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CAIO DE SOUZA CASTRO

INCOME SHOCKS AND MENTAL HEALTH: EVIDENCE FROM OIL ROYALTIES

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Dissertação apresentada à Escola de Economia de São Paulo como pré-requisito à obtenção de título de mestre em Economia de Empresas.

Orientador: Daniel Ferreira Pereira Gonçalves da Mata.

Coorientador: Marcos Yamada Nakaguma.

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Resumo

Esta dissertação examina como os choques de receita nos municípios brasileiros afetam a saúde mental de sua população. Exploramos uma possível exogeneidade em relação à distribuição de royalties de petróleo para estabelecer uma relação causal entre ganhos inesperados de recursos e o número de ocorrências de doenças mentais. Usando a variação municipal nas receitas do petróleo, descobrimos que o recebimento de mais royalties reduz as hospitalizações por cirrose e procedimentos ambulatoriais relacionados à saúde mental. Nossos resultados são robustos para uma série de exercícios. Nossas descobertas sugerem que uma possível explicação para isso é que os royalties têm um impacto positivo nos resultados econômicos locais, o que é consistente com as descobertas da literatura.

Palavras-chave: Royalties do Petróleo, Saúde Mental, Choques de Renda

Abstract

This dissertation examines how revenue shocks in Brazilian municipalities a□ect the mental health of their population. We exploit a plausible exogeneity regarding oil royalties distribution to establish a causal relationship between resource windfalls and the number of occurrences of mental illness. Using within municipality variation in oil revenues, we find that receiving more oil royalties reduces both hospitalizations due to cirrhosis and ambulatory procedures related to mental health. Our results are robust to a series of exercises. Our findings suggest that one possible explanation for this is that royalties have a positive impact on local economic outcomes which is consistent with findings from the literature.

Keywords: Oil Royalties, Mental Health, Income Shocks.

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1 Introduction

Mental health disorders are a growing problem in modern societies. They affect both developed and developing countries, accounting for 13 percent of the overall global disease burden (Collins et al. (2011)).[1] Brazil is not an exception to this scenario. According to the World Health Organization (2017), Brazil leads the world in the prevalence of anxiety disorders and ranks fifth in depression rates.

Also, mental health disorders have direct impacts on economic activities. It affects human capital and productivity, generating losses on labor outcomes (Cronin, Forsstrom & Papageorge (2017), Fletcher (2014)). Additionally, it consumes a great amount of public resources. The Brazilian federal government spends annually R$ 2.4 billion with mental health (Oliveira (2017)). This means that mental health should be a major topic of discussion, which is already the case at many health economics conferences.

Economic performance is usually associated with mental distress. For instance, there is a large medical literature on this topic. Leinsalu, Reile & Stickley (2019) and Gili et al. (2013) provide evidence relating economic crisis to mental disorders. Other works show a relationship with a particular mental health indicator: suicide (Harper et al. (2015), Reeves, McKee & Stuckler (2014)). In the economic literature, there are several papers focusing either on nation-wide (McInerney, Mellor & Nicholas (2013), Lachowska (2017)) or individual-level shocks (Christian, Hensel & Roth (2019). Lindqvist, Östling & Cesarini (2018)). It is important to point out that individual-level shocks are much more intuitive in terms of interpretation since there are fewer factors acting. Aggregate shocks, such as the one studied in this paper, have a greater number of events happening simultaneously, which makes it more difficult to identify the mechanisms by which the shock affects the outcomes of interest.

This paper contributes to the literature by exploring region-wide income shocks as captured by variations in resource-based windfalls received by Brazilian municipalities. An analysis of this type of shock in the context of mental health for the Brazilian case is one innovation of this study. Additionally, we use a unique database that combines royalties, mental health disorders cases, and the provision of health-related public goods.

Exploring the heterogeneity regarding the payment of royalties, we examine 952 municipalities from 2006 to 2013. We analyze the effects of oil revenues on a series of mental health indicators, such as the number of suicide death, hospitalizations due to overdoses and ambulatory procedures related to mental disorders. Our identification strategy is based

[1] Mental health includes our emotional, psychological, and social well-being. It a□ects how we think, feel, and act. It also helps determine how we handle stress, relate to others, and make choices. Mental health is important at every stage of life, from childhood and adolescence through adulthood

on two facts.First, revenues are generated through oil production are divided according to a series of exogenous determined criteria and formulas, which mitigates the influences that the municipalities might have on them. Second, since we control for both municipality and time fixed effects, we are accounting for shocks that affect all our municipalities that receive royalties, allowing us to isolate the causal effect of the transfers.

In the analysis, we use yearly level data on Brazilian municipalities from two main sources. The first source of data comes from *Agência Nacional de Petróleo, Gás Natural e Combustíveis* (ANP), which is the regulatory body for the activities that integrate the oil, natural gas and biofuels industries in Brazil. They are the source of our annual royalties value information. The second source of data is the DATASUS, an institution of the Ministry of Health, with the responsibility of collecting, processing, and disseminating health information. The DATASUS provides us with information about hospitalizations, ambulatory procedures, and deaths that occur each year in Brazil. The data also contains the International Statistical Classification of Diseases and Related Health Problems (ICD) code, a medical classification list by the World Health Organization (WHO), which is fundamental to our analysis since we use it to classify our outcome variables.

Our analysis indicates that an increase in one million reais in the royalties received by a municipality in $t-1$ is responsible for a reduction of 0.09% in the number of hospitalizations related to cirrhosis. The same variation generates at least a decrease of 0.2% in the ambulatory procedures related to mental health disorders. We propose two possible mechanisms. The first one will be a possible relation between royalties and economic performance, measured by local economy variables. The second alternative is to focus on the provision of public goods, particularly the ones related to public health. We find evidence to the first one, through the number of service and retail plants.

The rest of the paper is organized as follows. In section 2, we review the literature related to the relationship between shocks and mental health. In section 3, we present an institutional background regarding oil royalties. Then in section 4, we describe the databases that will be used throughout the paper. Fifth, we present our empirical strategy. In section 6, we discuss our main results. In section 7, we do some robustness exercises. In section 8, we propose some mechanisms. In section 9, we provide further analysis with a different identification strategy. Finally, we conclude.

2 Literature

This paper is related to previous studies that have analyzed the impact of shocks on health indicators. An important feature is the type of shock that the paper investigates. It can be nation-wide, region-wide, or individual-level. This article studies one of the second type, more specifically in the public sector. The analysis of this type of shock is one of the contributions of this study. Additionally, we try to understand if income shocks affect mental health indicators and what could be possible.

The medical literature has explored extensively the nation-wide shocks. For instance, Gili et al. (2013) and Leinsalu, Reile & Stickley (2019) study the effect of an economic crisis in different countries of Europe and find a positive relationship between economic downturns and the greater occurrences of mental order disorders. Harper et al. (2015) and Reeves, McKee & Stuckler (2014) focus specifically on the effect of the crisis in the suicide rates and again find a positive correlation. In all these papers, the mechanism by which the shocks affect the mental health era through changes in the individual lives: job loss, debt, mortgage payment difficulties, and other problems that are generated by the macro shocks.

The economics literature also started studying nation-wide shock. Works as Oswald (1997), Tella, MacCulloch & Oswald (2001) and Tella, MacCulloch & Oswald (2003) explore the relationship between individual-level variables that measure happiness that is obtained through surveys with macro variables such as GDP growth and unemployment. They conclude that there is a direct relationship between how good the economy is and how happy people feel in a determined country. More recent work by McInerney, Mellor & Nicholas (2013) investigates the impacts of a nation-wide crisis on the individual level. They found that that the 2008 crash reduced wealth and increased feelings of depression and use of antidepressant drugs.

Some works focus on individual-level shocks. Gardner & Oswald (2007) and Apouey & Clark (2015) investigate the effects of winning a prize lottery on some health outcomes, including mental health. They both find a positive relationship between income shocks and mental health conditions. An explanation for this is that winning itself and spending money has a positive effect on mental condition. Another way to investigate income shocks at this level is to use Randomized Control Trials. Baird, Hoop & Özler (2013) tries to see the effects of a positive income shock on mental health among adolescent girls using evidence from a cash transfer experiment in Malawi. They found that offers of cash transfers strongly reduced psychological distress among baseline schoolgirls. Using a cash transfer program in Indonesia, Christian, Hensel & Roth (2019) examines how income

shocks affect the suicide rate and find a negative relationship between them both. They provide evidence that income shocks may ignite suicidal behavior by affecting people's mental health.

Another type of analysis that is possible is to investigate the long term impacts on the mental health of shocks that happened in the life of the individual. Again, the type of shock can vary. Lindqvist, Östling & Cesarini (2018) uses an individual-level shock generated by a prize lottery to investigate the long-run effects and finds small effects on mental health indicators. The main channel suggested is that life satisfaction is related to financial satisfaction. Other works focus on nation-wide shocks' effects when they happen on individual early life. Adhvaryu, Fenske & Nyshadham (2019) using time series of cocoa prices and a household survey in Ghana, shows that psychological well-being in adulthood varies with the circumstance in early life. People born at producing localities are less likely to be subject to no mental distress compared to non-producers if they faced larger prices of cocoa in their early life. Here, the mechanisms are nutritional availability in utero, maternal health, and initial health endowments such as vaccination rates and breast-feeding. Lastly, we have Pierce & Schott (2020), which investigates the impact of a large and persistent economic shock on "deaths of despair" and finds that areas more exposed to a change in international trade policy exhibit relative increases in fatal drug overdoses, an event that is related to the individual mental health.

Finally, we can also relate our work to the literature that studies natural resources and, more specifically, oil. It is worth highlighting four works that are specifically about oil production and royalties in the Brazilian context. Monteiro & Ferraz (2010) and Monteiro (2015) use the oil royalties as an instrument to government spending. In the first one, they investigate if voters reward incumbent mayors for increasing government spending and whether this reward varies over time as voters learn about the source of revenues and public service delivery. Monteiro (2015) studies the correlation between government expenditure on education, and school achievement. Caselli & Michaels (2013) uses oil production, instead of the royalties, to investigate the effects of resource windfalls on government behavior. And Chan & Karim (2019) paper examines how royalties windfalls affect municipalities' provision of education and finds a positive relationship between them.

3 Background

3.1 Oil Royalties

In this section we discuss how the revenue generated from the oil production is distributed and present some anecdotal evidence relating local economic performance and the oil royalties. [2] The producers must pay up to 10 percent of output value in royalties to the government. [3] This revenue is then distributed to the various levels of public administration. Local governments are the ones that receive the greatest direct amount of oil royalties and these benefits are largely concentrated in so-called producing municipalities. Nevertheless, not only that oil-producing localities are entitled to resources: municipalities that have oil transportation facilities, municipalities that are crossed by oil pipelines, and municipalities that are neighboring oil producers are also entitled to receive oil windfalls. [4]

An important feature to discuss is what determines if a locality is considered or not a producer and this depends whether the production is onshore or offshore. In the case of the first group, the municipality where the well is located is classified as a producer and thus receives a fraction of the royalties of this well. However, when we deal with the production of oil in the sea we have much more complicated criteria. A municipality is an offshore oil producer if it faces oil fields according to the geodesic lines that are orthogonal and parallel to the Brazilian coast. These criteria were established by the National Bureau of Statistics and according to Monteiro & Ferraz (2010) no political interests were influencing this determination.

The distribution of oil royalties follows a combination of several pieces of legislation. One that is a landmark is the Oil Law from 1997. This law increased the royalties payment from 5 to 10 percent and created the payment of special quotas to highly productive oil fields. A more detailed and long discussion regarding the law structure is presented in Monteiro & Ferraz (2010). We highlight a change in legislation that occurred more recently. With the discovery of huge reserves of oil in the so-called Pre Salt, a topic of public discussion is the distribution of the benefits of these huge stocks of oil. As a result, the royalties distribution was slightly changed by Law 12,734/2012, which came into effect

[2] Oil and gas are also called petroleum or hydrocarbons. Following Cavalcanti, Mata & Toscani (2019), throughout this paper, we will use the term oil to refer to oil and gas. The oil industry is loosely divided into two segments: upstream and downstream. Upstream refers to exploration and production of oil, while downstream refers to processing and transportation (refineries, terminals, etc).

