ABSTRACT

Title of dissertation: DISCRETIONARY FEDERAL RESOURCES DISTRIBUTION IN BRAZIL

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The Brazilian budgetary process is characterized by heavy central government control with wide ranging discretionary authority. State and municipal governments may try to exploit the discretionary power of the central government by choosing fiscal actions that will induce the latter to help them. This behavior might result in an inefficient budget structure in which local governments would try to act as free riders on federation resources.

This dissertation models the Brazilian budgetary process in two different frameworks. The first considers an altruistic central government that aims to maximize the sum of the state utility functions. The second maximizes the federal government's probability of being reelected. In a sequential game in which local governments play first and the central government plays afterwards, the signs of the derivatives of the federal government's discretionary resources distribution reaction functions are evaluated. The theoretical results are similar for both models in that there appears a soft budget constraint for decentralized governments.

These reaction functions are then empirically evaluated and negative correlations between state GDP and discretionary transfers, and between compulsory grants and discretionary transfers are found. The tests could not detect any significant relation either between discretionary transfers and local tax collection or between discretionary transfers and local debt service payments. In other words, no fiscal behavior exploiting a soft budget constraint was found for Brazilian states and municipalities. A positive and significant relationship was detected between discretionary transfers and the political power of states. This finding runs counter to the hypothesis of a purely benevolent federal government; it is consistent with the use of those transfers to support the re-election of the incumbent federal government. In addition, the findings indicate that the federal government has used discretionary grants to offset, at least in part, the redistributive effect of the equalization grants.

DISCRETIONARY FEDERAL RESOURCES DISTRIBUTION IN BRAZIL

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

Federal systems, either in pure form or in some impure variety, are contemporaneously the dominant administrative arrangement of government. Of course the world has experienced other types of government structures, from the Greek city-states to the British Empire, but today federalism appears to be the system most compatible with democracy.

Nonetheless, federalism is a very broad concept, which encompasses a variety of political, administrative and economic features. This paper is primarily concerned with the economic aspects of a federal system, although it has been recognized in the literature that there are important interactions between the different features[1].

The definition of economic federalism, which is far less restrictive than its legal counterpart, requires that there be at least two levels of government: a higher level, in general called federal government which must have some economic decision power over all jurisdictions, and a set of lower level governments, each of them exerting economic decision power only over a restricted part of the national territory (Goodspeed 2000).

Thus, the main focus of the economic approach to federalism is on who decides about the economic aspects of the federation rather than who has the legal right

[1]Oates (1972) provides the rationale for these interactions as well as some examples. See pages 15 and 16.

of deciding. For example, if a dictatorial regime delegates some economic decision power to its appointed provincial officials, it will be considered an economic federation (e.g. present day China) but not a legal federation. At the other extreme, if in a democratic country the population delegates to the central government all economic decision power (e.g. New Zealand), this country will not be considered a federation in the economic sense[2].

The important point about economic federalism is that the existence of a number of jurisdictional governments, not to mention different levels of government, will produce several potential channels of interaction. Some of these interactions will not be economic; the necessity of previous authorization for a police force to cross a border during the pursuit of criminals is a non-economic example of jurisdictional interaction.

Economic interactions between governments within a federation, which are the main topic of this dissertation, have increasingly gained attention in the public finance literature during the last decades. Since the early work of Musgrave (1959) and Oates (1972), many social researchers have studied this subject under the title of *Fiscal Federalism*.

Recently, the new developments of microeconomic theory have been used to study the interactions between governments to provide a strategic perspective. From this point of view, governments within a federation do not behave as isolated institutions taking the actions of others as exogenous. Rather, they act with the

[2]Unless the central government implements specific economic policies for each administrative unit of the country, in which case it would be acting as an economic federation.

full knowledge that their acts affect and are affected either by the actions at other government levels or other jurisdictional governments.

One of the manifestations of these strategic interactions between governments can be a situation in which lower level governments engage in excessive expenditures because they anticipate financial rescue by the central government. This phenomenon has attracted great interest in the fiscal federalism literature; its source is so-called *Soft Budget Constraints*. The description of this behavior was first advanced by Kornai (1980) to explain the relationship between state-owned enterprises and socialist governments in former communist countries in Europe. However, the concept has been extended to encompass not only the relationship of firms and governments in other countries (Qian and Roland, 1998), but also to describe the interaction between governments within a federation (Rodden, Eskeland and Litvack, 2004).

In the context of a federation, the existence and the potential harmful consequences of soft budget constraints depend on the institutional mechanisms. Thus, although some general rules may apply, each case must be considered as having its own characteristics. Because of this, knowing the general implications of soft budget constraints is not enough either to establish its presence in a governmental system or to understand how it works in practice in a given federation. Understanding the peculiar characteristics of each State is crucial to developing effective measures for budgetary reform.

