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Assessing Fiscal Distress in Subnational Governments: The Case of Brazil

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Chapter 1

Introduction

There is a clear consensus both in the academic literature and in the policy debate that sound management of fiscal risks is essential for both fiscal sustainability and macroeconomic stability of sovereign countries (Brixi & Schick 2002, George Kopits 2014, IMF 2016). One of the classes of fiscal risks that were particularly neglected in the usual fiscal sustainability analysis is that related to contingent liabilities, that is, liabilities whose occurrences depends on the outcome of an uncertain event (Brixi & Schick 2002). A second important development in recent years is that with the increased decentralization in the provision of public services, the contingent liabilities, both explicit and implicit, arising from subnational governments (SNGs) are increasingly relevant for fiscal sustainability analysis. This relevance is higher the more spending and taxation powers are given to the subnational entities in the fiscal framework currently in place in a given country.

Although the above characterization could be employed to describe the recent economic history of several countries, Brazil might as well be the canonical example. A federation with one Federal District, 26 states, and 5,570 municipalities, Brazil experienced in the 80s and 90s repeated fiscal crisis of subnational entities with three rounds of debt restructurings. These episodes severely threatened the success of several macroeconomic stabilization programs that hoped to control the three-to-four-digit annual inflation rates that wreak havoc the Brazilian economy from 1980 through 1994. It was only with the success of the Real Plan in fighting the hyperinflation, and with a more comprehensive debt restructuring that aimed to correct the underlying SNG fiscal problems, that the political and economic conditions enabled for a complete reformulation of the fiscal institutions in place, culminating with the publication of a Fiscal Responsibility Law (FRL) in 2000 (Manoel et al. 2013, p. 34-35).

The FRL was a comprehensive law that promoted several changes in the

institutions related to the Brazilian budgetary process. However, for the purposes of this study, the focus will be on the controls that were put forth for SGNs borrowings. Following the typology of borrowing controls used by Ahmad et al. (2005) and first proposed by Ter-Minassian & Craig (1997), Brazil has adopted both a rules-based control and an administrative control for SNG borrowing. In a rules-based control, a fiscal rule is imposed that directly constrains the SNG ability to borrow. In Brazil, the FRL adopted both a golden rule and a debt ceiling rule. In an administrative control, the central government has some form of direct control over the SGN borrowing. In Brazil, if the central government must offer a guarantee for an individual borrowing operation, then the Finance Ministry, through the National Treasury Secretariat (NTS), must assess that entity "payment capacity" before the operation is authorized. The current methodology employed by NTS was enacted in 2012 and makes use of several fiscal indicators to classify the SGNs entities in different credit classifications, similar in spirit to the process adopted by rating agencies in giving credit ratings. However, this methodology is currently being revised [1], as the NTS is looking for an alternative suite of fiscal indicators that are more transparent and more easily calculated. In this context, the assessement of the statistical and practical significance of both the current and the newly set of fiscal indicators used by the National Treasury Secretariat to assess the fiscal sustainability of subnational governments in Brazil is both necessary and timely.

The strand of literature on Early Warning Systems (EWS) for economic crisis are particularly relevant for this endeavour. Following the seminal work by Kaminsky et al. (1998) and Berg & Pattillo (1999) on currency crisis, it was not long until fiscal crisis were also tackled (Manasse et al. 2003, Fuertes & Kalotychou 2007, Baldacci et al. 2011, Berti et al. 2012, Dawood et al. 2017). In this study, the focus will be on what is usually called the parametric approach, that makes use of limited dependent variables models, such as probit and logit. There are three main contributions. First, as usually true in most countries, disaggregate fiscal data on regional governments tends to have a much lower quality and standardization then those available for central governments[2]. This study aims to compile, consolidate and make available

[1]The NTS published the new set fiscal indicators and opened the methodology for a public revision process in the period of 10/05/2017 to 30/06/2017. The material related to this revision is available at http://www.tesouro.fazenda.gov.br/sistemagarantiauniao

[2]Although there are several initiatives in place in Brazil to modernize the information available for SNGs, in the fiscal transparency evaluation conducted by the IMF in Brazil completed in June 2016 and published in May 2017 it is noted that "Weaknesses in fiscal reporting also undermine the ability to assess the fiscal position and risks. Not all states

on machine readable format regional discriminated data on the fiscal variables that are needed to compute the fiscal indicators used by the NTS for payment capacity evaluation. To the best of the author's knowledge, this database is inexistent today. The second contribution is the expansion of the Early Warning System literature for dealing with subnational governments. Most of the studies focus on sovereign governments, but, as noted by Ianchovichina et al. (2007), SGNs are sufficiently different from sovereign governments and demand separate analysis. The third and final contribution is that by recognizing a fiscal crisis as a rare event as suggested by King & Zeng (2001), that is, a binary dependent variable with dozens to thousands of times fewer ones than zeros, we make use of the bias-reduction method first proposed by Firth (1993) and implemented by Kosmidis (2017) in the R-package `brglm`.