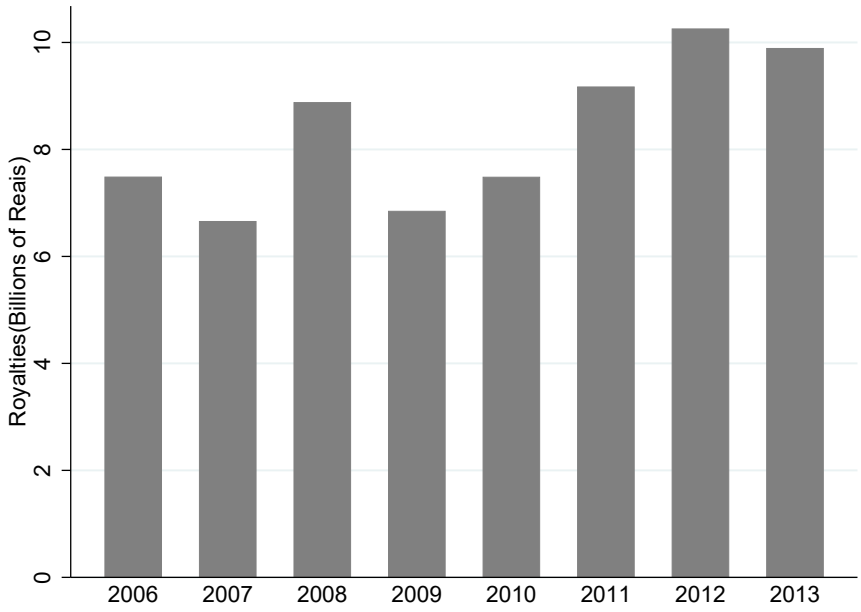
[3] Here we are calling royalties two di□erent types of payments: royalties and "participações especiais". The last one was created by the Oil Law of 1997 and is paid to highly productive oil fields

[4] A more in-depth description of the calculation and distribution of royalties can be seen in Appendix A.

in 2013. The main changes that this new law created were the following: to increase the transfer of money to non-producing states and municipalities, to spread to more people the benefits from the new oil fields. On the other hand, this decreased the transfers to producing municipalities.

Another relevant observation is that the value of oil royalties received is not irrelevant. In fact, from 2006 to 2013 the municipalities that are considered in our sample received more than 6 billions of reais. This means that there is a considerable amount of money being transferred to these cities.

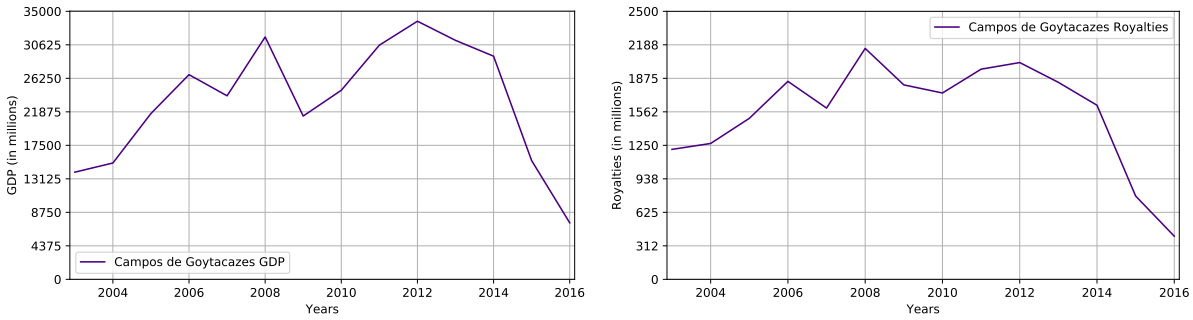
Figure 1: Total of Oil Royalties



Note: The graph shows the total of Oil Royalties received by the 952 that are used as sample from 2006 to 2013.

The next step is to argue that oil royalties are important to municipalities and variations on their values are relevant in terms of income. To do so, we show how the GDP and royalties revenue follows a similar time trend for Campos de Goytacazes, This is one of Brazil's greatest oil producers and looking at Figure 2 it is clear that the evolution of its economy is deeply related to the oil sector. This anecdotal evidence shows that oil revenue can be a good income shock to examine.

Figure 2: Campos de Goytacazes - GDP and Oil Royalties



(a) GDP (b) Royalties

Note: Figure 2 (a) shows the evolution Campos de Goytacazes GDP (in millions of reais) while (b) shows the evolution of its Oil Royalties. Here we see the evolution from 2003 to 2014.

3.2 Brazilian Health System

The Brazilian Health System is composed of a network of complementary and competitive service providers and purchasers, that includes both public and private institutions. [5]. The health system has two big sectors. One is the public subsector, in which services are financed and provided by the state at the federal, state, and municipal levels. The other is the private subsector, which can be for-profit and non-profit. In this one, services are financed using public and private funds, with the important participation of the private health insurance sector.

The public health system is called Universal Health System (SUS) and was first discussed by the 1988 Brazilian Constitution and implemented by regulation instituted in the following years. The system is composed of the Ministry of Health, States, and Municipalities, as determined by the Federal Constitution. Besides decentralization, another important feature of this health system is that it enables multiple nation-wide initiatives, such as an HIV/AIDS prevention and control program, for example. Finally, this system created tools so that multiple information systems that gather health outcomes and shall be explored through this paper.

It is important to point out that the private subsystem has a connection with the public sector by providing services contracted-out by the SUS. Part of this supply is financed using public money and the rest is financed by private sources. Given this connection, some of the data that will be utilized, for example regarding hospitalizations, include occurrences in private hospitals that are financed by the SUS.

[5] Here we do not make a extensive review regarding the Brazilian Health System. To see more about the topic see paim2011brazilian

4 Data

4.1 Royalties

In Brazil, oil production is overseen by the federal regulating body, the Agência Nacional do Petroleo, Gas Natural e Biocombustiveis, or ANP. Since the law of 1997 described before, it was determined that the main oil company in Brazil, Petrobras, must transfer 10% of its oil revenues to various levels government, of which approximately 30% went to municipalities. Since Petrobras is practically the only national producer, this amounts to a large regular transfer of funds to municipal governments coming from overall oil production in Brazil.

So we obtain royalties data from ANP. ANP discloses monthly information on royalty payments made to municipalities since 1999. [6] Since this oil royalties values are those reported directly by the regulator, ANP, from their calculations, in principle these values are not subject to misreporting because of municipal-level corruption. In our main specification, we will use information from 2005 to 2013 and a total of 952 municipalities. As we will discuss in the next section since we use a lag of one period of the amount of royalties received by a municipality. means that the last year in our baseline specification is 2012. The main reason to do so is to do not have our results biased by the big change in royalties distribution law that we discussed in the previous section.

As we pointed out in the previous section, not only producing municipalities receive royalties. The municipalities' location can be seen in Figure 3. The map shows that the majority of oil municipalities are those close to the coast. Another point is that we will always use the value of royalties in millions of reais.

[6] The information is available at http://www.anp.gov.br/royalties-e-outras-participacoes/royalties

Figure 3: Royalties Geographical Distribution

Note: The picture shows the location of the 952 municipalities that we are going to consider in our sample and that received oil royalties in any year from 2005 to 2013 (darker blue). The municipalities that do not receive royalties are in light blue.

Table 1 provides summary statistics regarding royalties for the sample displayed in Figure 3. There is a fluctuation in the mean value, with increases and decreases throughout our sample. As we can see, there is a great variation on the amount of royalties received by municipalities, with the standard deviation being always really high. Also, few cities receive huge amounts of royalties.

Table 1: Royalties - Sample summary statistics

	2006	2007	2008	2009	2010	2011	2012	2013
Royalties (Millions of Reais)								
Mean	7.861	6.989	9.323	7.189	7.858	9.630	10.77	10.39
SD	74.75	63.32	83.66	69.27	67.37	77.05	80.51	73.81
p25	0.00183	0.0139	0.0234	0.0208	0.0232	0.0165	0.0207	0.0234
p50	0.0508	0.0467	0.0560	0.0320	0.0424	0.0706	0.0694	0.0718
p75	0.318	0.644	1.072	0.520	1.243	2.181	2.553	2.762
p90	9.445	8.566	11.99	8.206	9.701	10.69	12.31	12.26

Note: This table shows the summary statistics for the Royalties variable for our 952 municipalities. We are using the period of 2006 to 2013

4.2 Health

We will use available information about public health produced in the Universal Health System (SUS), which is one of the largest public health systems in the world. In 2016, of the 7,522 hospitals of Brazilians, 5,536 (73.60%) attended the SUS (Marinho (2017)). There

is a lot of available information, regarding different topics such as mortality, hospital and ambulatory procedures, the workforce in the public system care, and many others. Here we will obtain our outcomes variables to try to verify if there is a relationship between the income shocks generated by royalties revenue received by a municipality and the mental health.

Our analysis exploits a data from three sources: *Sistema de Informações Hospitalares* (SIH-SUS), *Sistema de Informações Ambulatorais* (SIA-SUS), and *Sistema de Informações sobre Mortalidade* (SIM-SUS). All of them are from Brazil's Ministry of Health and provide highly detailed information regarding, respectively, hospitalizations, ambulatory procedures, and mortality in Brazil. They contain information on the day and location of each occurrence, as well as primary and secondary causes of occurrences. Our analysis focuses on different types of mental disorders.

It shall be explored different types of mental disorders, The idea here is to shed a light to the fact that mental health includes a wide range of outcomes and can not be summarized in only one variable such as suicide or depression. Our outcome variables will be related to mortality, the number of ambulatory procedures, and hospitalizations. Using the International Classification of Disease (ICD), we consider occurrences from Chapter V - "Mental and behavioral disorders" and some of Chapter XX - "External causes of morbidity and mortality", which represent the multiple types of suicide. [7]

An outcome that will be analyzed is the number of cases (hospitalizations or deaths) that are classified as cirrhosis. Many medical papers have already pointed the existence of a relation between mental health disorders and excessive alcohol consumption (Caldwell et al. (2002), Weitzman (2004), Pereira et al. (2013))). Also, since it is observable and symptomatic, many times it is easier to diagnose than a lot of mental disorders, which are sometimes asymptomatic and hard to classify (Millon & Davis (1996), Phillips & Kupfer (2013)). It can be the case that many of the occurrences are generated by a mental illness, making this variable a good one to examine.

Another mental outcome is the cases classified as overdose. As in the case of alcohol, substance abuse is known to be related to many mental disorders (Tobin & Latkin (2003), Burns et al. (2004), Burns et al. (2004)), it is again a good variable to measure mental health. And the final one is the cases related to suicide. In the case of hospitalization variables, the suicide variable refers to suicide attempts, whereas the mortality variable refers to actual self-caused death. We can interpret this as the most extreme case of mental disorder. This is the one that has already got some attention in the economics literature in works such as Christian, Hensel & Roth (2019).

We will focus on multiple variables to capture different dimensions of mental health

[7] The disorders that are included in this chapters and that we consider in this paper are in Tables 14, 15 and 16 of the Appendix

disorders. The first one will be the total of occurrences that are classified in Chapter V and considers; all possible mental health disorders. This will be called “ICD - F” since this is the letter in the classification that refers to this chapter. We will use this information in all systems.

Afterward, we will analyze some subcategories of this typification. The first one is alcohol-related mental illness. We explore also all ICD related to drugs. Two other important groups are also highlighted. The first one is what we call "humor diseases", which includes depression. The other one is named "stress diseases" and comprehends different types of anxiety disorders. This is important to investigate whether the results observed by the whole category are driven by a specific category or they are a common trend.

Finally, it is important to notice one aspect of the ambulatory data. Practically all procedures associated with an ICD F are performed at the *Centros de Atenção Psicossocial* (CAPS), centers focused on mental health that is integrated into the Brazilian Public Health System. [8] We have the data specifically to these centers and we will investigate if there is any difference between this data and all ambulatory procedures.