The general objective of this work is to place the institutions and the functioning of Brazilian fiscal federalism within the perspective of the public finance

literature and to study empirically the consequences of its *modus operandi* in order to see whether soft budget constraints exist, and, if so, how they manifest themselves. In particular, we study the budgetary process in Brazil to see how it may generate soft budget constraints for states and municipalities by giving too much discretionary power to the federal government.

In order to accomplish this task, this dissertation is divided into six chapters including this introduction. Chapter two presents a brief description of the development of the theory of fiscal federalism in order to place this research within the context of the existing literature. It describes the early literature in fiscal federalism and how this literature has developed more recently. It also tries to connect the modeling strategies utilized here with the basic game theoretical principles of threats and promises.

In Chapter 3, we explore the structure and functioning of Brazilian federal institutions in order to capture their main features and include them in the theoretical model, at least in a stylized form. It begins with a brief overview of the Brazilian federal system, followed by a description of the division of expenditure and taxation responsibility between government layers. Afterwards, the existing grant mechanisms are described. The chapter then turns to an analysis of the debts of the decentralized levels of government and how they have been bailed out by the central government. The last topic of this chapter treats the relevant political issues within the Brazilian federation.

The theoretical models are developed in Chapter 4. These models aim to capture the main features of Brazilian federalism and to shed light on the implicit

relationships between government levels. Indeed, this chapter explores three distinct but intimately related models. First, it considers the totally centralized decision model in order to establish the properties of the first-best solution. The second model explores a decentralized decision structure in which the federal government has a distributive role and acts benevolently. The last model also deals with a decentralized setting in which the federal government pursues its own interests.

The empirical tests appear in Chapter 5. The reaction functions determined in the preceding chapter are estimated and the significance of some key variables are scrutinized in order to evaluate which model is more adequate in explaining the functioning of the Brazilian federation. Chapter 6 concludes by summarizing the results, exploring their policy implications, and indicating perspectives for future research.

Chapter 2

The Soft Budget Constraint in the Second Generation Theory of Fiscal Federalism

2.1 Basis of the Theory of Fiscal Federalism

The basic theory of fiscal federalism appeared within the context of traditional public finance theory. This "First Generation Fiscal Federalism Theory" (FGT), as Oates (2005) described it[1], is primarily concerned with the assignment of public functions to the various government levels as well as the welfare implications of this assignment. This normative theory prescribed how the government should intervene (because of the existence of public good provision problems, externalities, market failures, etc.) and defined which level of government is best suited to do the job.

There were several elements in FGT. A key assumption is that local government knows best. Thus, the lower the government level, the better it can adjust the provision of the public goods whose consumption is limited to local residents.

The rationale for this proposition is twofold. The first is a pragmatic one. There are political difficulties associated with the unequal provision of public goods across jurisdictions. Many federal countries have laws or regulations that prevent such an asymmetrical distribution of public outputs. More generally, a basic sense

[1]Or "First Generation Economic Theory" on federalism as it is called by Qian and Weingast (1997).

of fairness may preclude such variation in public outputs.

A more theoretical justification is related to an information problem. Specifically, the costs incurred by the central government in order to acquire all the information necessary to tailor the public good provision to the local population needs would be greater than those of local governments. What is not clear from the perspective of the FGT is why the central government cannot get local agents to act on its behalf. Local representatives could, in principle, collect and use all relevant information in order to provide local public goods in welfare maximizing quantities (and quality). The new approaches to the theory of fiscal federalism have explored this information asymmetry problem in interesting ways, as we shall see later in this chapter.

The capacity of lower level governments to provide efficient outputs of public goods encounters two obstacles: scale economies and externalities. One could expect that some programs will be less expensive if they are structured to encompass the nation as a whole rather than serving each state, province or city; thus there might be some advantages in favor of the centralized provision.

This argument does not consider the possibility of formation of public consortia with the objective of providing certain public services. These consortia could decrease the unit price of each of the participating governments by taking advantage of the existing economies of scale.

A second factor that may favor centralized provision is the presence of externalities. Since the actions of a regional government may affect residents of other jurisdictions, it may be that regional decisions underestimate the true social costs (or

benefits) of regional programs. In this case a central government could internalize these externalities, increasing the overall welfare. Although externalities may really have a considerable weight in the provision of public goods, this line of argument neglects the existence of other mechanisms to deal with them (such as Pigouvian taxes/subsidies).

This trade-off between decentralized fiscal choice versus externalities and economies of scale was first expressed by Oates (1972) in the "Decentralization Theorem". The theorem lays out a set of sufficient conditions for local provision of public outputs to yield a higher level of social welfare than a uniformly centrally determined level of output.