The remainder of this study is organized as follows. Section 2 presents a brief literature review on the main characteristics of early warning systems for economic crisis and also give a general overview of the institutional context under which the National Treasury Secretariat conducts its payment capacity evaluations. Section 3 presents a descriptive analysis of the data and also outline the econometric model used. Section 4 presents the empirical results and section 5 summarizes our conclusions.

and municipalities comply with their reporting obligations, and information on subnational finances is generally less timely and comprehensive than information on the central governments. (IMF 2017, p. 62)"

Chapter 2

Literature Review

As noted by Baldacci et al. (2011), the literature that aims to build models that can provide early warning signals of fiscal sustainability problems tend to differ with respect to three major characteristics: the definition of the crisis event; the statistical methodology employed; and the set of explanatory variables used. Broadly following this differences, in section 2.1 we review theoretical definitions of fiscal sustainability in order to propose a definition of fiscal distress[1] event that will be used in this study. In section 2.2 we present a general formulation of the early warning system problem and the methodological approach pursued in this study. Regarding the set of explanatory variables, since the main objective of this study is to assess the significance of the fiscal indicators used by the National Treasury Secretariat in their mandate to evaluate the payment capacity of subnational governments, the explanatory variables are already defined. Therefore we let the presentation of the fiscal indicators for section 3.1 coupled with the exploratory analysis of the data.

2.1 Fiscal Distress

The focus of this study will be on the empirical analysis of the main determinants of fiscal distress episodes in subnational governments in Brazil in the 2008-2016 period. Nevertheless, it is important a brief theoretical review of the most used concepts of fiscal sustainability so that an appropriate characterization of what fiscal distress event entails, or, and perhaps even more importantly, what it do not entail.

There are a few distinct ways in which fiscal sustainability is defined in

[1]For the purposes of this study, fiscal distress, fiscal stress, fiscal crisis, and debt crisis will be used as synonymous

the economic literature. Although they all in some way or another alludes to the more general concept of sustainability, understood here as a process that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987), the differences are important for the interpretation of the empirical results and should be emphasized at the outset.

A more narrow definition of fiscal sustainability equates it to solvency, that is, the ability of an entity, in the case of this study a subnational government, to make payments in order to service its debt obligations on the due date. Although certainly useful for corporations, this definition is far too stringent when applied to governments. The reasoning is not as much because governments do not actually default on its debt, but, as pointed out by Burnside (2005), when it is clear that a policy mix is unsustainable, governments tend to take remedial actions in order to avoid an outright default. A more useful definition of fiscal sustainability takes this into account and can be equated "to a governments ability to indefinitely maintain the same set of policies while remaining solvent" (Burnside 2005, pg.11). Therefore it makes sense to speak of an unsustainable policy mix even though a default on the debt never actually took place. For the purposes of this study, both an explicit default on the debt and an unsustainable policy mix should be considered an indicator of a fiscal distress event.

It is worth pointing out that in the definitions given so far, no distinction was made between solvency and liquidity problems. A country may believe itself to be solvent, but it still faces problems in meeting its obligations because of cash flows problems. The reason we don't pursue this distinction is less based on the fact that there are no theoretical differences between the two concepts, but because the empirical consequences of both difficulties are likely to be observationally equivalent (Chuhan 2005, pg.89). Both solvency and liquidity are related to an entity ability to pay. However, especially because of the absence of clearly defined rules for bankruptcy in the public sector, the government willingness to pay also becomes important, in a tradition that goes back at least to Eaton & Gersovitz (1981). Again, however, for the purposes of this study, both are fiscal crisis episodes stemming from ability or willingness to pay are likely to be observationally equivalent.

One of the uses of fiscal sustainability that will not be used in this study is related to the costs, in terms of economic efficiency or growth, related to a given combination of fiscal and monetary policy. Although this use is suggested by Burnside (2005), we shall make no claim in this study related to it.

After looking at the theoretical definitions of fiscal sustainability, its worth to take a closer look into how previous literature on EWS defined the debt

crisis episodes for sovereign governments. Manasse et al. (2003) defines a country to be in a debt crisis if either the government fails to meet principal or interest payment on external obligation on the due date as classified by Standard & Poor's or if it receives a nonconcessional IMF loan in excess of 100 percent of its quota. Fuertes & Kalotychou (2007) considers a country to be in default in a given year if the arrears increase over a threshold percentage of external debt and a rescheduling agreement is reached in which the amount of debt rescheduled exceeds the decrease in the arrears stock. Baldacci et al. (2011) uses a more general definition and considers a fiscal crisis not only the episodes of debt default or restructuring and recourse to exceptional financing, but also an implicit default crystallized in high inflation rates and a deterioration in market access measured by high bond yields pressures (where high is those that yield spreads that are more than two standard deviations away from the mean).

Although the empirical literature is of limited applicability in giving operational guidance in defining fiscal crisis episodes for this study because of differences in sovereign and subnational governments, it is possible to see that the theoretical elements discussed of solvency and liquidity are present.

2.2 Early Warning Systems

Before we delve into the different methodological approaches used in the literature in early warning systems, we need a general framework to capture the purpose of an EWS model. Following Fuertes & Kalotychou (2007), we denote by d_{it} the dummy variable that equals 1 if the state i had a crisis event in period t and 0 otherwise. Since the objective is to signal crisis in advance, the dependent variable y_{it} of interest is forward-looking in nature, and it takes the value of one if a crisis happens during an h time horizon, that is

$$y_{it} = \begin{cases} 1 & \text{if } d_{i,t+k} = 1 \text{ for any } k = 0, \ldots, h-1 \\ 0 & \text{otherwise} \end{cases} \tag{2.1}$$

However, it is important to remark that the information set[2] for predicting y_{it} is that available at time $t-1$. To fix ideas, let the explanatory variable be the primary balance as a ratio of GDP and let $t = 2016$. A prediction $\hat{y}_{it} = 1$ from an EWS with horizon $h = 1$ implies that using the primary balance as a ratio to GDP from 2015 backwards, the model is signalling a potential crisis in 2016 for state i. Similarly, if $h = 2$, the model is signalling

[2]The information set, usually denoted by Ω_t consists of the set of all potential explanatory variables that could be included in a regression model.

a potential crisis in 2016 or 2017. Note that again only the primary balance as a ratio to GDP from 2015 backward is used to make this prediction.

