João Pedro Mussi

The effects of the Mariana disaster over capital flow and the banking system

Brasil

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Dissertação apresentada ao Curso de Mestrado Acadêmico em Economia, Universidade de Brasília, como requisito parcial para a obtenção do título de Mestre em Economia

Universidade de Brasília - UnB

Faculdade de Administração Contabilidade e Economia - FACE

Departamento de Economia - ECO

Programa de Pós-Graduação

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Resumo

O sistema bancário se transformou e aprimorou muito ao longo das últimas décadas com o aumento da velocidade da informação e desenvolvimento tecnológico. Para medir o efeito em tal sistema e pesquisar acerca das variáveis bancárias será feito um modelo de diff-and-diff de um choque exógeno de capital em determinada região em comparação com outra não afetada. O evento em análise é o desastre de Mariana/MG em 5 de Novembro de 2015 em que por consequência foi alocado capital na micro-região de Ouro Preto. Dado a situação, é proposta uma comparação entre micro-regiões para analisar se há diferenças estasticamente significantes por tal evento.

Palavras-chave: Econometria, Sistema Bancário e Integração Financeira:

Abstract

The banking system has changed and improved a lot over the last few decades with the increase in the speed of information and technological development. Therefore, we propose a study of the banking variables using a diff-and-diff model regarding an exogenous event that caused capital injection in a determined area. The event under analysis is the Mariana/MG disaster on November 5, 2015, in which capital was injected into the Ouro Preto micro region. Given the situation, we propose a comparison between micro regions to analyze if there were statistically significant results due to this event.

Keywords: Econometrics, Banking System and Financial Integration

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1 Introduction

The banking system is very sensitive and events such as wars, natural disasters and pandemics cause a wide array of impacts. The aftermath of these events requires exogenous assistance to the recovery of its resident. After humanitarian steps are taken, rebuilding starts with insurance reimbursements, income emergency transfers and special credit lines created mainly by central governments to support the revival of the local economy. The local banking system uses these extra financial resources that flow to their communities and depositors. In this article, we propose an analysis on what happens during the aftermath of an exogenous event. Our approach is specifically on how the banking system allocates resources regarding deposit and credit variables by the rebuilt and reimbursement applied in a controlled area.

The banking system is going through intense change and improvements over the past decades (GILJE; LOUTSKINA; STRAHAN, 2016). It relies more on capital markets and direct finance to fund load instead of direct deposits together with the 2008 financial crisis with new regulations, business strategies and models across the globe (CGFS, 2018). In addition, the technological improvements on information transfer enables an easier bank lending to a outside branch-based territory (PETERSEN; RAJAN, 2002). Also, the recent growth in fintechs, lowers the costs of all banking services and are improving the access of a previous not serviced part of the population, especially in undeveloped countries (VIVES, 2017).

The goal of our study is to model and measure branch network integration in relation to credit and deposit variables caused by an exogenous amount of money entering in a controlled territory. The event we study is the accident in the city of Mariana in the State of Minas Gerais, Brazil. This is an incident that can achieve our goal since there is a central damaged area as the micro region of Ouro Preto, there is a significant amount of funds transferred to those affected. Therefore, this event is exogenous to the economy with a specific location that enables the comparison between the interest variables of the damaged and undamaged areas.

The accident happened when a dam with 40 billion liters of iron mining waste broke on November 5th, 2015, resulting in 19 dead and a terrible environmental disaster, due to the contamination of the water and soil. The damage extended across 663,2 km of water resources ending in the coast of Espírito Santo and affecting the livelihood of nearby cities (IBAMA, 2015)[1]. The company responsible for the mining in that region was Samarco and consequently it's parent company VALE S/A and BHP Billiton. Fundação

[1] Preliminary Technical Report published by the Brazilian Agency of Environment and Natural Resources (IBAMA).

Renova is the company that was created to be responsible for the rebuilt of the region. According to them by the end of 2021 the indemnities summed R$ 8,71 billion reaching 363,5 thousand people in different affected areas (BRASIL, 2022) [2]. In this article we aim to measure how does that money transferred to that micro region will affect banking variables such as deposit, housing finance, credit supply and government expenses.