Tables 17, 19, 21 and 23 display summary statistics for our health-related variables that are going to be used as outcome variables in our estimations. Notice that our sample includes 952, which had 36,3% of the Brazilian population in 2016. Here, there are two important features. The first one is that the mental health variables average does not necessarily follow the same time trend than the total occurrences of its group (hospitalization, mortality, or ambulatory procedures). This is is important so that our models are not only capturing a general trend. Another thing is that we have a high standard deviation, which shows that we have within-municipality variation to make our estimations.

Finally, we can compare these variables with the rest of the Brazillian municipalities. Tables 18, 20, 22 and 24 display summary statistics for all municipalities in Brazil. An interesting feature is that for most of our outcomes, the oil receiving municipalities have a higher mean. This is more prominent in the CAPS related variables, which is important since this dataset focuses mainly on mental health.

4.3 Other Variables

In our main regressions, we use geographic controls as latitude, longitude, and an indicator variable that equals one if the municipality is the capital of the state. These

[8] The SIA data does not necessarily provide the ICD code and we use the occurrences that do so. However, all procedures that are done in CAPS have this code, so this is another indicator that the majority of SIA procedures that are classified as ICD F are realized at the CAPS.

geographical variables will serve as proxies to control geological features of territories that might be correlated to the production of oil and, therefore, to the value of royalties. They will also try to identify some sort of spatial correlation, which will be further addressed more formally in one of our robustness exercises

We will also use variables related to the local economy performance when we try to tackle the possible mechanisms to explain our results. We use the Relação Anual de Informações Sociais (RAIS; Ministry of Labor Administrative Dataset), over 2006 to 2013. This is an annual administrative data set assembled by the Brazilian Ministry of Labor. Effectively, it is a census of the Brazilian formal labor market, including workers for both private and public sectors.

Variables related to the public provision of health care will also be utilized in the search for possible channels that explain our results. Behind this mechanism, we are thinking that the extra amount of public revenues generated by royalties could be used by the government specifically in public policies that aim directly on mental illness. The SUS also collects data on both the number of professionals in the health area and different types of institutions that provided health assistance to the population.

5 Empirical Strategy

We are interested in estimating the effects of an oil revenue shocks on mental health indicators. The specification will focus on municipalities that receive revenue from oil, both producers and non-producers. Therefore, our model tries to evaluate different levels of exposure to royalties. One important point is that we regress the outcome variables against a lagged (by one year) oil royalties variable, to allow for the adjustment in municipal revenues to translate into changes in the provision of public goods and the local economy.

Our identification strategy is based on a fixed effect approach in which we explore the within-municipality changes in oil royalties. We argue that this allocation of royalties, conditional on ever receiving oil royalties, to be plausibly exogenous conditional on time and municipality fixed effects. One reason why this assumption is likely to be satisfied in our setting is that the rules for the determination of the royalties are based on objective criteria and determined by federal laws, which mitigates the influences that the municipalities might have on them. Another point is that since we are controlling for time fixed effects, we are controlling for shocks, for example, price changes, that affect all our municipalities that receive royalties. The empirical model we employ uncovers the causal impact royalties even if the municipalities are heterogeneous in terms of unobserved characteristics, provided that these differences are constant over the sample period.

The general regression that we will be estimating is the following :

$$Y_{it} = \alpha_i + \gamma_t + \beta R_{i,t-1} + \mathbf{X}_i \rho_t + \varepsilon_{it} \tag{5.1}$$

where Y_{it} denotes the municipality i mental health outcome in time t, $R_{i,t-1}$ are the royalties received by municipality i in $t-1$, X_i vector of municipal controls, α_i and γ_t are, respectively, municipality and time fixed effects and ε_{it} is the error term. In our vector of controls, we include a dummy that indicates if the municipality is a state capital or not and the latitude and longitude of the municipality centroid. It is important to point out that this vector of controls has a time-varying coefficient, otherwise its effect would already be captured by the municipality fixed effects.

The inclusion of year fixed effects allows us to control for temporal patterns in mental illness cases that are common across municipalities. Meanwhile, the municipality fixed effect controls for time-fixed factors that are specific for the localities i and can affect mental health indicators. The standard errors are clustered at the municipality level.

The next point is our dependent variables. As we pointed out before, we are going to use data regarding hospitalizations, ambulatory procedures, and morbidity provided by Brazil's Ministry of Health. Although we are using annual data, since we are focusing on

some specific causes, there are a lot of municipalities with zero occurrences in some of our variables of interest.

A first method to try to deal with this problem is to consider the natural logarithm and sum one to the number of occurrences to the municipalities with a value equal to zero. This is done to avoid possible sample selection bias since we use only the log we would drop from our sample the municipalities with no cases. [9] Another thing is that log transformation is still one most frequently used transformation in the medical and health literature.

A second approach is to use the Inverse Hyperbolic Sine Transformation (*arcsinh*). [10] This transformation has grown in popularity among applied econometricians because is similar to a logarithm and allows retaining zero-valued (and even negative-valued) observations (Burbidge, Magee & Robb (1988); MacKinnon & Magee (1990); Pence (2006)). Also, Bellemare & Wichman (2019) provides an understanding of the coefficient generated by Inverse Hyperbolic Sine Transformation to a variable for the cases where the arcsinh transformation is applied to the dependent variable with a continuous explanatory variable of interest , which is our design. Since this transformation follows a logic similar to the logarithm one, we will use it as a robustness exercise.

It is important to point out that we will utilize our outcomes per 10,000 persons, which is common in the medical and health literature.

All that considered, our baseline model is given by the following specification:

$$ln(1 + M_{it}) = \alpha_i + \gamma_t + \beta R_{i,t-1} + \mathbf{X}_i \rho_t + \varepsilon_{it} \tag{5.2}$$

where M_{it} is our mental health outcome at municipality i at time t measured per 10,000 inhabitants.

[9] This *ad hoc* approach is usual in empirical papers and has been used for a while. One of the first ones to do so was MaCurdy & Pencavel (1986)

[10] The *arcsinh* transformation has the following formula : $arcsinh(x) = ln(x + \sqrt{x^2 + 1})$

6 Results

We divide the results into three parts. Firstly, we start by discussing the effects of royalties on the hospitalizations variables. Secondly, we investigate the morbidity variables. Finally, we finish with the ambulatory variables. One important point is that we always present as the first outcome variable the total occurrences of the information system. The objective to do so is to identify if the behavior of the mental health cases follow or not a general trend.

Table 2: Baseline Results - Hospitalization and Mortality

Baseline Results	(1) Total	(2) Cirrhosis	(3) Overdose	(4) Suicide	(5) ICD - F
Panel A. Hospitalization					
Royalties (R_{t-1})	-0.000821	-0.000887**	0.000270	0.0000576	-0.000296
	(0.00109)	(0.000362)	(0.000401)	(0.000137)	(0.000370)
Panel B. Mortality					
Royalties (R_{t-1})	0.000305	0.0000574	0.0000381	-0.0000288	-0.000271
	(0.000348)	(0.000173)	(0.0000699)	(0.0000933)	(0.000310)
	(6) ICD - F - Alcohol	(7) ICD - F - Drugs	(8) ICD - F - Humor	(9) ICD - F - Stress	
Panel A. Hospitalization					
Royalties (R_{t-1})	-0.000105	0.0000244	-0.000490	-0.000131	
	(0.000315)	(0.000343)	(0.000471)	(0.000183)	
Panel B. Mortality					
Royalties (R_{t-1})	-0.000159	-0.000088	0.0000363	0.00002	
	(0.000251)	(0.0000948)	(0.000033)	(0.0000196)	
Municipalities	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

Table 3: Baseline Results - Ambulatory and CAPS

Baseline Results	(1) Total	(2) ICD - F	(3) ICD - F - Alcohol	(4) ICD - F - Drugs	(5) ICD - F - Humor	(6) ICD - F - Stress
Panel C. Ambulatory						
Royalties (R_{t-1})	0.000640	-0.00294***	-0.000779	-0.000560	-0.00151***	-0.000322
	(0.000425)	(0.00112)	(0.000547)	(0.000421)	(0.000572)	(0.000552)
Municipalities	952	952	952	952	952	952
Panel D. CAPS						
Royalties (R_{t-1})		-0.00211**	-0.000846	-0.000648	-0.00163***	-0.000615
		(0.000933)	(0.000531)	(0.000400)	(0.000630)	(0.000571)
Municipalities		952	952	952	952	832
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

Hospitalizations The first group of mental health outcomes is the hospitalization one and they are presented in Panel A from Table 2. In Column (1) we observe a negative

non-significant relationship between royalties and the total of hospitalizations. This means that the higher the value of Royalties that a municipality received in time $t-1$, the smaller was the total of hospitalizations in time t. However, this result is not statistically relevant.

Now, when we look at the outcomes regarding mental health we have only negative coefficients. The only one that statistically significant is the cirrhosis. According to Column (2), an increase in one million in the value received in royalties in the previous year decreases in approximately 0,0887% the number of hospitalizations per 10,000 inhabitants due to cirrhosis. It is important to notice that this result is consistent with the literature. Studies such as Dávalos, Fang & French (2012) and Compton et al. (2014) find this type of negative association. It is interesting that even that they are not significant, all coefficients related to no mental health, apart from drugs-related diseases, are negative.

Mortality The results to this information system are in Panel B from Table 2. We find no significant effects on any of our variables related to mortality. However, different from the hospitalizations results, we have mixed signals on the coefficients for the outcomes. Another interesting point is regarding suicide deaths. The coefficient is negative. Studies such as Christian, Hensel & Roth (2019) already pointed for this negative relation using individual-level shocks. The medical literature in papers such as Harper et al. (2015) and Reeves, McKee & Stuckler (2014) also find this type of association.

Our results indicate that an increase of 1 million reais in the value of royalties decreases the number of suicides by approximately 0.00288%. Notice that the total number of deaths has positive coefficients, so we are not capturing a growing tendency. Again our the sign of most of our results are consistent with the literature. Notice that the negative relation positive shocks and substance abuse are also noticed in studies like McInerney, Mellor & Nicholas (2013). However, in our case, all estimates are not significant and much close to zero.

Ambulatory Procedures Finally, we have the results regarding the ambulatory procedures that are represented in Panel C from Table 2. If for the number o general procedures we find a positive effect, the number of procedures specifically related to mental health, expressed in Column (2), are negatively related. The coefficient is statistically significant and indicates a variation of, respectively -0.294 % in the number of procedures for each extra million reais in royalties. The results here continue to follow the positive association between negative shocks and mental health disorders that has been found in the literature (Gili et al. (2013), Gardner & Oswald (2007)).

After seeing that for all ICD diseases that are labeled as F, we investigate more specif groups. We find the same negative relation, with only the coefficient regarding humor related disorders being significant. This group includes all depressive disorder and this is similar to what is seen in the literature (see Zivin, Paczkowski & Galea (2011)). As we pointed out before, all ambulatory procedures related to mental health are realized in

the nation spread CAPS. We expect that all coefficients related to this specific type of treatment are almost the same as the ones related to all ambulatory procedures. This is exactly what we see in Panel D.

7 Robustness

The first exercise that we realize is to re-estimate our specifications using the inverse hyperbolic transformation instead of the logarithm one. The estimations are in Tables 4 and 5 and are quite similar to our baseline results. The same coefficients remain the same and almost all estimations have the same sign.