In a more general notation, if we let $\boldsymbol{x}$ denote the explanatory variables included in the model, and the past of $\boldsymbol{x}$ for state i as $\boldsymbol{X}_{i,t-1} = \{\boldsymbol{x}_{i,t-1}, \boldsymbol{x}_{i,t-2}, \dots\}$, the prediction problem of an EWS with a given horizon h is given by

$$y_{it} = f(\boldsymbol{X}_{i,t-1}) \tag{2.2}$$

In practice using the whole past $\boldsymbol{X}_{i,t-1}$ of the explanatory variables is not possible, and we will follow other studies using only the last period variables, that is, $\boldsymbol{x}_{i,t-1}$. This is not problematic as long as there are stock variables that can capture the effects of flows from previous periods.

For estimating the function f in (2.2), there are two major approaches in the literature on early warning systems. The "indicators" or "signaling" approach and the multivariate regression analysis approach (Baldacci et al. 2011, pg. 5). The first approach belongs to the class of non-parametric methods. Their essential characteristic is that they do not assume a specific functional form for f, and simply try to estimate a smooth relationship between the explanatory and dependent variables. The second approach belongs to the class of parametric methods. In this case, a specific functional form for f is assumed, and, with this knowledge at hand, the relevant parameters are estimated[3]. In this study, we will take the latter approach. More specifically, we will make use of a limited dependent variable model know as logit regression[4].

As noted by Baldacci et al. (2011), the main reason for using the multivariate approach in this study is the easily available null hypothesis significance tests that can be conducted to assess the statistical significance of both individual variables and collection of variables. This allows for a clean way to attain one of the objectives of this study, that is, to compare and contrast the current and the newly set of fiscal indicators used by the National Treasury Secretariat to assess the payment capacity of SGNs in Brazil.

[3] James et al. (2013) is a nice introduction and overview of statistical learning techniques, both parametric and non-parametric. Hastie et al. (2009) is a more advanced and complete treatment.

[4] The specific characteristics of the model employed are discussed in section 3.2

Chapter 3

Methods

3.1 Data

The majority of the explanatory variables used in this study are derived from the fiscal reports made available by the National Treasury Secretariat (NTS), who is responsible for collecting primary fiscal data from subnational governments in Brazil. The consolidated dataset is available at https://github.com/fjuniorr/junior2017. The focus of this section is to present an exploratory and descriptive analysis of the fiscal indicators that are used (or whose use is proposed in the new methodology) by the NTS in its payment capacity evaluation.

The final dataset used in this study consists of fiscal indicators compiled for the 26 states and the federal district from 2008 through 2016, totaling $n = 243$ observations. Since the explanatory variables will be lagged 1 year, the sample size is reduced from 2009-2016, totaling $n = 216$ for estimation purposes.

For the purposes of this study, the publication of a decree of financial calamity[1] will be the event that characterizes a fiscal crisis in a given state-year. The reasoning is that, consistent with the discussion made in section 2.1, the decree of public calamity, although legally questionable[2], clearly signals that the policy mix has become unsustainable, and, even if there are still doubts about the states ability to pay in terms of solvency and liquidity, definitely they don't have the willingness to pay. Therefore the dummy default d_{it} will take the value of one in 2016 for the states of Rio de Janeiro (RJ), Rio Grande do Sul (RS), and Minas Gerais (MG). Following previous

[1] http://economia.estadao.com.br/noticias/geral,veja-por-que-os-estados-decretam-calamidade-financeira,10000096967

[2] http://g1.globo.com/bom-dia-brasil/noticia/2016/12/calamidade-financeira-de-estados-nao-e-reconhecida-pelo-governo.html

studies, we will use the time-horizon of one year $h = 1$, meaning that the forward-looking independent variable y_{it} will be equal to d_{it}.

Table 3.1 presents descriptive statistics for the explanatory variables that will be used in this study. With respect to the fiscal indicators of the current methodology, four variables are especially different in the non-calamity/calamity dichotomy. These variables show that the states that did not declared financial calamity have lower debt (Gross debt / Net current revenue - 0.86 ± 0.56 *vs* 2.19 ± 0.13), a less expensive payroll cost (Compensation of employees / Net current revenue - 0.54 ± 0.09 *vs* 0.74 ± 0.04), more savings (Current fiscal balance / Current revenue - 0.23 ± 0.17 *vs* 0.00 ± 0.12) and more investments (Gross investment in nonfinancial assets / Total expenditure - 0.09 ± 0.04 *vs* 0.03 ± 0.01) than those states that did declare financial calamity. The ratio Primary balance / Debt Service also shows that the calamity states were running on average a primary deficit (-0.66 ± 1.00), although with too much variability overall to characterize the differences between the two groups. The same holds true for the ratio Social contributions / Social benefits that shows that the states that declared calamity on average have a larger social security deficit, although with large variability overall.

