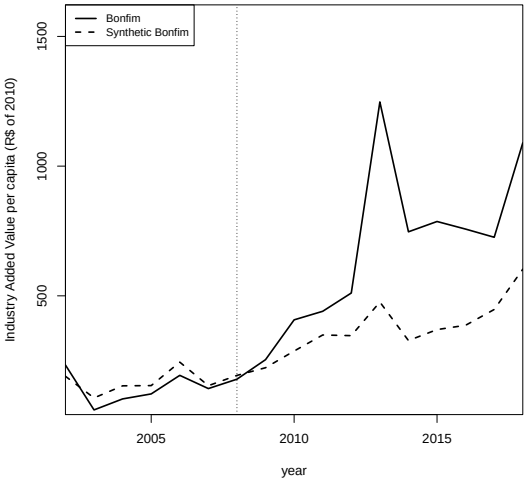
(a) GDP per capita



(b) Services Added Value per capita



(c) Agriculture Added Value per capita



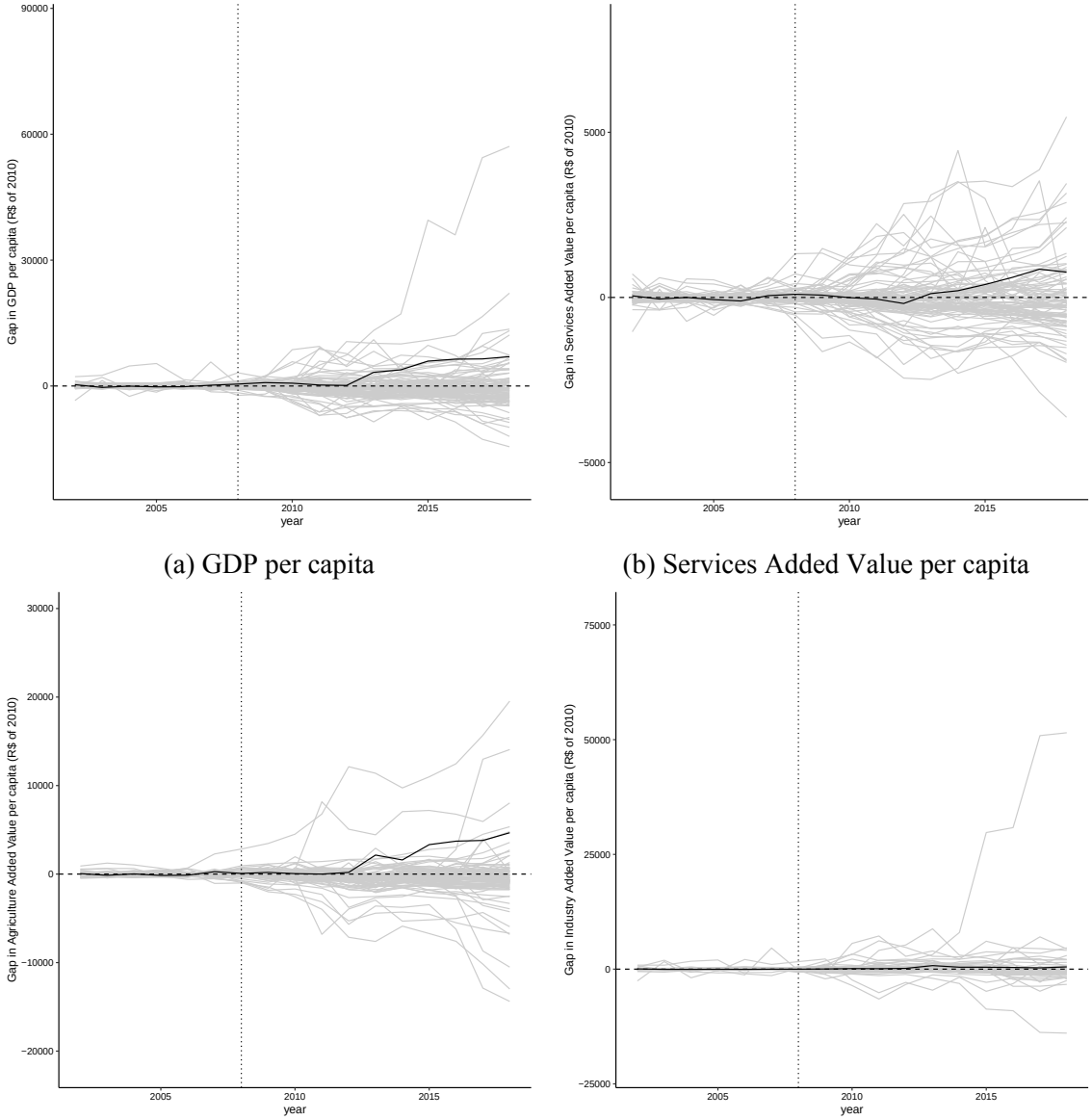
(d) Industry Added Value per capita

7.1 Placebo Tests

The statistical significance of the presented results has not yet been addressed, since no p-values were reported until now. In order to do that, Abadie et al. (2010) suggests applying the synthetic control method to all control units and checking the proportion of control units that present a higher RMSPE in comparison to the treated unit.

Figure 2 plots the gaps between all units and their respective synthetic control estimator, for the four analysed variables. The black lines indicate the actual treated unit's gap, while the grey ones refer to the control units. The bigger the gap after 2008 (dotted vertical lines) in relation to the gap before 2008 (for the black lines in comparison to the grey lines), the more significant the results.

Figure 2: Placebo tests for Bonfim



(a) GDP per capita

(b) Services Added Value per capita

(c) Agriculture Added Value per capita

(d) Industry Added Value per capita

Figure 2 indicates that the economic effect of the establishment of the FTA of Bonfim has a p-value of 45.05% for the Services Added Value per capita, 16.48% for the GDP per capita and for the Industry Added Value per capita, and 8.79% for the Agriculture Added Value per capita. Since the computation of the p-value in the adopted methodology considers the number of control units with a higher RMSPE than the treated unit, this means that, in the case of the GDP per capita and the Indutry Added Value per capita, 15 out of the 90 control units presented a higher RMSPE compared to the treated unit. In the case of the Agriculture Added Value per capita, only 8 out of the 90 control units presented a higher RMSPE compared to Bonfim's.

The results for Bonfim are surprising, on the one hand, since most of the fiscal incentives are auned at services and industry, while agriculture was the only sector truly

affected by the establishment of the FTA, considering a significance level of 10%. On the other hand, Superintendência da Zona Franca de Manaus (2014) points out that Bonfim's strongest sector is the agriculture, and its main comparative advantage is being located near the frontier, which enables the possibility of creating an exportation model based on agribusiness, and that it could be the leading activity of this FTA.