We use the differences-in-differences approach to explore with public data from the Brazilian Central Bank, IBGE and Portal da Transparencia where the dependent variable is regressed with dummies variables of location, time, and the interaction between them comparing all 66 micro regions of the state where the event occurred that is Minas Gerais. In addition, we use three different time spans as a short, medium and long term with two years, four years and the full period respectively.

The results show that when regressing deposits as a dependent variable there is a statistically significant growth over the long term of 72 per cent on deposits the micro region of Ouro Preto in comparison with the other ones. When controlling these results with other variables such as the number of bank branches it is also significant with a small positive increase of 0.9 per cent. When we regress the credit variable there is an increase of close to 10 per cent in credit operation and when adding the bank branches there is a significant negative impact on the credit. This is most likely due the fines and indemnities the companies had to pay and the use of the FGTS Calamity Withdrawal. The FGTS is the Service Time Guarantee Fund that every employee can withdrawal in occasion such unemployment, when one has specific diseases or natural disasters. It is due to this incident the Brazilian law now sees dam breakage as a natural disaster (BRASIL, 2015). Therefore the fund coming through these method are enough to make the deposits grow and lower the necessity of taking credit at the bank.

We also propose a more detailed comparison between micro regions with similar GDPs such as Pouso Alegre, Divinópolis and Uberaba to analyse if the effects are significant. The results when comparing Ouro Preto with such regions are scattered the previous group one, for example when comparing to Pouso Alegre deposits growth was statistically significant 32 percent while the credit operation value is not statically significant. On the other hand, when comparing with Uberaba the deposits are 111 per cent higher and credit operations are almost 70 per cent.

To achieve an analysis we take inspiration from articles that studied financial integration after an exogenous event. Capital allocation after a shock has different possible outcomes and methods to study it. In our study, we use the bank branches and the integration it provides to measure if there is a significant effect, BUSTOS; GARBER; PONTICELLI measure the same branch network effects on capital flow, however, we

[2] Published on https://agenciabrasil.ebc.com.br/geral/noticia/2022-01/indenizacoes-por-tragedia-em-mariana-atingiram-r-871-bilhoes-em-2021

use the number of branches due to bank concentration in our affected area and in the whole state with the 5 biggest banks being present in all micro regions. The allocation of funds increased deposits at a different rate than credit with minimal effect on the number of bank branches in the micro regions. In support of our estimation method, GILJE; LOUTSKINA; STRAHAN use banks exposed to shale boom counties in the USA that results in the deposits growth increasing the lending outside non-shale counties. Our estimates show that deposits and credit grow but in at different rates meaning that this money is allocated elsewhere. When we analyze just housing loans in a similar way to the (GILJE; LOUTSKINA; STRAHAN, 2016) there is no significant effect. One of the possibilities of this result is due to the characteristics of the event it can be inferred that the people of the affected area had more deposits and therefore could take less money borrowed by the bank for this specific type of loan. This allocation movement in our model can be sustained by the fact that a greater credit supply goes to high home ownership cities (FAZIO; SILVA, 2021).

We organize our work as follows. The next section introduces the tragedy of Mariana and explain its characteristics, problems and current state. Section 3 describes the procedures we adopt to tune and estimate the models. We detail the data set we use in Section 4 and present the results in Section 5. Section 6 summarizes and concludes the work.

2 The Event

The micro region of Ouro Preto is one of the 66 micro regions of the state of Minas Gerais, Brazil and has as its cities Ouro Preto, Mariana, Diogo de Vasconselos and Itabirito. According to GDP data provided by IBGE mining is the first economic activity of the region with hundreds of active mines according to the University of Ouro Preto, and well known due to the development of the region and services across this industry. On top that, the main city, Ouro Preto, is famous for its historic background, which makes touristic region, and its educational institution. Therefore, this region as one of the richest in the state of Minas Gerais being the one with the highest GDP per capita.