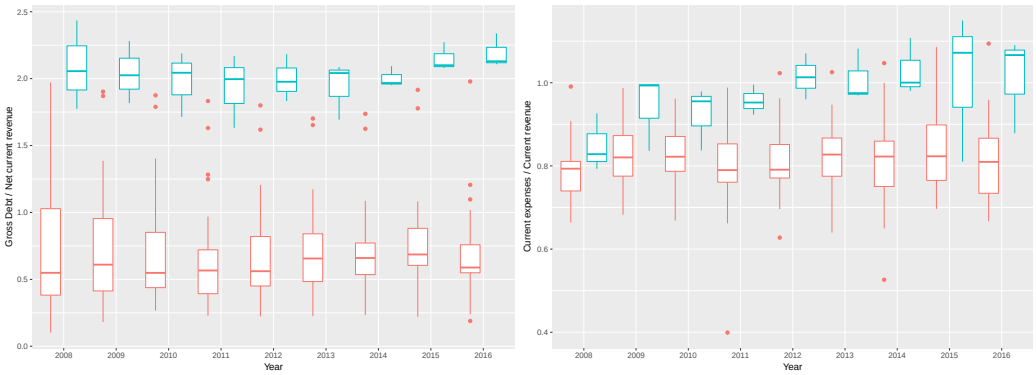
In regard to the fiscal indicators proposed by the new methodology, the non-calamity/calamity difference is startling. Besides the already identified higher debt and lower savings of calamity states, they have very large liquidity problems compared to the non-calamity states (Current liabilities / Cash and cash equivalents - 0.47 ± 0.36 *vs* 2.57 ± 0.70). Although with the data available it is not possible to distinguish how big is the arrears stock, this proxy indicates that the number is likely to be very large for calamity states.

One particular feature of the data that is not possible to gauge from table 3.1 is for how long the states that declared financial calamity in 2016 had worse fiscal indicators than the other states. Figure 3.1 shows this evolution for the fiscal indicators of the new methodology. The major trend is that in the whole 2008-2016 the two groups of states were different, but, the states that declared financial calamity in 2016 had a major fiscal deterioration in 2015 and 2016. The evolution of Current liabilities / Cash and cash equivalents is particularly marked, going from an average of 0.98 in 2014, to 1.88 in 2015 and ballooning to 2.57 in 2016.