Table 4: Robustness - Hospitalization and Mortality - Inverse Hyperbolic

Robustness: Inverse Hyperbolic	(1) Total	(2) Cirrhosis	(3) Overdose	(4) Suicide	(5) ICD - F
Panel A. Hospitalization					
Royalties (R_{t-1})	-0.000852	-0.00117**	0.000320	0.0000915	-0.000283
	(0.00117)	(0.000478)	(0.000501)	(0.000178)	(0.000436)
Panel B. Mortality					
Royalties (R_{t-1})	0.000384	0.0000807	0.00005	−0.0000469	-0.000352
	(0.000426)	(0.000239)	(0.000086)	(0.000126)	(0.000409)
Municipalities	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes

	(6) ICD - F - Alcohol	(7) ICD - F - Drugs	(8) ICD - F - Humor	(9) ICD - F - Stress
Panel A. Hospitalization				
Royalties (R_{t-1})	-0.000170	0.0000555	-0.000653	-0.000156
	(0.000410)	(0.000448)	(0.000609)	(0.000234)
Panel B. Mortality				
Royalties (R_{t-1})	-0.000197	-0.000108	0.0000414	0.0000230
	(0.000328)	(0.000114)	(0.0000384)	(0.0000226)
Municipalities	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.1 using the period of 2006 to 2013 and transforming the outcome variables using the inverse hyperbolic. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

Table 5: Robustness - Ambulatory and CAPS - Inverse Hyperbolic

Robustness: Inverse Hyperbolic	(1) Total	(2) ICD - F	(3) ICD - F - Alcohol	(4) ICD - F - Drugs	(5) ICD - F - Humor	(6) ICD - F - Stress
Panel C. Ambulatory						
Royalties (R_{t-1})	0.000652	-0.00332***	-0.000997	-0.000745	-0.00200***	-0.000402
	(0.000439)	(0.00126)	(0.000639)	(0.000499)	(0.000686)	(0.000659)
Municipalities	952	952	952	952	952	952
Panel D. CAPS						
Royalties (R_{t-1})		-0.00223**	-0.00108*	-0.000850*	-0.00215***	-0.000766
		(0.00108)	(0.000620)	(0.000471)	(0.000760)	(0.000683)
Municipalities		952	952	952	952	832
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.1 using the period of 2006 to 2013 and transforming the outcome variables using the inverse hyperbolic. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

A possible concern is that our results are in some way driven by royalties recipient municipalities that are located in a state that undergoing specific economic fluctuations, such as booms or crisis. This means that if there is an unobservable within a state that affects both the production of oil in a region and the mental health outcomes, our results

could have some sort of bias. To try to see if that is the case, we estimate all outcomes for all information systems replacing the year fixed effects with state-year interaction, that is:

$$Y_{it} = \alpha_i + \delta_{jt} + \beta R_{i,t-1} + \mathbf{X}_i \rho_t + \varepsilon_{it} \tag{7.1}$$

where j in δ_{jt} indicates the state which the municipality belongs.

The results are in Tables 6 and 7. For all groups of variables, we have that all mental health outcomes have an identical sign and are also very similar in magnitude. The significance also remains to the cirrhosis coefficient. We do the same exercise for the inverse hyperbolic transformation and find similar results.[11]

Table 6: Robustness - Hospitalization and Mortality - State Specific Year Fixed Effects

Robustness: State	(1) Total	(2) Cirrhosis	(3) Overdose	(4) Suicide	(5) ICD - F
Panel A. Hospitalization					
Royalties (R_{t-1})	-0.000823	-0.000683**	0.000202	−0.0000258	0.000274
	(0.00108)	(0.000316)	(0.000427)	(0.000191)	(0.000383)
Panel B. Mortality					
Royalties (R_{t-1})	0.000265	0.0000467	0.0000958	0.0000582	-0.000104
	(0.000240)	(0.000192)	(0.0000962)	(0.000121)	(0.000332)
	(6) ICD - F - Alcohol	(7) ICD - F - Drugs	(8) ICD - F - Humor	(9) ICD - F - Stress	
Panel A. Hospitalization					
Royalties (R_{t-1})	0.000132	0.000185	-0.000253	-0.000133	
	(0.000326)	(0.000371)	(0.000357)	(0.000205)	
Panel B. Mortality					
Royalties (R_{t-1})	0.0000387	−0.0000949	0.0000520	0.0000165	
	(0.000261)	(0.0000970)	(0.0000368)	(0.0000222)	
Municipalities	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equations 5.2 using the period of 2006 to 2013. Here we have state-year interaction dummies. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital.
Significance at the *10%, **5%, *** 1% level.

[11] For the better organization of the paper, we present the robustness exercises using the inverse hyperbolic transformation in the Appendix.

Table 7: Robustness - Ambulatory and CAPS - State Specific Year Fixed Effects

Robustness: State	(1) Total	(2) ICD - F	(3) ICD - F - Alcohol	(4) ICD - F - Drugs	(5) ICD - F - Humor	(6) ICD - F - Stress
Panel C. Ambulatory						
Royalties (R_{t-1})	0.000667	-0.00148	-0.000532	-0.000354	-0.000726	0.000259
	(0.000456)	(0.00115)	(0.000671)	(0.000472)	(0.000610)	(0.000572)
Panel D. CAPS						
Royalties (R_{t-1})		-0.00102	-0.000607	-0.000477	-0.000884	−0.0000521
		(0.000840)	(0.000649)	(0.000444)	(0.000651)	(0.000583)
Municipalities		952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equations 5.2 using the period of 2006 to 2013. Here we have state-year interaction dummies. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital.
Significance at the *10%, **5%, *** 1% level.

Since we are dealing with oil royalties, the production of oil is important. One of the main features that determine the production of an oil well is the geology and soil characteristics of the region. But these aspects are in general common to a much bigger area than just one well and we can think, for instance, that they are similar for municipalities that are in the same mesoregion.[12] So we estimate Equation (5.2) adding as controls mesoregion dummies interacted with year dummies. The results are in Tables 8 and 9. All the results are quite similar to the baseline specification, with the difference that now that the mortality coefficient for humor related mental disease estimate is significant. The same pattern is observed doing this exercise with the inverse hyperbolic transformation.

Table 8: Robustness - Hospitalization and Mortality - Mesoregion Fixed Effects

Robustness: Meso	(1) Total	(2) Cirrhosis	(3) Overdose	(4) Suicide	(5) ICD - F
Panel A. Hospitalization					
Royalties (R_{t-1})	-0.00106	−0.00111	−0.0000263	−0.0000393	0.0000218
	(0.00109)	(0.000299)	(0.000406)	(0.000188)	(0.000351)
Panel B. Mortality					
Royalties (R_{t-1})	0.000275	-0.000116	−0.0000303	0.000233	-0.000111
	(0.000239)	(0.000188)	(0.0000955)	(0.000111)	(0.000330)

	(6) ICD - F - Alcohol	(7) ICD - F - Drugs	(8) ICD - F - Humor	(9) ICD - F - Stress	
Panel A. Hospitalization					
Royalties (R_{t-1})	0.0000292	−0.0000787	-0.000199	-0.000268	
	(0.000319)	(0.000369)	(0.000306)	(0.000202)	
Panel B. Mortality					
Royalties (R_{t-1})	−0.0000237	-0.000104	0.0000881	0.0000207	
	(0.000255)	(0.0000960)	(0.0000358)	(0.0000221)	
Municipalities	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013. Here we have mesoregion-year interaction dummies. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

In our baseline analysis, we cluster data at the municipality level. We perform a robustness test in which we consider the possibility of the existence of spatial correlation.

[12] Mesoregion is a subdivision of Brazilian states that brings together several municipalities in a geographic area with economic and social similarities. It was created by the *Instituto Brasileiro de Geografia e Estatítisca* (IBGE) and is used for statistical purposes and therefore does not constitute a political or administrative entity

Table 9: Robustness - Ambulatory and CAPS - Mesoregion Fixed Effects

Robustness: Meso	(1) Total	(2) ICD - F	(3) ICD - F - Alcohol	(4) ICD - F - Drugs	(5) ICD - F - Humor	(6) ICD - F - Stress
Panel C. Ambulatory						
Royalties (R_{t-1})	0.000562	−0.00250	-0.00130	-0.00103	-0.00160	-0.000299
	(0.000445)	-0.0011	-0.000671	-0.000473	-0.000618	(0.000572)
Panel D. CAPS						
Royalties (R_{t-1})		−0.00232	-0.00139	-0.00115	-0.00178	-0.000686
		(0.000837)	(0.000639)	(0.000404)	(0.000641)	(0.000582)
Municipalities		952	952	952	952	832
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013. Here we have mesoregion-year interaction dummies. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

This is can be the case since much of the factors that determine both production and, therefore, royalties are geographical. To estimate this to our logarithm and inverse hyperbolic specification, we follow Conley (1999) and we estimate the models for three cutoffs: 100, 250 and 500 kilometers.

Our estimates are in Tables 10 and 11. Again, for almost all of our specifications the signal, significance, and value are the same compared to our baseline model. Controlling for the spatial dependence, the cirrhosis related hospitalizations remains significant and has a negative signal, which is consistent with the literature and with our previous findings. These results are quite similar when we use the inverse hyperbolic transformation.

Table 10: Robustness - Hospitalization and Mortality - Spatial Clustered Errors

Robustness: Spatial	(1) Total	(2) Cirrhosis	(3) Overdose	(4) Suicide	(5) ICD - F
Panel A. Hospitalization					
a.Royalties (R_{t-1}) - 100 km	-0.000821	-0.000887**	0.000270	0.0000576	-0.000296
	(0.000633)	(0.00036)	(0.000436)	(0.000103)	(0.000208)
b.Royalties (R_{t-1}) - 250 km	-0.000821	-0.000887**	0.000270	0.0000576	-0.000296
	(0.000620)	(0.00038)	(0.00043)	(0.000113)	(0.000221)
c.Royalties (R_{t-1}) - 500 km	-0.000821	-0.000887**	0.000270	0.0000576	-0.000296
	(0.000619)	(0.0004)	(0.000426)	(0.000116)	(0.000218)
Panel B. Mortality					
a.Royalties (R_{t-1}) - 100 km	0.000305	0.0000574	0.0000381	-0.0000288	-0.000271
	(0.000318)	(0.000106)	(0.0000314)	(0.0000842)	(0.00019)
b.Royalties (R_{t-1}) - 250 km	0.000305	0.0000574	0.0000381	-0.0000288	-0.000271
	(0.000320)	(0.000111)	(0.0000284)	(0.0000863)	(0.00019)
c.Royalties (R_{t-1}) - 500 km	0.000305	0.0000574	0.0000381	-0.0000288	-0.000271
	(0.000319)	(0.000113)	(0.0000276)	(0.0000873)	(0.00019)

	(6) ICD - F - Alcohol	(7) ICD - F - Drugs	(8) ICD - F - Humor	(9) ICD - F - Stress	
Panel A. Hospitalization					
a.Royalties (R_{t-1}) - 100 km	-0.000105	0.0000244	-0.000490	-0.000131	
	(0.000421)	(0.000251)	(0.000551)	(0.000145)	
b.Royalties (R_{t-1}) - 250 km	-0.000105	0.0000244	-0.000490	-0.000131	
	(0.000441)	(0.000250)	(0.000551)	(0.000184)	
c.Royalties (R_{t-1}) - 500 km	-0.000105	0.0000244	-0.000490	-0.000131	
	(0.000462)	(0.000245)	(0.000551)	(0.000188)	
Panel B. Mortality					
a.Royalties (R_{t-1}) - 100 km	-0.000159	-0.000088	0.0000363	0.00002	
	(0.000785)	(0.0004)	(0.0000392)	(0.0000466)	
b.Royalties (R_{t-1}) - 250 km	-0.000159	-0.000088	0.0000363	0.00002	
	(0.000826)	(0.000368)	(0.0000392)	(0.0000469)	
c.Royalties (R_{t-1}) - 500 km	-0.000159	-0.000088	0.0000363	0.00002	
	(0.000833)	(0.000387)	(0.0000390)	(0.0000475)	
Municipalities	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013.The cutoff for the spatial clustered errors are (a) 100 km, (b) 250 km and (c) 500 km.. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

Table 11: Robustness - Ambulatory and CAPS - Spatial Clustered Errors

Robustness: Spatial	(1) Total	(2) ICD - F	(3) ICD - F - Alcohol	(4) ICD - F - Drugs	(5) ICD - F - Humor	(6) ICD - F - Stress
Panel C. Ambulatory						
a.Royalties (R_{t-1}) - 100 km	0.000640	-0.00294***	-0.000779	-0.000560	-0.00151***	-0.000322
	(0.000577)	(0.000266)	(0.000546)	(0.000418)	(0.000538)	(0.000424)
b.Royalties (R_{t-1}) - 250 km	0.000640	-0.00294***	-0.000779	-0.000560	-0.00151***	-0.000322
	(0.000590)	(0.000206)	(0.000571)	(0.000431)	(0.000596)	(0.000449)
c.Royalties (R_{t-1}) - 500 km	0.000640	-0.00294***	-0.000779	-0.000560	-0.00151***	-0.000322
	(0.000595)	(0.000256)	(0.000562)	(0.000420)	(0.000595)	(0.000448)
Panel D . CAPS						
a.Royalties (R_{t-1}) - 100 km		−0.00211	-0.000846	-0.000648	-0.00163***	-0.000615
		(0.000566)	(0.000552)	(0.000416)	(0.000553)	(0.000442)
b.Royalties (R_{t-1}) - 250 km		−0.00211	-0.000846	-0.000648	-0.00163***	-0.000615
		(0.000534)	(0.000579)	(0.000434)	(0.000626)	(0.000479)
c.Royalties (R_{t-1}) - 500 km		−0.00211	-0.000846	-0.000648	-0.00163***	-0.000615
		(0.000546)	(0.000570)	(0.000417)	(0.000618)	(0.000478)
Municipalities	952	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013.The cutoff for the spatial clustered errors are (a) 100 km, (b) 250 km and (c) 500 km.. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

8 Mechanisms

Now we propose possible explanations to the negative relationship between petroleum royalties and some of our mental health indicators. The first one will be a possible relation with economic performance, measured by local economy variables. The second alternative is to focus on the provision of public goods, particularly the ones related to public health.