On November 5^{th} of 2015 in the city of Mariana, one of the cities that composes the micro region of Ouro Preto, a damn, made by the company Samarco, one of the companies under the umbrella of Vale S/A and BHP Billiton, broke and contained 45 million cubic meters of composed of iron oxide and silica (a waste of the mining). It buried the sub district of Bento Rodrigues and left 19 dead. According to the IBAMA Technical Report the wastewater affected over 600 km of the water ways going across Espírito Santo and into the ocean. Figure 1 show the accident point marked in yellow and the damaged area that has 36 cities across the state of Minas Gerais according to the Transaction Term and Adjustment of Conduct (TTAC) provided by Samarco. This is considered by the agency as a massive environmental accident due to the extent of the damages and amount of waste.

The main effects are first the loss of houses and lives of the families who lived near, following the intrusion of this waste on the city and environmentally protected areas poisoning the soil, river and under soil water supply and therefore affecting the agriculture, water consumption, tourism, fishing, energy supply and causing death of wild animals and plants. The government of Minas Gerais estimates that the total damages that include the destruction, future damages, restitutions, and other costs R$ 126 billion [1] while prosecutors defends that this value is around R$ 150 billion [2] by the companies involved.

Even though many years have passed there are still lawsuits, and the city still has its scars from the disaster. In total there were 21 people and 4 companies who were federally prosecuted with homicide with eventual intent of harm, however by 2020 sixteen of these lawsuits were dropped and the 5 remaining were changed from the accusation of homicide for the qualified inundation, infrastructure collapse and 12 environmental

[1] According to the report made by Legislative Assembly of Minas Gerais: https://www.almg.gov.br/acompanhe/noticias/arquivos/2022/08/18-release-debate-publico-novo-acordo-tragedia-mariana

[2] https://agenciabrasil.ebc.com.br/geral/noticia/2022-11/sete-anos-apos-tragedia-de-mariana-entenda-o-processo-indenizatorio

crimes.[3] On top of that IBAMA applied 25 penalties that have the summed value of R$ 350 million. The judicial consequences of the disaster is considered slow by the victims,[4] and the problems are considered far from over due to the difficult of the process.

Over the years there were and still are a lot of different problems from the existence of the Renova Foundation created by Vale S/A, BHP , and representatives of the victims to be in charge of the reconstruction and restitution of all affected areas, lack of agreement towards the estimated value of the damages, how to define who was damaged by the disaster due to the extent it got, how slow the companies are to fulfill legal orders, the complexity of environmental reconstruction and many more bureaucracies issues.

On the other hand, the companies claims according to their official media[5] that has been doing all the necessary measures to provide the social-economic and environmental support that is necessary for the affected areas across 42 different programs that have spent around R$ 24,7 billion[6] and of that amount R$ 9,8 billion for the Program 02 "Compensation and Indemnities for those Impacted". This program is the main transfer of funds to the direct affected materially and/or morally as well as those who experienced losses connected to their economic activity without the necessity of bureaucracies or lawsuits according to the Renova Foundation. This program is the main one regarding the analysis proposed by this article due to the direct transfer to businesses and families, therefore, are affecting the banking variables along the period up to the end of 2021.

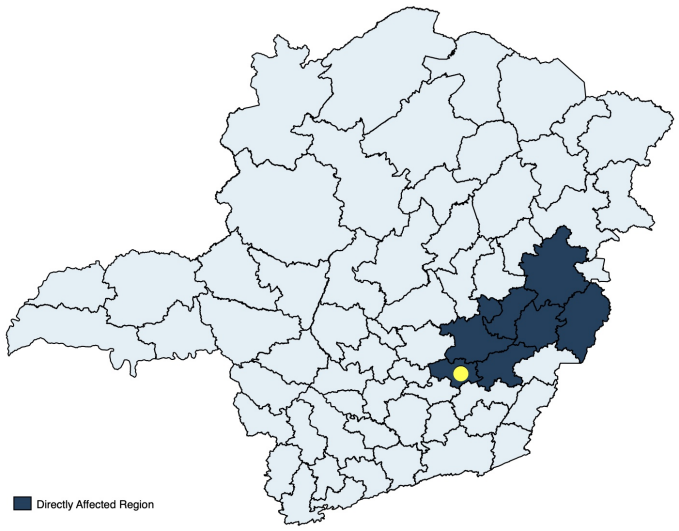

Figure 1 – Affected micro regions of Minas Gerais
[7]