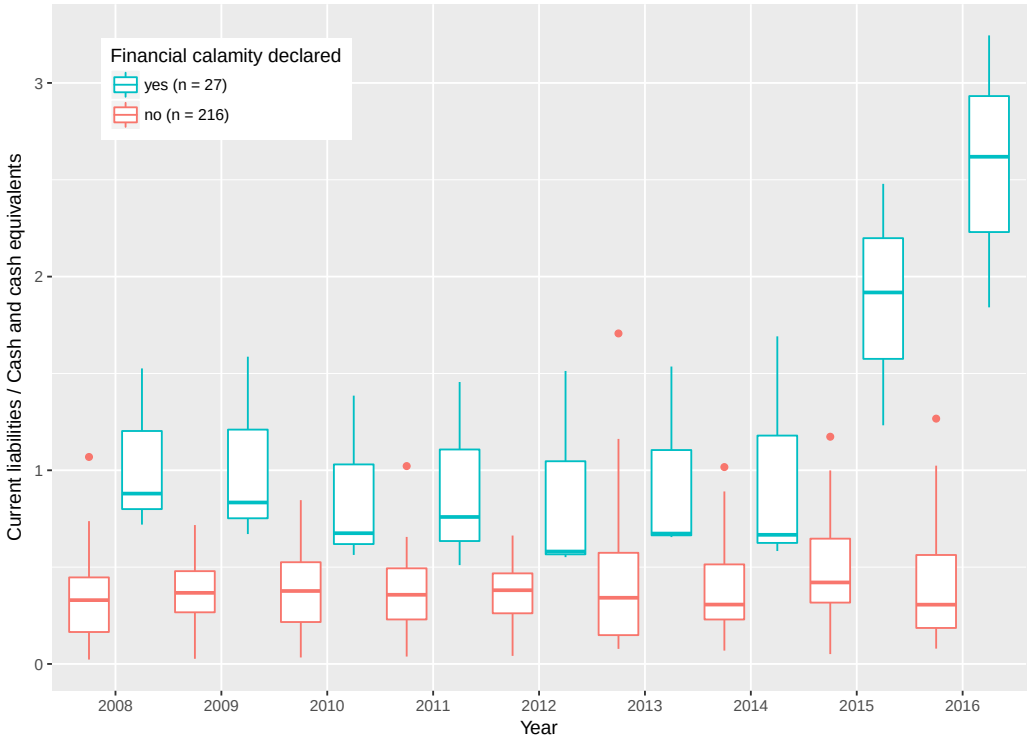
Table 3.1: Descriptive statistics

Explanatory Variables	2008-2016		
	All	Calamity not declared	Calamity declared
Observations	243	240	3
Current Methodology (Finance Minister Decree/Order nº 306, 10/09/2012)			
Gross debt / Net current revenue - (⬇ better)	0.87 (0.58)	0.86 (0.56)	2.19 (0.13)
Debt service / Net current revenue - (⬇ better)	0.08 (0.04)	0.08 (0.04)	0.07 (0.03)
Primary balance / Debt service - (⬆ better)	0.44 (2.09)	0.46 (2.10)	(0.66) (1.00)
Compensation of employees / Net current revenue - (⬇ better)	0.54 (0.09)	0.54 (0.09)	0.74 (0.04)
Current fiscal balance / Current revenue - (⬆ better)	0.22 (0.17)	0.23 (0.17)	(0.00) (0.12)
Gross investment in nonfinancial assets / Total expenditure - (⬆ better)	0.09 (0.04)	0.09 (0.04)	0.03 (0.01)
Social contributions / Social benefits - (⬆ better)	0.93 (1.44)	0.93 (1.45)	0.37 (0.28)
Tax revenues / Current expenses + Principal payments - (⬆ better)	0.59 (0.18)	0.59 (0.18)	0.68 (0.08)
Proposed Methodology			
Gross debt / Net current revenue - (⬇ better)	0.87 (0.58)	0.86 (0.56)	2.19 (0.13)
Current expenses / Current revenue - (⬇ better)	0.83 (0.10)	0.83 (0.10)	1.01 (0.12)
Current liabilities / Cash and cash equivalents - (⬇ better)	0.49 (0.43)	0.47 (0.36)	2.57 (0.70)

Notes:
1) All variables are reported as averages across the observations with standard deviation reported in parentheses
2) The variable Gross debt / Net current revenue is reported twice only to acknowledge that it was present in both methodologies. The variables Current fiscal balance / Current revenue and Current expenses / Current revenue have a different calculation rule, but convey the same information. For econometric purposes, only one will be used to avoid multicollinearity issues



(a) Gross Debt / Net current revenue (b) Current expenses / Current revenue



(c) Current liabilities / Cash and cash equivalents

Figure 3.1: Evolution of SGNs Financial Ratios proposed in the Payment Capacity Evaluation - 2008-2016

Source: Own elaboration

3.2 Econometric Model

In this section we mostly follow the expositions and results from Greene (2011), Heij et al. (2004) and Davidson & MacKinnon (2004) adapted to the notation used in this study.

To assess the relative importance of these several potential explanatory variables, we need to use multiple regression analysis. The main model in this study will be a logit model, which is a special case of a binary response model. The binary response model can be derived from an underlying latent variable model. The latent variable model is

$$y_{it}^* = \boldsymbol{x}_{i,t-1}'\boldsymbol{\beta} + \epsilon_{it}, \quad (i = 1, \ldots, N \text{ and } t = 1, \ldots, T) \tag{3.1}$$

This is the so-called index function, $\boldsymbol{x}_{i,t-1}'\boldsymbol{\beta}$ is the systematic term and ϵ_{it} is an idiosyncratic error term. In our case, the latent variable y_{it}^* can be interpreted as either a propensity to default or as a measure of creditworthiness. We don't observe y_{it}^*, only y_{it} according to

$$y_{it} = \begin{cases} 1, & \text{if } y_{it}^* \geq 0 \\ 0, & \text{if } y_{it}^* < 0 \end{cases} \tag{3.2}$$

Assuming that ϵ_{it} has a standard logistic distribution we have that

$$\begin{aligned} \Pr(y_{it} = 1 \mid \boldsymbol{x}_{i,t-1}) &= \Pr(y_i^* \geq 0 \mid \boldsymbol{x}_{i,t-1}) \\ &= \Pr(\boldsymbol{x}_{i,t-1}'\boldsymbol{\beta} + \epsilon_{it} \geq 0 \mid \boldsymbol{x}_{i,t-1}) \\ &= \Pr(\epsilon_{it} \geq -\boldsymbol{x}_{i,t-1}'\boldsymbol{\beta} \mid \boldsymbol{x}_{i,t-1}) \\ &= 1 - \Lambda(-\boldsymbol{x}_{i,t-1}'\boldsymbol{\beta}) \\ &= \Lambda(\boldsymbol{x}_{i,t-1}'\boldsymbol{\beta}) \end{aligned} \tag{3.3}$$

The density (pmf) for each observation is given by

$$f(y_{it} \mid \boldsymbol{x}_{i,t-1}) = \Lambda(\boldsymbol{x}_{i,t-1}'\boldsymbol{\beta})^{y_{it}} + [1 - \Lambda(\boldsymbol{x}_{i,t-1}'\boldsymbol{\beta})]^{1-y_{it}}$$

Therefore the log-likelihood $\ell(\boldsymbol{\beta})$ for a random sample of size $n = N \cdot T$ is given by

$$\begin{aligned} \ell(\boldsymbol{\beta}) &= \ln\left(\prod_{i=1}^{N}\prod_{t=1}^{T} f(y_{it} \mid \boldsymbol{x}_{i,t-1})\right) = \sum_{i=1}^{N}\sum_{t=1}^{T} \ln f(y_{it} \mid \boldsymbol{x}_{i,t-1}) \\ &= \sum_{i=1}^{N}\sum_{t=1}^{T} y_{it} \cdot \ln[\Lambda(\boldsymbol{x}_{i,t-1}'\boldsymbol{\beta})] + (1 - y_{it}) \cdot \ln[1 - \Lambda(\boldsymbol{x}_{i,t-1}'\boldsymbol{\beta})] \end{aligned} \tag{3.4}$$

Maximization of 3.4 with respect to $\boldsymbol{\beta}$ gives the maximum likelihood estimates.