While the first explanation is explored vastly in the literature, this is one of the first studies that investigate the second one. Since no other work has yet investigated if public revenue shocks affect or not mental health indicators, there exists no possible explanation using the provision of public goods. Focusing directly on what we can real variables related to mental health care, we have a good alternative to try to identify the mechanism by which the royalties windfall can affect our mental health indicators.

8.1 Local Economy Outcomes

A first link we could try is to connect the revenues generated by oil exploration and the general economic performance of a region. Papers such as Leinsalu, Reile & Stickley (2019) and Gili et al. (2013) show a positive relation between economic crisis and mental health disorders. More specifically, papers such as Tella, MacCulloch & Oswald (2001) and Tella, MacCulloch & Oswald (2003) show a negative relation between people happiness and employment.

Corbi, Papaioannou & Surico (2019) shows that in the context of Brazil, changes in local government expenditure stemming from 'locally' exogenous shifts in federal transfers are associated with a significant boost in employment in the formal sector. So, given the changes in the municipal revenues from variations in the royalties distributions, the effects in the local economies could affect the mental health of the inhabitants of the locality.

To test the hypothesis we estimate the following model:

$$L_{it} = \alpha_i + \delta_t + \beta R_{i,t-1} + \mathbf{X}_i \rho_t + \varepsilon_{it} \tag{8.1}$$

where L_{it} is a labor outcome of municipality i in time t. The ones that we are going to explore are: the total number of workers, the total number of plants, the number of workers in the manufacture and construction sectors, the number of plants in the manufacture and construction sectors, the number of workers in the service and retail sectors, the number of plants in the service and retail sectors and the municipality average real wage. All outcomes, except the last one, are measured per 10,000 inhabitants.

The results of the estimations are presented in Table 12. For the number of workers variables, we always find effects in different directions, but non-significant relationship. This means that as the royalties revenue increased in the previous year, the municipalities face an increase in the total number of formal jobs, but faces a reduction in the manufacturing and construction sectors.

The plant's variables do not always have the same sign, and some of them are significant. The effect of the number of service and retail is positive, while the manufacture and construction is negative. However, the first is bigger, which may be a reason to the total also be positive, even that the point estimate is not significant. A intuition behind this result is that the oil royalties generate a stimulus to some specific sector at the expense of others. It makes sense also that the benefited are service and retail since they provide goods to the workforce that is related to the oil production. This means that the local economic performance may be the channel by which the royalties can affect the mental health of inhabitants of a municipality.

However, since we use a shock that is more related to the public sector, it is valid to investigate a hypothesis related to something that is more directly connected with the public administration of the municipality.

Table 12: Mechanism - Local Economy Outcomes

	(1) Workers - Total	(2) Workers - Manufacture and Contruction	(3) Workers - Service and Retail	(4) Plants - Total	(5) Plants - Manufacture and Contruction	(6) Plants - Service and Retail	(7) Average Wage
Royalties (R_{t-1})	0.258	-0.0547	0.0784	0.0219	-0.00457*	0.0212*	0.434
	(0.452)	(0.0634)	(0.244)	(0.0161)	(0.00256)	(0.0112)	(0.310)
Municipalities	952	952	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation (8.1) using the period of 2006 to 2013. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if it is state capital. Significance at the *10%, **5%, *** 1% level.

8.2 Public Goods Provision

As we pointed out before, the royalties are a revenue that is distributed to the public sector. So, we can see if government responses regarding this new cash flow are in favor to invest in the public health system. This is inspired by Chan & Karim (2019), which investigates the oil windfalls impact on the provision of educational public goods.

It is important to point out that we will try to see if this is a possible mechanism even though Caselli & Michaels (2013) points out a lack of correlation between oil-driven revenues and public goods provision due to high levels of corruption that exist in many Brazilian municipalities. But, Chan & Karim (2019) using a corruption measure based on

Ferraz & Finan (2011) show that the relationship they find between educational goods and royalties is homogeneous through different levels of corruption. Also, different from Caselli & Michaels (2013) we are using a panel data structure and a year that are not in their sample.

We estimate the following equation:

$$H_{it} = \alpha_i + \delta_t + \beta R_{i,t-1} + \mathbf{X}_i \rho_t + \varepsilon_{it} \tag{8.2}$$

where H_{it} is a health-related variable in municipality i in year t. We use the number of hospital beds in SUS, the total number of psychologists, the total number of psychiatrists, the number o psychologist in basic care, the number of psychiatrists in basic care, the number of psychologists in hospital, the number of psychiatrists in hospitals. We also use some CAPS related variables such as the number o CAPS, the number of psychologists in CAPS, and the number of psychiatrists in CAPS. All variables are per 10,000 per inhabitants.

The results of the estimations are presented in Table 13. We have mixed signals regarding the relationship with royalties. For example, using the estimates from Column (1) we have that if we increase the value of royalties in 1 million, the number of Public Hospital beds would increase by 0.176 %. However, we have some coefficients that are significant and have different signals. The total number of psychiatrists have a positive relationship with oil revenues, while the number o CAPS and number o psychologists in basical care. Given these different signals, we have no clear indication of whether this is a possible mechanism and what is the direction that its affecting mental health outcomes.

Table 13: Mechanism - Public Goods Provision

	(1) SUS Hospital Beds	(2) Psychologists - Total	(3) Psychiatrists - Total	(4) Psychologists - Hospitals	(5) Psychiatrists - Hospitals
Royalties (R_{t-1})	0.00176	0.000552	0.000461*	0.000996	-0.0000171
	(0.00125)	(0.00106)	(0.000266)	(0.000722)	(0.000235)
	(6) Psychologists - Basical Care	(7) Psychiatrists - Basical Care	(8) Number of Caps	(9) Psychologists - CAPS	(10) Psychiatrists - CAPS
Royalties (R_{t-1})	-0.000926*	0.000233	-0.000147***	0.000440	0.0000878
	(0.000503)	(0.000152)	(0.0000471)	(0.000442)	(0.000174)
Municipalities	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation (8.2) using the period of 2006 to 2013.Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if it is state capital. Significance at the *10%, **5%, *** 1% level.

9 Further Extensions

One main concern that rises in our estimations is whether our identification strategy truly identifies the causal effect of oil revenues. Our main assumption is that conditional on time and municipality fixed effects, there is no unobserved value that affects simultaneously the lagged royalties value and the mental outcomes that are analyzed in this work. But one can think that is not the case.

Given that there is some open area that we can explore in terms of different identification strategies in our set up, we propose in this section an extension can be explored in future work and can help to understand better which is based on the fact that municipalities do not always receive royalties in the whole period. This means that the treatment effect is not constant across groups and over time, and our regressions may not identify that effect under the standard "common trends" assumption.

Having that in mind, we propose an identification strategy that uses a two-way fixed effects estimators with heterogeneous treatment effects proposed by Chaisemartin & d'Haultfoeuille (2019). This estimator identifies the average treatment effect across all the (i, t) cells whose treatment changes from $t-1$ to t, allowing us to identify a causal estimator even when our treatment status is not constant over time. This means that the main point of this strategy is to define our treatment status based on the oil royalties received by a municipality. Inspired by Cavalcanti, Mata & Toscani (2019), we define that the treatment status T_{it} equals to one from the first moment that our municipality receives royalties.

For each pair of consecutive periods $t-1$ and t, the command computes a Difference-in-Difference(DID) estimator comparing the outcome evolution among the switchers, the groups whose treatment changes from 0 to 1 between $t-1$ and t, to the same evolution among control groups whose treatment is equal to 0 both in $t-1$ and t. [13] Then, the fixed effect estimator in which we are interested, i.e: the royalties effect, is equal to the average of those DIDs across all pairs of consecutive periods. Under a parallel trend assumption, the estimator is an unbiased and consistent estimator of the average treatment effect among switchers, at the period when they switch. Following a similar logic, we can include in the estimation lags and leads. [14] It is important to point out that time-fixed effects control for shocks that are common to all municipalities that receive royalties (which are the ones that we are considering in our sample), while the municipality fixed effects

[13] A municipality changes from 0 to 1 if it starts receiving royalties. This can happen for several reasons: the municipality becomes a producer, it becomes a neighbor of a producer or is in some way associated with production.

[14] For an algebraic treatment see Chaisemartin & d'Haultfoeuille (2019)

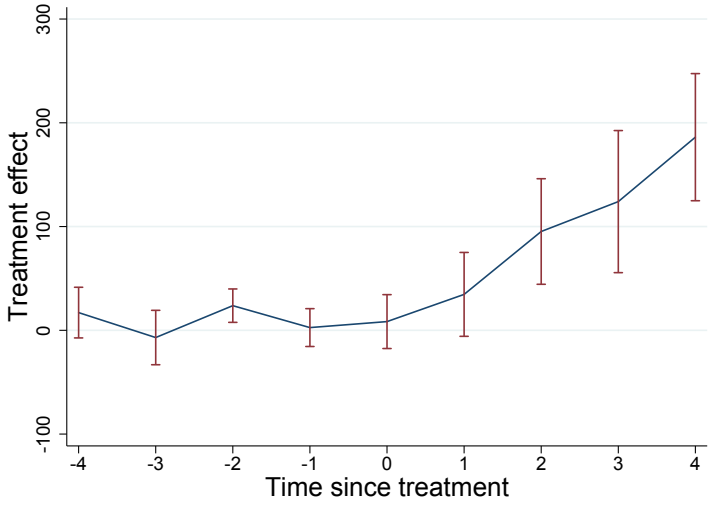
capture time-invariant municipality characteristics.

As a first exercise, we analyze the effect of this treatment on the number of ICD F procedures performed in CAPS and the number of CAPS per 10,000 inhabitants between 2006 and 2013. We use as controls the share of the rural population, illiterate, poor, and the Theil index from the 2000 Brazilian Census. All variables have time-varying coefficients. We also estimate 4 leads and lags. Since we are considering only municipalities that received royalties at some point, the control group in a specif year is a municipality that did not do the switch but will make it in some posterior time.

According to Figure 4, the average treatment effect is 10.6, which means that a municipality that starts to receive royalties in t has, on average, 10.6 more ICD F procedures performed in CAPS per 10,000 inhabitants compared to ones that do not. It is important to point out that we find a positive impact on this variable that is increasing over time. We also see no evidence that treated and non treated where different before the treatment. We can observe a similar pattern in Figure 5: an increase in the number of CAPS per 10,000 inhabitants and no evidence of effects before treatment.