[3] According to G1:https://g1.globo.com/mg/minas-gerais/noticia/2019/10/28/mariana-dos-700-mil-atingidos-estimados-pelo-ministerio-publico-de-minas-9-mil-foram-indenizados.ghtml

[4] According to the report made by G1: https://g1.globo.com/mg/minas-gerais/noticia/2020/11/05/tragedia-de-mariana-5-anos-sem-julgamento-ou-recuperacao-ambiental-5-vidas-contam-os-impactos-no-periodo.ghtml

[5] https://transparencia-fundacaorenova.hub.arcgis.com/

[6] Values until to October/2022

[7] Disaster location marked in yellow. Affected area as suggest by Renova Foundation TTAC.

3 Methodology

To measure the effects of such a disaster on the money transfer to that area through the banking system we use an OLS in a difference-in-differences model. This model is used across different fields for the combination of a timing and location comparison and the interaction between both (FREDRIKSSON; OLIVEIRA, 2019). Therefore, we organize the data by before and after the disaster in November 2015 and the location uses a treatment and control group where the controls are different micro regions of Minas Gerais and Ouro Preto micro region. The equation follows:

$$Y_t = \beta_0 + \beta_1 \times X_t + \beta_2 \times AffectedRegion + \beta_3 \times Post + \beta_4 \times (Post \times AffectedRegion) + u_t \tag{3.1}$$

First, the dependent variable vector Y_t is the measure of financial activity of the dataset that are variables such as deposits, regular loans, housing loans and government expenses. The vector X_t are the independent variables that are controls to help provide more information of the differences between regions and how it affects Y_t and is composed by micro regional variables such as population log, area in km^2, number of agencies. Because we use DID as our location dummy variable, we divide the dataset into control and affected area, represented by the variable "Affected Region". The time dummy variable that divides prior and post the accident is represented by the variable "Post" and finally the interaction between the two is "Post× Affected Region". This last variable is the one we are the most interested in for the study because its value will most likely explain if there is a statistically significant change in the dependent variables of Ouro Preto after the tragedy compared with the other micro regions.

Our main model compares outcomes between the affected region, Ouro Preto, against all micro regions from the same Brazilian state, i.e., Minas Gerais. In a more detailed test, we consider counterfactual to similar regions in terms of characteristics prior to the disaster. First, since Ouro Preto's GDP was R$ 14,6 billion and its population was roughly 184 thousand in 2014, we take control regions that have similar GDP. The reason to pick this method of comparison is according to data collected from IBGE in 2014, Ouro Preto was the region with the highest GDP per capita of the state, with roughly R$ 78,000. Therefore, we preferred to use the ones with similar GDP values such as Divinópolis, Pouso Alegre and Uberaba (see Table 1). Even though they are not the closest in per capita values they are still on a high tier in a state comparison. On top of that these cities were not directly damaged by our exogenous event making good candidates for our control group.

Table 1 – Micro Regions Comparison

Micro Region	GDP (x1000)	Pop.	Area(km^2)	Branches
Ouro Preto	14,601,765.48	185,065	3,149.2	17
Uberaba	13,163,485.21	373,951	9,373.6	42
Pouso Alegre	13,747,497.71	350,481	4,920.2	48
Divinópolis	11,918,137.38	526,917	5,090.4	19