The lack of statistical significance for the other variables could be a consequence of the creation of the FTA of Boa Vista in the same year. Boa Vista's superior economic environment led investors, according to Superintendência da Zona Franca de Manaus (2014), to abandon their plans to invest in Bonfim's industry and services sectors and allocate their resources, instead, in the FTA of Boa Vista.

Nonetheless, the significance of the FTA of Bonfim's impact on Agriculture Added Value per capita means that the effect of the establishment of this FTA was responsible for 52.8% of the realized Agriculture Added Value per capita from 2018.

8 Robustness Check

In order to do a robustness check on the results, I run a differences-in-differences regression, applying the following model:

$$y_{i,t} = \theta T_{i,t} + \beta x_{i,t} + \alpha_i + \delta t + \epsilon_{i,t} \tag{12}$$

where i indexes the cities and t indexes the time periods. Therefore, $y_{i,t}$ indicates city i's GDP per capita or Sectoral Added Value per capita for the year t. $T_{i,t}$ is a dummy variable that equals to 1 for the cities where the FTAs where established after their creation and 0 otherwise; $x_{i,t}$ is a vector of control variables related to the cities' economy, containing the sectoral shares of the GDP and the population density; α_i represents city i's fixed effect; δ_t represents the time fixed effect for year t and $\epsilon_{i,t}$ is the error term.

Conley and Taber (2011) propose, when dealing with policies applied on a small number of units, but with a large number of control units, to set a 90%-confidence interval for the coefficient of interest (θ) as an inference method.

The regression was run with data from the cities from the North Region located in the border strip, excluding the other FTAs. This was both necessary, in order to consider only Bonfim's impact in the treatment variable, and correct, since Superintendência da Zona Franca de Manaus (2014) understands that the FTAs are supposed to impact the sectors in different ways, according to each city's economic dynamics. Therefore, it would be incorrect to assume that, even though the same fiscal incentives are available to all FTAs, the cities would be impacted in a similar manner. Because of that, $T_{i,t}$ only assumes the value 1 for Bonfim after 2008.