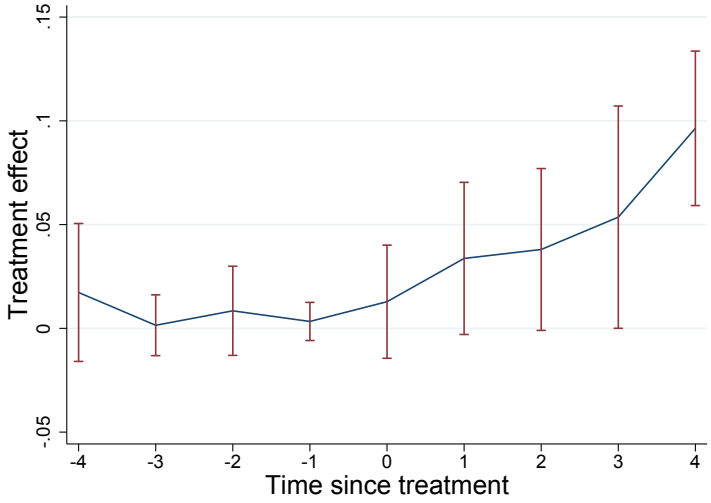
These results are quite different from the one we had presented before, which raises some points. We can interpret this as another robustness test to our baseline results, in which our result does not sustain. Another thing is that given the fact that the method relies heavily on the treatment status and the sample that is utilized, maybe the definition of both demands is biasing the results. Either way, this preliminary exercise shows that there is a different possible approach to tackle our problem that can be explored in the future.

Figure 4: Results - ICD F procedures in CAPS



Note: The picture shows the estimation based on Chaisemartin & d'Haultfoeuille (2019) for the number of ICD F procedures per 10,000 inhabitants that happened in CAPS from 2006 to 2013. Here we use as time invariant controls the share of rural population, illiterate, poor and the Theil index from the 2000 Brazilian Census. Our sample consists of 952 municipalities.

Figure 5: Results - ICD F procedures in CAPS



Note: The picture shows the estimation based on Chaisemartin & d'Haultfoeuille (2019) for the number of CAPS per 10,000 inhabitants that happened in CAPS from 2006 to 2013. Here we use as time invariant controls the share of rural population, illiterate, poor and the Theil index from the 2000 Brazilian Census. Our sample consists of 952 municipalities.

10 Concluding Remarks

In this study, we analyzed the relationship between oil royalties transferred to Brazilian municipalities and those municipalities' mental health outcomes. Our results vary across the type of information that we use, giving some positive and some negative estimates. The significance also varies according to the specification. Of the possible mechanisms highlighted here, the local economy outcomes seems to be the more reasonable one.

Even if not in the estimates do not point out in a clear direction, we do have some evidence that resource windfalls can have some sort of influence on the mental health of municipalities. We also propose a future extension that could bring more light to the discussion. Our paper uses a region-level in the public sector positive shock in the public sector and identifies some effect. This opens a new range of discussion since most papers in the literature focuses on the effects on mental health after either individual-level income shocks or nation-wide shock.

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Appendix

APPENDIX A – Oil Royalties

Royalties are financial compensation for States, the Federal District, and municipalities that benefit from companies that produce oil and natural gas in Brazilian territory. The royalties are levied on the value of field production and are collected monthly by the concessionaires through payments made by the National Treasury Secretariat (STN) until the last day of the following month, those that occurred in the production. STN transfers the royalties to the beneficiaries based on the calculations made by the ANP, with an agreement established by Laws 9,478/1997 and 7,990/1989.

Royalties are levied on the monthly production of the producing field. The amount to be paid by the concessionaires is obtained by multiplying three factors:

- Rate of royalties from the producing field, which can vary from 5% to 15%;
- Monthly production of oil and natural gas produced by the field;
- Reference price for these hydrocarbons in the month

Then, we have that the royalties from a field is given by

$$R = A \times [(V_{pet} \times P_{pet}) + (V_{gas} \times P_{gas})]$$

where R is the royalties resulting from field production in the month of calculation, in R$, A is percentage determined in the field concession contract, $V{\cdot}pet$ is the volume of oil production from the field in the calculation month in m^3, P_{pet} is the reference price of oil produced in the field in the month of calculation, in R$ / m^3 , V_{gas} is the volume of natural gas production from the field in the calculation month in m^3 and P_{gas} is is the reference price of the natural gas produced in the field in the month of calculation, in R$ / m^3.

The next step is to divide the 5% to 15% rates of the royalties between different government bodies. The rule to distribute oil royalties is determined by Laws 7,990/1989, 9,487/1997 and 12,734/2012 legislation and depends on whether the oil is produced onshore or onshore. We will focus here on the amount of that is destined specifically to municipalities. Here we are based on MONTEIRO; FERRAZ, 2010

For onshore production, if the royalties rates are up to 5% royalty municipalities where the well is located receive 20% of royalty payments. If the rates are greater than

5%, this percentage goes down to 15%. Municipalities that have installations related to the well receive, respectively, 10% and 7.5%

The distribution of royalties from offshore production follows a more complex rule. Municipalities affected by oil output receive 30 percent of total royalty payments for fields with up to 5% rates from offshore wells. The production of the whole state is added up and divided among municipalities which are classified into three categories: (A) main production zone, (B) secondary production zone and (C) neighboring municipalities.

The main production zone comprehends municipalities that are either in front of oil wells or have in their territory three or more oil plants. The criteria to determine which municipality is 'facing' each oil well are based on parallel and orthogonal lines extracted from nautical letters. Main producing zone municipalities receive together 60% of royalty payments due to municipalities. The distribution of royalty payments within this group follows a population size rule. The law also guarantees that municipalities that have more production facilities should receive at least one-third of the share distributed to municipalities in the main production zone. Hence, the share that each municipality in the main zone receives depends on its location, population, and oil-producing plants and the ones from its neighbors.

The secondary production zone receives 20% of royalty payments due to municipalities and is composed of municipalities that are crossed by pipelines. The neighboring municipalities receive the remaining 10% of the municipal share. A municipality is classified in this group if it borders the main producing zone or if it is from the same mesoregion of main production zone municipalities. Here we also take into account the population size rule. The royalty rule also guarantees 10% of royalty payments to municipalities that have facilities to support transportation to and from oil sites.

For the offshore production that pays royalties with a rate greater than 5%, the 30% are divided using a much more simple rule. Municipalities located that have facing quotas, which are determined by the parallel and orthogonal lines, receive 22,5%. Municipalities that have facilities that facilitate oil transportation receive, weighting the amount received by the quantity of oil transported.

APPENDIX B – Tables

Table 14: ICD-10 Chapter V: Mental and behavioural disorders

Code	Disorder
F00	Dementia in Alzheimer's disease
F01	Vascular dementia
F02	Dementia in other diseases classified elsewhere
F03	Unspecified dementia
F04	Organic amnesic syndrome, not induced by alcohol and other psychoactive substances
F05	Delirium, not induced by alcohol and other psychoactive substances
F06	Other mental disorders due to brain damage and dysfunction and to physical disease
F07	Personality and behavioural disorders due to brain disease, damage and dysfunction
F09	Unspecified organic or symptomatic mental disorder
F10	Use of alcohol
F11	Use of opioids
F12	Use of cannabinoids
F13	Use of sedatives or hypnotics
F14	Use of cocaine
F15	Use of other stimulants including caffeine
F16	Use of hallucinogens
F17	Use of tobacco
F18	Use of volatile solvents
F19	Multiple drug use and use of other psychoactive substances
F20	Schizophrenia
F21	Schizotypal disorder
F22	Persistent delusional disorders
F23	Acute and transient psychotic disorders
F24	Induced delusional disorder
F25	Schizoaffective disorders
F28	Other nonorganic psychotic disorders
F29	Unspecified nonorganic psychosis
F30	Manic episode
F31	Bipolar affective disorder
F32	Depressive episode
F33	Recurrent depressive disorder
F34	Persistent mood (affective) disorders
F38	Other mood (affective) disorders
F39	Unspecified mood (affective) disorder
F40	Phobic anxiety disorders
F41	Other anxiety disorders
F42	Obsessive-compulsive disorder

Notes: This table shows the ICD-10 codes that are considered when we are dealing with mental health disorders.

Table 15: ICD-10 Chapter V: Mental and behavioural disorders

F43	Reaction to severe stress, and adjustment disorders
F44	Dissociative (conversion) disorders
F45	Somatoform disorders
F48	Other neurotic disorders
F50	Eating disorders
F51	Nonorganic sleep disorders
F52	Sexual dysfunction, not caused by organic disorder or disease
F53	Mental and behavioural disorders associated with the puerperium, not elsewhere classified
F54	Psychological and behavioural factors associated with disorders or diseases classified elsewhere
F55	Abuse of non-dependence-producing substances
F59	Unspecified behavioural syndromes associated with physiological disturbances and physical factors
F60	Specific personality disorders
F61	Mixed and other personality disorders
F62	Enduring personality changes, not attributable to brain damage and disease
F63	Habit and impulse disorders
F64	Gender identity disorders
F65	Disorders of sexual preference
F66	Psychological and behavioural disorders associated with sexual development and orientation (Specifically states that "sexual orientation by itself is not to be considered a disorder")[3]
F68	Other disorders of adult personality and behaviour
F70	Mild mental retardation
F71	Moderate mental retardation
F72	Severe mental retardation
F73	Profound mental retardation
F78	Other mental retardation
F79	Unspecified mental retardation
F80	Specific developmental disorders of speech and language
F81	Specific developmental disorders of scholastic skills
F82	Specific developmental disorder of motor function
F83	Mixed specific developmental disorders
F84	Pervasive developmental disorders
F88	Other disorders of psychological development
F89	Unspecified disorder of psychological development
F90	Hyperkinetic disorders
F91	Conduct disorders
F92	Mixed disorders of conduct and emotions
F93	Emotional disorders with onset specific to childhood
F94	Disorders of social functioning with onset specific to childhood and adolescence
F95	Tic disorders
F98	Other behavioural and emotional disorders with onset usually occurring in childhood and adolescence

Notes: This table shows the ICD-10 codes that are considered when we are dealing with mental health disorders.

Table 16: ICD 10 - Chapter XX: Intentional self-harm

Code	Disorder
X60	Intentional self-poisoning by and exposure to nonopioid analgesics, antipyretics and antirheumatics
X61	Intentional self-poisoning by and exposure to antiepileptic, sedative-hypnotic, antiparkinsonism and psychotropic drugs, not elsewhere classified
X62	Intentional self-poisoning by and exposure to narcotics and psychodysleptics [hallucinogens], not elsewhere classified
X63	Intentional self-poisoning by and exposure to other drugs acting on the autonomic nervous system
X64	Intentional self-poisoning by and exposure to other and unspecified drugs, medicaments and biological substances
X65	Intentional self-poisoning by and exposure to alcohol
X66	Intentional self-poisoning by and exposure to organic solvents and halogenated hydrocarbons and their vapours
X67	Intentional self-poisoning by and exposure to other gases and vapours
X68	Intentional self-poisoning by and exposure to pesticides
X69	Intentional self-poisoning by and exposure to other and unspecified chemicals and noxious substances
X70	Intentional self-harm by hanging, strangulation and suffocation
X71	Intentional self-harm by drowning and submersion
X72	Intentional self-harm by handgun discharge
X73	Intentional self-harm by rifle, shotgun and larger firearm discharge
X74	Intentional self-harm by other and unspecified firearm discharge
X75	Intentional self-harm by explosive material
X76	Intentional self-harm by smoke, fire and flames
X77	Intentional self-harm by steam, hot vapours and hot objects
X78	Intentional self-harm by sharp object
X79	Intentional self-harm by blunt object
X80	Intentional self-harm by jumping from a high place
X81	Intentional self-harm by jumping or lying before moving object
X82	Intentional self-harm by crashing of motor vehicle
X83	Intentional self-harm by other specified means
X84	Intentional self-harm by unspecified means

Notes: This table shows all the ICD-10 codes that are considered in the variable suicide (both attempted and deaths).