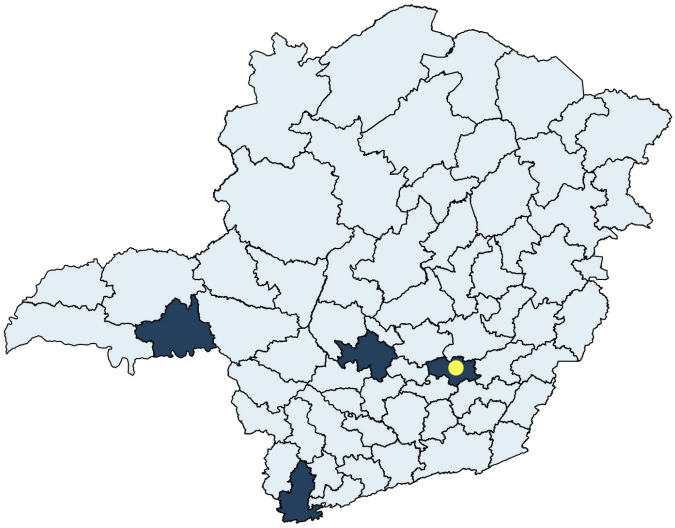

Figure 2 – Selected Comparison Micro Regions Highlight
[1]

[1] From left to right: Uberaba, Pouso Alegre, Divinópolis and Ouro Preto

4 Data

The data we use is public and under the domain of ESTBAN[1], IBGE[2] and "Portal da Transparencia" [3] for the government expenditure in analyzed regions. The ESTBAN data base is acronym for the Monthly Banking Statistics and provided by the Central Bank of Brazil. It provides monthly values of balance sheet variables of all assets and liabilities of every bank branch at every city e.g cash, the different deposit and credit accounts, the amount of debt, etc. We acquire all the data of Minas Gerais banks sub divided by all 66 micro regions through 2013 up to 2021 ending up with 6996 observations.

Next, IBGE is the Brazilian Institute of Geography and Statistics is the main government institute of data and information of Brazil. Its goal to provide the full description of the country that civilians, government agencies as well as states and cities needs to help exercise their citizenship. For our analysis it was responsible to provide all the data of Minas Gerais such as the city's population, GDP, the main economic activities and location data to map the micro regions. Finally, the last main database we use is "Portal da Transparencia" the website where all public expenses are accessible for the citizens' information and control, and we used it to obtain the amount of money transferred to the micro regions of interest.

Table 2 – Micro Regions Data

Variables	Average	Std. Dev.	Median	Max	Min
Deposits2014(x1000)	2,606,558.1	11,194,502.14	789,285.2	93,925,517.4	18,924.2
Credit operations2014(x1000)	2,438,924.9	9,531,560.24	842,304.82	83.837.695,77	17,499.91
GDP2014 (x1000)	7,827,787.6	21,198,944.64	3,601,972.24	171,440,627.7	548,842.96
Area	8,886.57	6,940.6	6,959.65	35,008.78	1,767.6
Branches2014	31	71	19	652	1
Population2014	314,152.98	612,690.57	207,474.01	5,079,661.7	44,605.99

Note: Data provided by IBGE.

[1] https://www4.bcb.gov.br/fis/cosif/estban.asp?frame=1
[2] https://www.ibge.gov.br/acesso-informacao/institucional/o-ibge.html
[3] https://www.portaltransparencia.gov.br/

5 Results

The first model is regarding every micro region with our dependent variables being deposits (Table 3), credit operations (Table 4). The results come three different periods that we divide as short-term, medium-term and long-term. The short period has a year difference from the accident going through October 2014 to October 2016. The medium has a two-year difference from the accident going through October 2013 to October 2017. Finally, the long has the complete period of January 2013 to December 2021. The deposit results reflect that the only statistically significant period is the long-term. This shows that there was no quick money transferred to the region accounts and therefore during this long period it was the main capital allocation to the city. In the long-term result, there is a 72 per cent increase regarding the sum of all deposits (savings account, inter-bank and term deposits) compared to other micro regions. The same effect appears when using the credit operations variable with an increase of almost 10 per cent in the Ouro Preto micro region.