Perfect Classifier

A common problem in applied work with binary dependent variables occurs whenever there is a linear combination of the explanatory variables that can perfect classify every observation. That is

$$y_{it} = \begin{cases} 1, & \text{when } \boldsymbol{x}'_{i,t-1}\boldsymbol{\beta} > 0 \\ 0, & \text{when } \boldsymbol{x}'_{i,t-1}\boldsymbol{\beta} < 0 \end{cases} \tag{3.5}$$

This phenomenon is called complete separation, and it produces infinite parameter estimates in the usual numerical optimization algorithms that attempt to make the value of 3.4 as close to zero as possible. Davidson & MacKinnon (2004) gives three main reasons for the occurrence of this phenomenon in practice. The sample size is very small, the model fits extremely well, or the dataset is characterized by a much larger proportion of $1s$ or $0s$. It is likely the case that this study fulfills all three criteria, and therefore a different estimation procedure is warranted. We make use of a maximum penalized likelihood estimation first suggested by Firth (1993) and implemented by Kosmidis (2017) in the R-package `brglm`. The advantage of this procedure is that the even in cases of complete or quasi-complete separation the estimates and their standard errors are always finite (Kosmidis 2017).

Inference and Goodness of fit

Inference on the logit model can be conducted in the usual fashion. The significance of individual explanatory variables can be tested by the usual t-test and the significance of joint variables can be tested by the likelihood ratio test (Heij et al. 2004, p. 453). The former is based on the loss of log-likelihood that results from the imposition of g independent restrictions on the parameters of a given model. The test statistic can be computed as

$$LR = 2(l(\hat{\theta}_u) - l(\hat{\theta}_r)) \xrightarrow{d} \chi^2_{(g)}$$

where $l(\hat{\theta}_u)$ is the log-likelihood of the unrestricted model and $l(\hat{\theta}_r)$ the log-likelihood of the restricted model (the one with the restrictions applied). The null hypothesis $H_0 : \hat{\theta}_r$ is rejected in favor of the alternative $H_1 : \hat{\theta}_u$ if the test statistic is sufficiently large.

Chapter 4

Results

Before presenting the econometric results, a word of caution is in order. It is important to keep in mind that all the results rest on the definition of fiscal distress event, which, in this study, produced only 3 crisis episodes across the sample of 243 observations. As discussed in section 3.2, this raises issues of bias in the estimates and problems related to complete and quasi-complete separation. Although we are making use of a bias reduction method proposed by Firth (1993) and implemented by Kosmidis (2017), by no means this puts a definitive end to concerns related to the robustness of the results.

In this study, we followed two different specification strategies in order to better serve the objectives of the study, namely, to test the statistical significance of the fiscal indicators used the by the National Treasury Secretariat (NTS) in payment capacity evaluations. The first was a "testing down" approach, while the second a "testing up", in the sense suggested by Kennedy (2008).

In the "testing down" approach, we began with a model that includes all explanatory variables. From this full model, we considered two reduced nested models that were formed based on the fiscal indicators present in each payment capacity methodology. This allows us to test for the joint significance of several explanatory variables and directly compare the significance of each methodology.

In the "testing up" approach, the base model uses as explanatory variables only the 3 fiscal ratios proposed in the new payment capacity evaluation. We then run individual regressions against each of the fiscal variables set forth in the Finance Minister Decree n 306, 10/09/2012. Finally, all significant variables of the second stage are then added one by one to the base model, and we conduct tests for the significance and look for changes in sign and/or significance of the base variables. This strategy allows us to better grasp if the proposed set of fiscal indicators of the new methodology could usefully be

expanded with previously used ratios while minimizing the number of tests conducted. We don't "test down" the full model because it is not clear what criteria should be used to exclude a given variable at each stage without either going through all combinations or making more or less arbitrary choices.

Two last remarks are in order before we delve into the results. First, the ratio Gross Debt / Net current revenue is included in both methodologies but obviously will be included only once in the full model. Similarly, the calculation rule of the ratio Current fiscal balance / Current revenue was changed in the new methodology to Current expenses / Current revenue. However, since they convey the same information, in order to avoid multicollinearity issues, only the ratio Current expenses / Current revenue from the newly proposed methodology will be used for estimation purposes. Second, we follow the suggestion given in Gelman (2008) and scale all fiscal indicators with a division by two standard deviations, that is, $z_{i,t-1} = x_{i,t-1} - mean(x)/2 \cdot sd(x)$. The interpretation of the regression coefficients is equal to the mean ± 1 standard deviation, the same comparison of possible untransformed binary predictors. To say it differently, the coefficients can now be interpretable as changes from low to high values of the explanatory variable of interest.

Testing down

Table 4.1 presents the regression estimates for the three first models of interest. Model 1 is the full model and includes all fiscal indicators used by the NTS, be in the current or the new methodology. We also estimate two nested models that correspond to particular restrictions applied to the full model. Model 2 corresponds to a restricted model in which all variables of the current methodology are set to zero. Model 3 on the other hand, corresponds to the restricted model in which all variables of the new methodology are set to zero. Although, in this case, only the ratio Current liabilities / Cash and cash equivalents is set to zero.

It is worth reminding the reader that, contrary to linear models, the coefficients in non-linear models can't be interpreted as marginal effects, although we can interpret both the sign and the relative magnitude of the relative magnitude of the coefficients.