Table 17: Health - Sample summary statistics

	2006	2007	2008	2009	2010	2011	2012	2013
Panel A. Hospitalization								
Total	414.9	415.4	366.2	377.7	382.1	365.2	335.2	315.3
	(472.8)	(490.5)	(458.7)	(483.2)	(503.3)	(500.8)	(487.0)	(473.1)
Cirrhosis	1.783	1.793	1.496	1.572	1.677	1.606	1.613	1.575
	(2.422)	(2.861)	(2.494)	(2.470)	(2.291)	(2.443)	(2.425)	(2.507)
Overdose	0.519	0.531	0.453	0.493	0.629	0.572	0.624	0.635
	(1.016)	(0.938)	(1.054)	(1.183)	(1.001)	(0.924)	(1.112)	(1.038)
Suicide	0.337	0.348	0.268	0.381	0.444	0.459	0.426	0.499
	(1.178)	(1.395)	(1.211)	(1.627)	(2.234)	(2.371)	(1.995)	(1.800)
ICD - F	11.61	10.35	10.27	8.420	8.929	8.799	8.191	6.942
	(14.81)	(10.92)	(10.80)	(8.223)	(8.719)	(8.879)	(8.315)	(7.722)
ICD - F - Alcohol	2.338	2.263	1.856	1.610	1.827	1.773	1.577	1.289
	(4.488)	(4.064)	(3.567)	(2.885)	(3.082)	(3.235)	(2.889)	(2.648)
ICD - F - Drugs	0.561	0.737	1.059	0.769	0.944	0.962	0.927	0.860
	(1.159)	(1.471)	(1.796)	(1.443)	(1.803)	(1.850)	(1.821)	(1.731)
ICD - F - Humor	1.287	1.294	1.291	1.160	1.200	1.201	1.135	0.976
	(2.108)	(1.998)	(1.857)	(1.774)	(1.918)	(1.811)	(1.683)	(1.631)
ICD - F - Stress	0.0490	0.0619	0.0697	0.0421	0.0716	0.0970	0.122	0.0587
	0.218	0.274	0.314	0.180	0.305	0.476	0.583	0.329

Note: This table shows the summary statistics for the health related variables for our 952 municipalities. We are using the period of 2006 to 2013

Table 18: Health - Brazil summary statistics

	2006	2007	2008	2009	2010	2011	2012	2013
Panel A. Hospitalization								
Total	392.2	386.6	346.6	351.7	358.5	341.2	321.5	310.2
	(436.3)	(438.5)	(407.1)	(421.2)	(434.4)	(427.7)	(422.8)	(416.2)
Cirrhosis	2.138	2.145	1.789	1.877	1.959	1.916	1.881	1.846
	(3.374)	(3.298)	(2.959)	(3.288)	(3.505)	(3.101)	(2.887)	(2.702)
Overdose	0.625	0.691	0.608	0.602	0.685	0.638	0.663	0.670
	(1.543)	(1.752)	(1.432)	(1.455)	(1.509)	(1.370)	(1.481)	(1.354)
Suicide	0.524	0.523	0.495	0.560	0.494	0.482	0.420	0.459
	(2.215)	(2.231)	(2.085)	(2.055)	(1.915)	(1.691)	(1.457)	(1.547)
ICD - F	14.61	13.85	14.09	13.06	13.78	14.10	13.53	12.23
	(17.28)	(15.98)	(16.54)	(15.87)	(16.29)	(16.81)	(16.29)	(15.55)
ICD - F - Alcohol	3.882	3.876	3.423	3.472	3.789	3.897	3.674	3.367
	(6.768)	(6.802)	(6.362)	(6.664)	(6.851)	(6.980)	(6.631)	(6.489)
ICD - F - Drugs	0.844	1.092	1.720	1.527	1.797	1.973	2.020	1.796
	(2.151)	(2.623)	(3.926)	(3.639)	(3.848)	(4.183)	(4.290)	(3.683)
ICD - F - Humor	2.087	2.092	2.178	2.241	2.339	2.472	2.500	2.250
	(3.694)	(3.763)	(3.846)	(4.299)	(4.548)	(4.808)	(4.915)	(4.870)
ICD - F - Stress	0.127	0.107	0.115	0.118	0.127	0.146	0.149	0.107
	(0.605)	(0.439)	(0.541)	(0.620)	(0.603)	(0.644)	(0.612)	(0.620)

Note: This table shows the summary statistics for the health related variables for all Brazilian municipalities. We are using the period of 2006 to 2013

Table 19: Health - Sample summary statistics

	2006	2007	2008	2009	2010	2011	2012	2013
Panel B. Mortality								
Total	38.54	39.38	39.93	40.32	41.96	43.47	43.36	43.27
	(20.94)	(23.22)	(23.30)	(23.17)	(24.55)	(24.27)	(25.23)	(25.24)
Cirrhosis	0.862	0.897	0.898	0.901	0.964	1.060	1.021	1.068
	(0.967)	(0.915)	(0.858)	(0.897)	(0.932)	(1.001)	(0.975)	(1.069)
Overdose	0.0155	0.0105	0.0182	0.00962	0.0169	0.0193	0.0167	0.0374
	(0.108)	(0.0741)	(0.135)	(0.0669)	(0.122)	(0.0952)	(0.0877)	(0.165)
Suicide	0.433	0.474	0.492	0.468	0.458	0.542	0.520	0.443
	(0.108)	(0.0741)	(0.135)	(0.0669)	(0.122)	(0.0952)	(0.0877)	(0.165)
ICD - F	0.704	0.705	0.723	0.688	0.809	0.859	0.790	0.779
	(0.932)	(0.913)	(0.879)	(0.801)	(0.918)	(1.003)	(1.027)	(0.902)
ICD - F - Alcohol	0.514	0.523	0.508	0.467	0.547	0.558	0.566	0.512
	(0.784)	(0.777)	(0.692)	(0.627)	(0.736)	(0.764)	(0.873)	(0.709)
ICD - F - Drugs	0.0705	0.0647	0.0811	0.0885	0.109	0.115	0.0851	0.103
	(0.309)	(0.197)	(0.295)	(0.301)	(0.331)	(0.374)	(0.259)	(0.287)
ICD - F - Humor	0.0387	0.0353	0.0259	0.0344	0.0348	0.0437	0.0317	0.0460
	(0.176)	(0.179)	(0.146)	(0.153)	(0.175)	(0.183)	(0.142)	(0.188)
ICD - F - Stress	0.00280	0.00497	0.00569	0.00333	0.00625	0.00385	0.00386	0.00623
	(0.0496)	(0.0581)	(0.0741)	(0.0365)	(0.101)	(0.0610)	(0.0440)	(0.100)

Note: This table shows the summary statistics for the health related variables for our 952 municipalities. We are using the period of 2006 to 2013

Table 20: Health - Brazil summary statistics

	2006	2007	2008	2009	2010	2011	2012	2013
Panel B. Mortality								
Total	36.60	36.91	36.60	37.06	38.29	39.33	39.11	38.81
	(20.97)	(21.91)	(21.31)	(21.79)	(22.71)	(23.18)	(23.49)	(23.49)
Cirrhosis	0.904	0.901	0.934	0.954	1.030	1.032	1.041	1.063
	(1.278)	(1.186)	(1.224)	(1.229)	(1.270)	(1.272)	(1.280)	(1.301)
Overdose	0.0164	0.0119	0.0145	0.0132	0.0183	0.0180	0.0234	0.0300
	(0.169)	(0.111)	(0.136)	(0.139)	(0.159)	(0.155)	(0.175)	(0.213)
Suicide	0.620	0.641	0.644	0.641	0.649	0.672	0.710	0.711
	(1.167)	(1.121)	(1.091)	(1.097)	(1.136)	(1.125)	(1.213)	(1.206)
ICD - F	0.623	0.644	0.685	0.670	0.681	0.747	0.707	0.668
	(1.098)	(1.102)	(1.058)	(1.059)	(1.051)	(1.140)	(1.128)	(1.043)
ICD - F - Alcohol	0.455	0.457	0.483	0.462	0.448	0.477	0.473	0.450
	(0.932)	(0.917)	(0.856)	(0.864)	(0.830)	(0.869)	(0.893)	(0.860)
ICD - F - Drugs	0.0573	0.0602	0.0723	0.0700	0.0813	0.100	0.101	0.0845
	(0.320)	(0.303)	(0.362)	(0.324)	(0.342)	(0.397)	(0.406)	(0.329)
ICD - F - Humor	0.0297	0.0259	0.0294	0.0280	0.0271	0.0348	0.0316	0.0311
	(0.222)	(0.175)	(0.198)	(0.196)	(0.183)	(0.223)	(0.200)	(0.181)
ICD - F - Stress	0.00242	0.00490	0.00262	0.00354	0.00298	0.00372	0.00442	0.00472
	(0.0521)	(0.103)	(0.0450)	(0.0605)	(0.0538)	(0.0763)	(0.0953)	(0.0721)

Note: This table shows the summary statistics for the health related variables for all Brazilian municipalities. We are using the period of 2006 to 2013

Table 21: Health - Sample summary statistics

	2006	2007	2008	2009	2010	2011	2012	2013
Panel C. Ambulatory								
Total	121,774	129,493	136,284	147,498	164,849	162,028	171,364	177,613
	(59, 861)	(62, 675)	(138, 192)	(102, 115)	(133, 459)	(124, 834)	(194, 137)	(226, 946)
ICD - F	54.35	122.9	167.1	222.8	242.8	256.1	251.8	80.53
	(198.0)	(282.5)	(346.4)	(460.5)	(461.6)	(467.6)	(448.0)	(269.9)
ICD - F - Alcohol	1.228	3.693	4.696	5.599	6.790	8.024	7.647	0.535
	(6.647)	(14.35)	(17.60)	(20.66)	(22.07)	(23.90)	(22.53)	(2.161)
ICD - F - Drugs	0.466	1.729	2.150	2.703	3.605	5.151	4.668	0.728
	(2.814)	(8.471)	(9.728)	(10.96)	(13.64)	(20.20)	(18.13)	(4.016)
ICD - F - Humor	11.65	28.38	31.72	39.24	44.37	46.13	43.66	2.395
	(49.82)	(79.13)	(86.20)	(98.22)	(108.4)	(109.3)	(103.1)	(12.44)
ICD - F - Stress	8.124	20.44	23.15	27.07	29.46	30.43	28.63	1.846
	(36.07)	(65.86)	(73.88)	(80.68)	(84.43)	(80.50)	(74.34)	(7.659)

Note: This table shows the summary statistics for the health related variables for our 952 municipalities. We are using the period of 2006 to 2013

Table 22: Health - Brazil summary statistics

	2006	2007	2008	2009	2010	2011	2012	2013
Panel C. Ambulatory								
Total	105,088	117,899	124,428	147,000	152,586	171,977	164,392	172,811
	(59, 514)	(69, 638)	(168, 134)	(181, 333)	(170, 455)	(263, 612)	(195, 491)	(269, 007)
ICD - F	39.98	106.1	417.8	534.6	536.3	533.9	546.1	435.7
	(144.7)	(299.0)	(1, 962)	(2, 288)	(2, 109)	(2, 012)	(2, 065)	(2, 025)
ICD - F - Alcohol	0.912	3.183	3.361	3.906	4.852	5.822	5.992	0.544
	(11.63)	(34.55)	(32.32)	(34.95)	(42.85)	(48.41)	(43.30)	(12.35)
ICD - F - Drugs	0.438	1.706	2.142	2.535	3.458	4.293	4.296	0.405
	(11.29)	(32.26)	(30.89)	(31.42)	(40.29)	(40.43)	(35.61)	(3.208)
ICD - F - Humor	6.896	19.21	22.35	26.11	28.89	31.11	29.61	1.369
	(36.24)	(77.72)	(90.30)	(96.16)	(96.97)	(102.7)	(95.23)	(9.255)
ICD - F - Stress	3.556	11.54	13.70	15.63	17.21	18.49	17.94	1.127
	(20.69)	(53.98)	(64.47)	(69.52)	(72.68)	(75.99)	(73.90)	(8.042)

Note: This table shows the summary statistics for the health related variables for all Brazilian municipalities. We are using the period of 2006 to 2013