By this data is possible to affirm a statistically significant effect of the allocated money to the area and can be inferred by the difference in the growth of each variable. The deposits are used instead of debt and by branch networking to other regions. This is due to the difference in the growth of the variables and that deposits and credit are highly correlated because the first limits the amount of the latter even by each branch. In sum, it is most likely they are used by bank branches in other regions. On top of these results, when adding the number of bank branches by micro region there are positive results on both variables and making "PostxAffected Region" with similar values. In credit operations' result the "Affected Region" variable is omitted due to collinearity and is not significant in the deposits result which is expected in both cases.

Table 3 – log(deposits)

Dep. Var [a]	Short- Term[b]	Medium-Term[c]	Long- Term[d]	Short- Term	Medium-Term	Long-Term
Affected Region	-0.135	.0987	-0.0819	0.013	0. .250	0.08
	(0.344)	(0.243)	(0.206)	(0.284)	(0. 197)	(0..166)
Post	-0.303	-0.180***	-0.046	-0.296***	-0.165***	-0.005
	0.0611	(0.042)	(0.0308)	(0.050)	(0. 034)	(0.024)
PostxAffected Region	0.563	0.475	0.727***	0.556	0.459	0.697***
	(0.497)	(0.348)	(0.250)	(0 .410)	(0.282)	(0 .201)
No. Branches				0.009***	0.009***	0.009***
				(0.0003)	(0.0002)	(0.0001)
R^2	0.015	0.006	0.003	0.3292	0.3463	0.354
Groups	66	66	66	66	66	66
Obs	1650	3234	6.696	1350	3234	6696

[a] Notes: *p<0.1; **p<0.05; ***p<0.01. Data provided by ESTBAN from Jan/2013 to Dec/2021.
[b] Short-Term period goes from Oct/2014 from Oct/2016.
[c] Medium-Term period goes from Oct/2013 from Oct/2017.
[d] Long Term takes the complete time span Jan/2013 from Dec/2021

Table 4 – log(credit operations)

Dep. Var [a]	Short- Term[b]	Medium-Term[c]	Long- Term[d]	Short- Term	Medium-Term	Long-Term
Affected Region	0	0	0	0	0	0
Post	-0.155	-0.0375	0.0520	-0.162***	-0.040	-0.319
	(0.0453)	(0.0295)	(0..0390)	(0.047)	(0. 029)	(0.039)
PostxAffected Region	0.0404	0.0115	0.0973***	0.0473	0.0141	0.111***
	(0.0453)	(0.0295)	(0.0390)	(0.047)	(0.029)	(0.039)
No Branches				-0.009	-0.0016	-0.004***
				(0.013)	(0.004)	(0.0014)
R^2	0.0041	0.0002	0.0003	0.3081	0.3378	0.3498
Groups	66	66	66	66	66	66
Obs	1.650	3.234	6.696	1.650	3.234	6696
Region FE[e]	Yes	Yes	Yes	Yes	Yes	Yes

[a] Notes: *p<0.1; **p<0.05; ***p<0.01. Data provided by ESTBAN from Jan/2013 to Dec/2021.
[b] Short-Term period goes from Oct/2014 from Oct/2016.
[c] Medium-Term period goes from Oct/2013 from Oct/2017.
[d] Long Term takes the complete time span Jan/2013 from Dec/2021
[e] We use FE robust method due to considerable outliers

When we analyse just housing loans in a similar way to the (GILJE; LOUTSKINA; STRAHAN, 2016) there is no significant effect. One of the possibilities of this result is due to the characteristics of the event it can be inferred that the people of the affected area had more deposits and therefore could take less money borrowed by the bank for this specific type of loan. When controlled by bank agencies of the micro region the effect is very minimal even though is statistically significant, especially regarding credit operations.

The branch network even though very important, it is very specific to certain Brazilian areas as Ouro Preto due to the concentration of the main 5 banks. According to the Brazilian Central Bank (BCB, Brasília, 2021) the bank concentration by 2021 shows that these 5 banks, Itaú Unibanco, Santander, Bradesco, Banco do Brasil, Caixa Econômica, concentrated a total of 72,6 per cent of the credit and 63,1 per cent of all the revenue in a market with 441 institutions. This is very clear in the data for the overwhelming presence of these banks compared to others in the whole State of Minas Gerais and is possible to assume that there was no larger presence of these banks on affected areas and therefore that the information cost to use these deposits is minimal.