In model 1, both Current liabilities / Cash and cash equivalents and Gross investment in nonfinancial assets / Total expenditure were significant at a 5% level. However, the sign in the latter was somewhat surprising. We would expect that states that were on the verge of a crisis would reduce their investment rate because of the discretionary nature of this type of expenditure. Therefore, in a predictive sense, a higher investment rate would translate into a smaller probability of a fiscal crisis, the opposite of what was

found in model 1. In model 3 the sign is negative as expected, but the variable was no longer significant. One possible explanation is related to a large amount of investment spending undertaken by Rio de Janeiro for the 2016 Summer Olympics, even when they were already financially constrained. In model 2 only Current liabilities / Cash and cash equivalents was significant at a 5% level. In model 3, that excludes only Current liabilities / Cash and cash equivalents with respect to model 1, several variables were significant. Gross debt / Net current revenue and Primary balance / Debt service were significant at the 5% level while Current expenses / Current revenue and Compensation of employees / Net current revenue at the 10% level. Because of this drastic change of the significant explanatory variables in going from model 1 to model 3, it does raises concerns about an omitted variable bias in model 3.

In order to better grasp which model is in some sense better, we can conduct a likelihood-ratio test described in section 3.2. First, likely due to the bias-reduction method employed, the log-likelihood for model 2 is, in fact, **greather** than the log-likelihood for the unrestricted model 1, meaning that there was a **likelihood gain** moving from imposing the parameter restriction. For model 3, the test statistic is $LR = 2 \cdot (-5.964 + 8.246) = 4.56$. Compared with a χ^2 with one degree of freedom, the p-value is equal to 0.033. We, therefore, reject the null hypothesis at a 5% significance level, meaning that the loss of likelihood in imposing the restriction is likely different from zero and the unrestricted model (model 1) should be considered the best one. Together, these results indicate that in choosing between the information set of the current versus the newly proposed methodology, the newly proposed methodology appears to be the better choice.

Table 4.1: Regression results for binary dependent variable - Testing down

	(1)	(2)	(3)
Gross debt / Net current revenue	1.674	1.048	4.089**
	(1.283)	(1.254)	(1.785)
Current expenses / Current revenue	−1.754	−1.110	−2.805*
	(1.288)	(1.278)	(1.491)
Current liabilities / Cash and cash equivalents	5.001***	3.531**	
	(1.932)	(1.396)	
Debt service / Net current revenue	−0.882		0.444
	(1.341)		(1.239)
Primary balance / Debt service	0.704		−4.482**
	(0.717)		(2.027)
Compensation of employees / Net current revenue	0.876		1.976*
	(0.943)		(1.069)
Gross investment in nonfinancial assets / Total expenditure	2.926**		−1.306
	(1.472)		(1.459)
Social contributions / Social benefits	0.482		0.731
	(0.812)		(0.714)
Tax revenues / (Current expenses + Principal payments)	−0.051		−0.087
	(1.523)		(1.375)
Constant	−5.834***	−5.813***	−6.098***
	(1.349)	(1.280)	(1.434)
Observations	216	216	216
Log Likelihood	-5.964	-5.804	-8.246
Akaike Inf. Crit.	31.929	19.608	34.492

Notes: *p<0.1; **p<0.05; ***p<0.01 and standard errors reported in parentheses
1) Model 1 is the full model, model 2 is the reduced model using only the fiscal indicators of the newly proposed methodology and model 3 is the reduced model using only the fiscal indicators given in the Finance Minister Decree n 306, 10/09/2012

Testing up

Table 4.2 presents the regression estimates for the "testing up" approach. Model 1 (Model 2 in table 4.1) is the base model that uses the fiscal ratios proposed in the new payment capacity evaluation as explanatory variables. We first ran individual simple regressions against each of the fiscal variables set forth in the Finance Minister Decree n 306, 10/09/2012. The ratios Debt service / Net current revenue, Compensation of employees / Net current revenue and Gross investment in nonfinancial assets / Total expenditure were significant in the individual regression. We then added the ratios to the base model. This is reported in models 2 through 4 in table 4.2. Debt service / Net current revenue (Model 2) was not significant and didn't change the sign of the other explanatory variables. Compensation of employees / Net current revenue (Model 3) was also not significant, but with its inclusion in the model Current expenses / Current revenue was significant at a 5% level. The sign, however, was somewhat puzzling. It indicates that holding compensation of employees fixed, lower savings reduces the probability of a crisis. There are no readily available explanations for this result except for the observation that Compensation of employees is the most significant component of current expenses in all states. Gross investment in nonfinancial assets / Total expenditure was (Model 4) was not only significant at the 10% level, but made Gross debt / Net current revenue significant as well at the same level. The sign was again positive, implying that higher investment is correlated with higher probability of a fiscal crisis.

We finally add Compensation of employees / Net current revenue and Gross investment in nonfinancial assets / Total expenditure to the base model (Model 5) giving what can be considered the final specification of the "testing up" strategy. In this model Current liabilities / Cash and cash equivalents and Gross investment in nonfinancial assets / Total expenditure were significant at the 5% level. We again conduct a likelihood ratio test to compare the unrestricted model (model 5) with the restricted one (model 1). The test statistic is $LR = 2 \cdot (-4.063 + 5.804) = 3.48$. Compared with a χ^2 with two degrees of freedom, the p-value is equal to 0.175. We, therefore, fail to reject the null hypothesis. The interpretation is that it might be the case that the loss of likelihood by excluding the two variables from the unrestricted model is not different from zero. Again this indicates that restricting the information set to the fiscal indicators of the newly proposed methodology appears to be a reasonable choice.