Table 23: Health - Sample summary statistics

	2006	2007	2008	2009	2010	2011	2012	2013
Panel D. CAPS								
ICD - F	74.82	116.4	125.4	152.4	172.1	183.4	176.7	208.4
	(229.9)	(274.5)	(280.8)	(312.7)	(333.4)	(342.2)	(337.9)	(493.7)
ICD - F - Alcohol	1.226	3.693	4.688	5.595	6.782	7.998	7.623	0.507
	(6.645)	(14.35)	(17.59)	(20.65)	(22.08)	(23.89)	(22.52)	(2.140)
ICD - F - Drugs	0.463	1.702	2.082	2.648	3.554	5.100	4.585	0.624
	(2.813)	(8.446)	(9.694)	(10.95)	(13.62)	(20.19)	(18.11)	(3.622)
ICD - F - Humor	11.64	28.38	31.51	39.12	44.29	46.01	43.58	2.264
	(49.82)	(79.13)	(86.11)	(98.12)	(108.3)	(109.2)	(103.0)	(12.36)
ICD - F - Stress	8.119	20.44	22.79	26.81	29.23	30.03	28.24	1.429
	(36.07)	(65.86)	(73.70)	(80.47)	(84.23)	(80.02)	(73.74)	(6.218)

Note: This table shows the summary statistics for the health related variables for our 952 municipalities. We are using the period of 2006 to 2013

Table 24: Health - Brazil summary statistics

	2006	2007	2008	2009	2010	2011	2012	2013
Panel D. CAPS								
ICD - F	47.00	72.66	76.62	89.69	102.8	113.6	110.1	135.9
	(179.4)	(231.6)	(263.1)	(286.4)	(303.8)	(330.4)	(311.6)	(517.7)
ICD - F - Alcohol	0.911	3.182	3.338	3.893	4.837	5.798	5.964	0.512
	(11.63)	(34.55)	(32.30)	(34.93)	(42.82)	(48.37)	(43.27)	(12.33)
ICD - F - Drugs	0.430	1.671	2.060	2.494	3.406	4.227	4.240	0.352
	(11.28)	(32.20)	(30.79)	(31.35)	(40.22)	(40.34)	(35.51)	(2.956)
ICD - F - Humor	6.892	19.20	22.05	25.93	28.71	30.92	29.45	1.186
	(36.24)	(77.72)	(90.00)	(96.05)	(96.85)	(102.6)	(95.15)	(8.263)
ICD - F - Stress	3.548	11.54	13.28	15.39	16.98	18.25	17.67	0.816
	(20.69)	(53.98)	(64.05)	(69.27)	(72.34)	(75.76)	(73.63)	(5.626)

Note: This table shows the summary statistics for the health related variables for all Brazilian municipalities. We are using the period of 2006 to 2013

Table 25: Robustness - Inverse Hyperbolic - Hospitalization and Mortality - State Specific Year Fixed Effects

Robustness: State	(1) Total	(2) Cirrhosis	(3) Overdose	(4) Suicide	(5) ICD - F
Panel A. Hospitalization					
Royalties (R_{t-1})	-0.000874	-0.000915**	0.000239	−0.0000132	0.000344
	(0.00118)	(0.000415)	(0.000537)	(0.000243)	(0.000449)
Panel B. Mortality					
Royalties (R_{t-1})	0.000310	0.0000622	0.0000103	0.0000616	-0.000132
	(0.000284)	(0.000261)	(0.000122)	(0.000154)	(0.000440)

	(6) ICD - F - Alcohol	(7) ICD - F - Drugs	(8) ICD - F - Humor	(9) ICD - F - Stress
Panel A. Hospitalization				
Royalties (R_{t-1})	0.000137	0.000260	-0.000338	-0.000162
	(0.000421)	(0.000486)	(0.000462)	(0.000262)
Panel B. Mortality				
Royalties (R_{t-1})	0.0000607	-0.000118	0.0000594	0.0000185
	(0.000341)	(0.000117)	(0.0000396)	(0.0000222)
Municipalities	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equations 5.2 using the period of 2006 to 2013. Here we have state-year interaction dummies. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital.
Significance at the *10%, **5%, *** 1% level.

Table 26: Robustness - Inverse Hyperbolic - Ambulatory and CAPS - State Specific Year Fixed Effects

Robustness: State	(1) Total	(2) ICD - F	(3) ICD - F - Alcohol	(4) ICD - F - Drugs	(5) ICD - F - Humor	(6) ICD - F - Stress
Panel C. Ambulatory						
Royalties (R_{t-1})	0.000683	-0.00172	-0.000702	-0.000506	-0.00106	0.000318
	(0.000470)	(0.00130)	(0.000781)	(0.000562)	(0.000722)	(0.000681)
Panel D. CAPS						
Royalties (R_{t-1})		-0.00100	-0.000790	-0.000655	-0.00126	0.0000766
		(0.000979)	(0.000754)	(0.000525)	(0.000777)	(0.000697)
Municipalities		952	952	952	952	832
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equations 5.2 using the period of 2006 to 2013. Here we have state-year interaction dummies. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital.
Significance at the *10%, **5%, *** 1% level.

Table 27: Robustness - Inverse Hyperbolic - Hospitalization and Mortality - Mesoregion Fixed Effects

Robustness: Meso	(1) Total	(2) Cirrhosis	(3) Overdose	(4) Suicide	(5) ICD - F
Panel A. Hospitalization					
Royalties (R_{t-1})	-0.00113	-0.00147***	−0.0000524	0.000102	0.0000229
	(0.00108)	(0.000467)	(0.000403)	(0.000180)	(0.000396)
Panel B. Mortality					
Royalties (R_{t-1})	0.000341	-0.000165	−0.0000425	0.000280	-0.000128
	(0.000309)	(0.000278)	(0.0000950)	(0.000111)	(0.000330)
	(6) ICD - F - Alcohol	(7) ICD - F - Drugs	(8) ICD - F - Humor	(9) ICD - F - Stress	
Panel A. Hospitalization					
Royalties (R_{t-1})	0.0000324	0.0000137	-0.000264	-0.000331	
	(0.000315)	(0.000360)	(0.000355)	(0.000208)	
Panel B. Mortality					
Royalties (R_{t-1})	−0.0000000623	-0.000122	0.000103	0.0000234	
	(0.000249)	(0.0000965)	(0.0000370)	(0.0000221)	
Municipalities	952	952	952	952	
Municipality Fixed Effects	Yes	Yes	Yes	Yes	
Time Fixed Effects	Yes	Yes	Yes	Yes	

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013. Here we have mesoregion-year interaction dummies. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

Table 28: Robustness - Inverse Hyperbolic - Ambulatory and CAPS - Mesoregion Fixed Effects

Robustness: Meso	(1) Total	(2) ICD - F	(3) ICD - F - Alcohol	(4) ICD - F - Drugs	(5) ICD - F - Humor	(6) ICD - F - Stress
Panel C. Ambulatory						
Royalties (R_{t-1})	0.000580	−0.00284	-0.00159	-0.00131	-0.00204	-0.000344
	(0.000444)	(0.00102)	(0.000671)	(0.000450)	(0.000645)	(0.000578)
Panel D. CAPS						
Royalties (R_{t-1})		−0.00170	-0.00146	-0.00227	-0.000828	-0.000633
		(0.000830)	(0.000649)	(0.000424)	(0.000611)	(0.000582)
Municipalities		952	952	952	952	832
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013. Here we have mesoregion-year interaction dummies. Standard errors are clustered at the municipal level. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

Table 29: Robustness - Inverse Hyperbolic - Hospitalization and Mortality - Spatial Clustered Errors

Robustness: Spatial	(1) Total	(2) Cirrhosis	(3) Overdose	(4) Suicide	(5) ICD - F
Panel A. Hospitalization					
a.Royalties (R_{t-1}) - 100 km	-0.000852	-0.00117**	0.000320	0.0000915	-0.000283
	(0.00061)	(0.00036)	(0.000426)	(0.000131)	(0.000208)
b.Royalties (R_{t-1}) - 250 km	-0.000852	-0.00117**	0.000320	0.0000915	-0.000283
	(0.000619)	(0.00038)	(0.000436)	(0.000143)	(0.000221)
c.Royalties (R_{t-1}) - 500 km	-0.000852	-0.00117**	0.000320	0.0000915	-0.000283
	(0.000619)	(0.0004)	(0.000446)	(0.00016)	(0.000218)
Panel B. Mortality					
a.Royalties (R_{t-1}) - 100 km	0.000384	0.0000807	0.00005	−0.0000469	-0.000352
	(0.000324)	(0.000126)	(0.0000314)	(0.0000842)	(0.00019)
b.Royalties (R_{t-1}) - 250 km	0.000384	0.0000807	0.00005	−0.0000469	-0.000352
	(0.000326)	(0.000141)	(0.0000254)	(0.0000863)	(0.00019)
c.Royalties (R_{t-1}) - 500 km	0.000384	0.0000807	0.00005	−0.0000469	-0.000352
	(0.00031)	(0.000143)	(0.0000276)	(0.0000873)	(0.00015)
	(6) ICD - F - Alcohol	(7) ICD - F - Drugs	(8) ICD - F - Humor	(9) ICD - F - Stress	
Panel A. Hospitalization					
a.Royalties (R_{t-1}) - 100 km	-0.000170	0.0000555	-0.000653	-0.000156	
	(0.000421)	(0.000251)	(0.000551)	(0.000145)	
b.Royalties (R_{t-1}) - 250 km	-0.000170	0.0000555	-0.000653	-0.000156	
	(0.000441)	(0.000250)	(0.000551)	(0.000184)	
c.Royalties (R_{t-1}) - 500 km	-0.000170	0.0000555	-0.000653	-0.000156	
	(0.000462)	(0.000245)	(0.000551)	(0.000188)	
Panel B. Mortality					
a.Royalties (R_{t-1}) - 100 km	-0.000197	-0.000108	0.0000414	0.0000230	
	(0.000785)	(0.0004)	(0.0000390)	(0.0000466)	
b.Royalties (R_{t-1}) - 250 km	-0.000197	-0.000108	0.0000414	0.0000230	
	(0.000826)	(0.000368)	(0.0000388)	(0.0000489)	
c.Royalties (R_{t-1}) - 500 km	-0.000197	-0.000108	0.0000414	0.0000230	
	(0.000833)	(0.000387)	(0.0000389)	(0.0000475)	
Municipalities	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013.The cutoff for the spatial clustered errors are (a) 100 km, (b) 250 km and (c) 500 km.. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.

Table 30: Robustness - Inverse Hyperbolic - Ambulatory and CAPS - Spatial Clustered Errors

Robustness: Spatial	(1) Total	(2) ICD - F	(3) ICD - F - Alcohol	(4) ICD - F - Drugs	(5) ICD - F - Humor	(6) ICD - F - Stress
Panel C. Ambulatory						
a.Royalties (R_{t-1}) - 100 km	0.000652	-0.00332***	-0.000997	-0.000745	-0.00200***	-0.000402
	(0.000587)	(0.000266)	(0.000546)	(0.000433)	(0.000548)	(0.000424)
b.Royalties (R_{t-1}) - 250 km	0.000652	-0.00332***	-0.000997	-0.000745	-0.00200***	-0.000402
	(0.000590)	(0.000236)	(0.000571)	(0.000432)	(0.000596)	(0.000449)
c.Royalties (R_{t-1}) - 500 km	0.000652	-0.00332***	-0.000997	-0.000745	-0.00200***	-0.000402
	(0.000593)	(0.000211)	(0.000562)	(0.000422)	(0.000596)	(0.000448)
Panel D . CAPS						
a.Royalties (R_{t-1}) - 100 km		-0.00223**	-0.00108*	-0.000850*	-0.00215***	-0.000766
		(0.000566)	(0.000552)	(0.000426)	(0.000653)	(0.000442)
b.Royalties (R_{t-1}) - 250 km		-0.00223**	-0.00108*	-0.000850*	-0.00215***	-0.000766
		(0.000544)	(0.000579)	(0.000434)	(0.000626)	(0.000479)
c.Royalties (R_{t-1}) - 500 km		-0.00223**	-0.00108*	-0.000850*	-0.00215***	-0.000766
		(0.000524)	(0.000570)	(0.000417)	(0.000618)	(0.000478)
Municipalities	952	952	952	952	952	952
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results of estimating Equation 5.2 using the period of 2006 to 2013.The cutoff for the spatial clustered errors are (a) 100 km, (b) 250 km and (c) 500 km.. Control variables are: longitude, latitude and indicator if the municipality is a state capital. Significance at the *10%, **5%, *** 1% level.