The possible reasons behind this disparity between deposits and credit comes from the money transferred by the responsible companies in the long-run and in short-run due to the FGTS Calamity Withdrawl program. The FGTS[1] is the Service Time Guarantee Fund that every employer has to deposit an additional 8 per cent of the employees salary to an account under their names. It can be withdrawn by the employee in a number of occasions such as unemployment, certain diseases and natural disasters. It was due to this accident that the law considers dam breakage as a natural disaster[2]. This decision made possible that people from the affected area could withdrawal up to R$ 6220 at the first days after the incident in a very efficient and fast method. Therefore due to these two providers of funds there is less need to take credit and a growth in deposits.

On top of the overall proposition of all micro-regions, when we compare Ouro Preto with similar non affected areas in 2014 GDP values Divinópolis, Pouso Alegre and Uberaba. The results (Table 5 and 6 in the Appendix) are scattered when compared with the overall model but there are statistically significant ones. The Divinópolis regressions show a 30 percent decrease in credit operations and no significant value at the deposits variable. Pouso Alegre, on the other hand, has a deposit growth in 32,7 per cent and the data does not provide a relevant outcome for credit operations. Finally, in Uberaba, both interest variables are statistically significant. The results are a 111,16 per cent growth in deposits and a 69,9 per cent increase in credit operations. These finding are relevant for our study to analyse that close economic cities did not have similar outcomes along our period of interest and to support that and overall comparison as more relevant model for

[1] Fundo de Garantia do Tempo de Servico
[2] https://presrepublica.jusbrasil.com.br/legislacao/256176296/decreto-8572-15

our estimates.

6 Conclusion

Our estimates show that the money injected due to the accident affected the banking variables in the disaster area in both of our proposed models. In addition, it also provides a perspective that there is a reimbursement to the damaged areas when analyzing the deposits' growth in comparison to other regions. If the funds are enough during the time span of our results is outside the scope of our model. When measuring our model with deposits the results are statistically significant and determine an accentuated growth in comparison with other micro-regions. In comparison with the also significant but smaller growth of credit operation, we can assume that the citizens did not use bank loans for their reconstruction process. The government and the responsible companies' direct aid can also explain why the smaller necessity for bank loans.

Our results are therefore important for measuring the effects of the financial aid provided to Ouro Preto in comparison to other regions of Minas Gerais through the banking system analysis. However, there are also limitations to the method we approached. One of them is that there will always be other events during the studied period that affected the banking variables in an area where the disaster happened, such as government aid and the citizens affected income during the pandemic.

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7 Appendix

Table 5 – Dependent Variable: log(deposits)

Variable	Divinópolis	Uberaba	Pouso Alegre
Affected Region	-0.975***	0.713***	-0.801***
	(0.090)	(0.106)	(0.085)
Post	0.601***	0.431***	0.353***
	(0.077)	(0.091)	(0.073)
PostxAffected Region	0.0785	1.1116***	0.327***
	(0.109)	(0.128)	(0.104)
N	212	212	212
R^2	0.6885	0.7641	0.545
Groups	2	2	2

*Note: *p<0.1; **p<0.05; ***p<0.01*

Table 6 – Dependent Variable: log(credit operations)

Variable	Divinópolis	Uberaba	Pouso Alegre
Affected Area	-1.12***	0.871***	-0.838***
	(0.086)	(0.096)	(0.077)
Post	0.454***	-0.549***	0.102***
	(0.074)	(0.083)	(0.066)
PostxAffected Area	-0.304***	0.699***	0.046
	(0.104)	(0.117)	(0.094)
N	212	212	212
R^2	0.7904	0.7573	0.6218
Groups	2	2	2

*Note: *p<0.1; **p<0.05; ***p<0.01*