Table 3 reports the estimated results for θ of the model presented in Equation 12, as well as the p-values and the confidence intervals of 90% for all dependent variables.

Since only a small percentage of the cities were treated, the statistical significance is not as important in this case, because the estimates are considerably imprecise (hence the wide confidence intervals). Therefore, following the inference method proposed by Conley and Taber (2011), it is important to analyse whether the confidence intervals point to a similar effect of the treatment on the dependent variables, compared to the ones obtained by the synthetic control method.

Table 3: Differences-in-Differences Results

	Dependent Variables			
	GDP pc	SAV pc	AAV pc	IAV pc
	(1)	(2)	(3)	(4)
Estimate	1220.73	-439.95	955.03	-613.35
p-value (%)	30.95	20.44	11.13	36.57
Confidence Intervals	[-755.81, 3197.28]	[-1010.31, 130.41]	[-31.49, 1941.54]	[-1729.02, 502.31]

Note: XAV stands for Sector X Added Value per capita. Sample Size: 91.

The average estimated effect of the establishment of the FTA of Bonfim on the Agriculture Added Value per capita using the synthetic control method was R$1796.85 per year, from 2008 to 2018. This amount is within the range presented in the confidence intervals from Table 3, column (4). Therefore, the conclusions regarding the effect of the FTA of Bonfim on Agriculture Added Value per capita are considered robust.

The wide confidence intervals for the GDP per capita and Industry Added Value per capita are well-distributed between negative and positive values, which was expected, since the results obtained from the synthetic control method for these variables were not statistically significant.

The confidence interval for the Services Added Value per capita, on the other hand, ranges mostly through negative values, which goes against the results obtained for this variable through the synthetic control method, which were not statistically significant.

As a second robustness method, I apply the synthetic control method with a different control group, restricted to cities from Roraima, excluding Boa Vista. Cities located in the same state may present common characteristics to Bonfim, thus, serving as a better donor pool, than municipalities from the border strip located in different states. The downside of using this control group is the sample size being restricted to only 13 cities, besides Bonfim.

Figure 3 presents the placebo tests for Bonfim with this new donor pool. Both the sign, shape and average magnitude of the estimated impact of the establishment of the FTA of Bonfim on its economy, for all variables, is similar to the ones presented in Figure 2. This indicates that the results are robust.

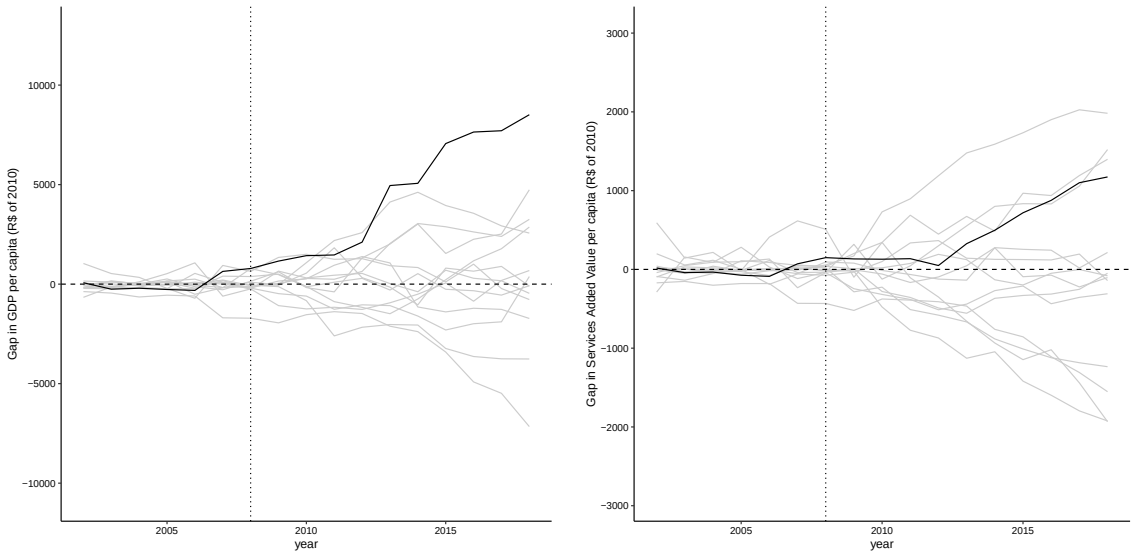
Because of the small sample size, though, achieving a p-value smaller than 10% would mean that Bonfim's RMSPE's posttreatment/pretreatment ratio would have to be the highest between all cities. Surprisingly, that is the case for Industry Added Value per capita, but not for Agriculture Added Value per capita.[2]

The Industry Added Value per capita's significance in Figure 3 was not expected, but the shape and magnitude of this variable was similar to the one obtained in Figure 2.