Table 4.2: Regression results for binary dependent variable - Testing up

	(1)	(2)	(3)	(4)	(5)
Gross debt / Net current revenue	1.048	0.806	1.451	6.002*	2.465
	(1.254)	(1.170)	(1.357)	(3.631)	(1.591)
Current expenses / Current revenue	−1.110	−1.625	−3.203**	0.112	−1.880
	(1.278)	(1.340)	(1.621)	(1.562)	(1.475)
Current liabilities / Cash and cash equivalents	3.531**	4.177**	4.237**	9.076*	4.617***
	(1.396)	(1.758)	(1.784)	(4.785)	(1.767)
Debt service / Net current revenue		−0.576			
		(1.207)			
Compensation of employees / Net current revenue			1.586		1.405
			(1.076)		(1.098)
Gross investment in nonfinancial assets / Total expenditure				8.737*	3.566**
				(4.782)	(1.686)
Constant	−5.813***	−5.580***	−6.433***	−14.206**	−6.973***
	(1.280)	(1.187)	(1.669)	(6.884)	(1.937)
Observations	216	216	216	216	216
Log Likelihood	-5.804	-6.039	-4.609	-2.505	-4.063
Akaike Inf. Crit.	19.608	22.078	19.218	15.010	20.127

Notes: *p<0.1; **p<0.05; ***p<0.01 and standard errors reported in parentheses
1) Model 1 is the base model using the variables proposed in the new methodology. Models 2 through 4 add the fiscal indicators defined on the Finance Minister Decree n 306, 10/09/2012 that were significant at the 5% significant level on the individual regressions

Chapter 5

Conclusion

The purpose of the current study was to evaluate the statistical and practical significance of both the current and the newly proposed fiscal indicators used by the National Treasury Secretariat (NTS) to assess the payment capacity of subnational governments in Brazil. The current methodology enacted in 2012 by the NTS was deemed to be overly complicated in general and also based on a set of fiscal indicators that could potentially be simpler in terms of dimensionality without harm in terms of predictive performance. This view was justified on the basis of the correlation between the fiscal indicators.

This study has identified that the new methodology that uses only 3 ratios instead of the 8 of the current methodology is in fact statistically superior in terms of the likelihood of the given data. This superior performance is mostly attributed to the ratio Current liabilities / Cash and cash equivalents who proved itself to be significant in all specifications employed in this study.

Expressing these results in the language of the concepts related to fiscal sustainability discussed in section 2.1, we can say that empirically, the willingness and ability to pay of an SGN in Brazil appear to be mostly explained by its liquidity position. Solvency ratios appear to be only instrumental for this explanation, in the sense that they matter only to the extent that indirectly they influence the trajectory of liquidity ratios. To exemplify, high debt ratios to net current revenue can only explain fiscal crisis episodes in Brazil to the extent that debt service obligations generate higher current liabilities.

The research has also shown that for the sample at hand, the fiscal indicators proposed in the new methodology proposed by the NTS could maybe fruitfully include Gross investment in nonfinancial assets / Total expenditure. However, this result appears to be more related to the observed behavior of Rio de Janeiro, who, even in financial difficulties, kept investment rates high because of the commitments made with the 2016 Summer Olympics.

There are four major sources of weakness in this study, all in some way or another related to data constraints. First, we did not allow for the presence of unobservable heterogeneity between states, by using, for example, a fixed effects logit model. The reason for this is simply that in fixed effect estimation all the observations corresponding to states that did not face a crisis episode in the sample horizon would be dropped out of the likelihood function, leaving only the observations of Rio de Janeiro, Rio Grande do Sul and Minas Gerais.

The second source of weakness is related to the definition of fiscal crisis episode adopted. The enactment of a decree of financial calamity is a political process that a given state might not participate because it does not align with the political calculus of the politicians involved in this decision. Although this sounds like a tautology, it is especially important in the current case. The reason is that the most common interpretation of the Brazilian legal system, shared by the Ministry of Finance[1], says that the decree of calamity should be restricted to natural disasters, and therefore the benefits, such as the possibility to delay payments to creditors and to bypass some legal requirements for procurement and budgeting process, is not valid under "financial calamity". A more reliable definition of fiscal crisis episode would need to make use of arrears data that still do not exist for SGN's in Brazil.

A third source of weakness comes from the 2008-2016 horizon employed. Brazil experienced in the 80s and 90s repeated fiscal crisis of subnational entities with three rounds of debt restructurings. These should clearly be considered a fiscal crisis episode. However, the majority of the explanatory variables used in this study were fiscal variables and indicators derived from the datasets provided by the National Treasury Secretariat. Although, the original period covered by the data published by NTS extends from 1986 through 2016, totalling 31 years of data, events like hyperinflation, change of currencies, change in fiscal reporting and budget classifications and no tracking of stock variables makes the process of compiling a cleaned and consistent dataset a research enterprise of its own.

Finally, because there were only three fiscal crisis episodes in the sample that happened in the same year, it was not possible to look into out of sample forecast accuracy measures, which are ultimately the final yardstick by which EWS models should be judged. (Berg et al. 2005).

Putting the need for the collection of a more comprehensive dataset of fiscal variables on SGN aside, the cited weakness of this study are useful alternatives for future work. Additionally, because most of the EWS literature is currently focused on sovereign countries, studies that use different

[1] http://g1.globo.com/bom-dia-brasil/noticia/2016/12/calamidade-financeira-de-estados-nao-e-reconhecida-pelo-governo.html

strategies in the three areas that tend to differentiate early warning systems models, namely, the definition of the crisis event, the statistical methodology employed, and the set of explanatory variables, but applied to SGNs, would be a welcome addition to the literature.

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