The lack of statistical significance for the Agriculture Added Value per capita in Figure 3 is not specifically relevant, considering the small donor pool. Its shape and magnitude are sufficient to indicate the robustness of the results concerning this variable.

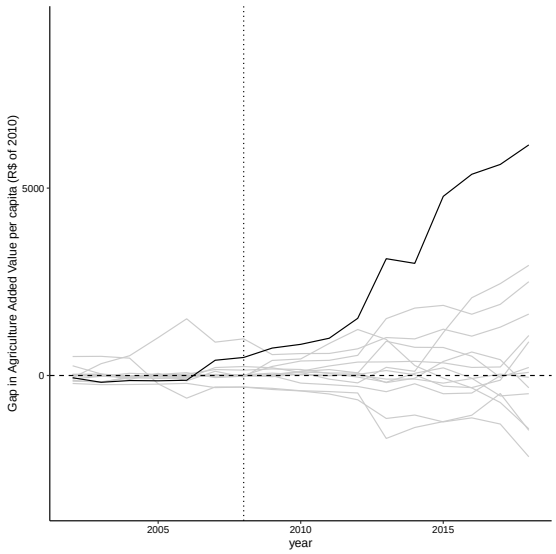
[2]The reported p-values for GDP per capita, Services, Agriculture and Industry Added Value per capita are, respectively, 28.57%, 42.86%, 28.57% and 7.14%.

Figure 3: Placebo tests for Bonfim using cities from the state of Roraima, besides Boa Vista, in the Donor Pool

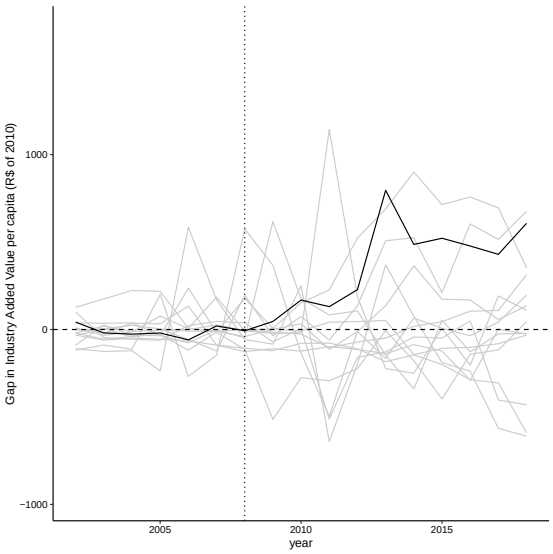


(a) GDP per capita

(b) Services Added Value per capita



(c) Agriculture Added Value per capita



(d) Industry Added Value per capita

9 Conclusion

By applying the Synthetic Control Method to the Free Trade Area of Bonfim, using the cities located in the North Region in the border strip as the donor pool, it was possible to evaluate the impact of its creation on Bonfim's economy. According to the results obtained with this methodology, the FTA had a positive impact only on the agricultural sector, where it had a positive impact. Since this sector contains Bonfim's main comparative advantages, one could argue that the FTA of Bonfim has achieved its goals.

However, the small number of pretreatment periods used for the analysis, due to the lack of previous city-level yearly data, should be taken into account, since this could affect the precision of the results. It is also important to take into consideration that these results could potentially have been remarkably more expressive if politics related to foreign trade with the city of Lethem were applied.

Given the differences (in terms of date of creation, place and socioeconomic environment) between the seven existing FTAs in the North Region of Brazil, the impact of the FTA of Bonfim does not necessarily translate to a similar impact of the other FTAs.

It is not possible to evaluate whether the FTA of Bonfim is cost-effective or not, since the tributary expenses of all FTAs are released aggregated. It is also feasible that the establishment of the FTAs negatively impacted the economies of the nearby cities, by attracting labour and investments that could have been directed to other municipalities.

The large amount of resources spent with the many FTAs, besides the Free Trade Zone of Manaus, illustrates the importance of a future cost-benefit analysis of the FTAs policy, as well as impact evaluations of the other FTAs.

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