Another main question addressed by the FGT was the so-called "tax assignment" problem. It consists in determining which types of taxes are more appropriate for each level of government. To deal with this subject, one must first recognize that a non-benefit tax levied on highly mobile tax bases such as labor or capital will cause distortions, since these factors will tend to relocate from regions where they are heavily taxed to those where tax burdens are lower. This argument favors the centralized collection of non-benefit taxes on bases that are highly mobile.

Local government could focus on taxation of non-mobile tax bases, property for example. This kind of specialization could bring some advantages to the general welfare, especially if one appeals again to the assumption that local government "knows better", since it is to be expected that the data collection and administration of property taxation would be done in a more efficient way by local governments than by the central government.

The utilization of benefit taxes[2] by local governments could also be welfare improving. This line of argument leads to the famous Tiebout model in which citizens relocate in order to choose the locality which provides the preferred combination of taxes and public goods output. Under the assumptions of perfect individual mobility and information, each household could increase its welfare by moving to such a locality and when all households relocate and consequently increase their utilities, society gets a Pareto optimal outcome. This Pareto improvement would happen because the existence of several localities with a different tax/public goods mix would provide conditions for a separating equilibrium in which households would spontaneously reveal their preferences over public good provision.

It is worthwhile noting that Tiebout sorting, i.e. the process that leads people to move in order to find the place that is better suited to their preferences, will tend to group people according to their preferences over public good provision. This homogenization of the demands in each locality will favor the decentralized provision of public goods, since the decentralization theorem shows that the higher the uniformity of preferences within communities, the greater the potential gains in welfare from the local provision of public goods. This line of argument links the Tiebout model to the main body of the FGT.

[2] Benefit taxes are those which are associated with the provision of some specific public good and are paid by the agents who actually take advantage of the use of the public good (Stiglitz 1988 and Hines 2000).

2.2 The Second Generation Theory of Fiscal Federalism

More recently some authors have developed a new approach to fiscal federalism. This new line of research, called the "Second Generation Theory of Fiscal Federalism "[3] (SGT), has introduced new ways to look at fiscal decentralization.

The main distinction between the two approaches is that, while the FGT uses methods and tools of the traditional Theory of the Firm such as economies of scale and externalities, the SGT aims to utilize the more recent developments of that theory, as for example the Theory of Contracts, Principal-Agent problems and agent strategic behavior.

Qian and Weingast (1997) considered the specific application of the Principal-Agent problem as the main feature of the SGT (see Qian and Weingast 1997, p.83), while some authors such as Crémer, Estache and Seabright (1996) associate the SGT with the "Theory of Contracts". Oates (2005) points out two distinctive characteristics of the SGT in relation to the FGT: information problems, understood as the cost of acquiring and processing the relevant information by the various agents in the federation, and public choice problems attached to federal political processes.

But what do all these approaches have in common? Which general feature would justify joining them together in a new theoretical structure? From my point of view, what distinguishes the SGT from the traditional theory of fiscal federalism is the strategic behavior and interaction of the participants in a federal system. Households, voters, firms and various levels of government in a federation may

[3]Qian and Weingast (1997),Oates (2005).

act strategically and know that the other agents are behaving strategically. This general characterization includes the "Principal-Agent" problem, the "Incomplete Contracts" problem and the "Strategic Vote" problem. The following discussion will explore some of these ideas in the context of the SGT approach to fiscal federalism.

The theory of public choice is not new. During the decade of the 1960's it ran parallel with traditional public finance theory. Nonetheless, the development of ideas that relate this theory to fiscal federalism is relatively recent although some of the primary insights can be found in earlier work.

For example, Brennan and Buchanan (1980) argue that fiscal decentralization may reduce the capacity of the state to exploit society through excessive taxation. This deterrent power of federalism would come from the fact that, mobile households and firms would constrain government access to tax revenues; economic units can simply leave the jurisdictions in which the local governments show greater voracity to those in which they are more moderate. Qian and Weingast (1997) and others developed this idea more precisely, with distinct modeling strategies, as will be seen below.

More recently public choice theory has been utilized in close connection with work in "Political Economy," and this interaction has had an impact on the public finance field in general, including its fiscal federalism branch. The introduction of public choice mechanisms in this field has been utilized mainly to study the benefits (or the disadvantages) of fiscal decentralization. The point here is that the process of voting may have an influence on the efficiency of a decentralized government.

Besley and Coate (2003) built a model in which the assumption that the

central government will supply a uniform level of the public good across localities is dropped. Their model incorporates both economies of scale of central provision and externalities. The inefficiency of central provision comes from the political economy process associated with the decision about the provision of local public goods across different regions. If the decision process obeys the logic of the minimum winning coalition, the paper shows the possibility of a misallocation of local public goods provision skewed towards localities in the coalition. Furthermore, another drawback in the centralized provision under the minimum coalition system is that it generates uncertainty over the public provision in each district since, the level of the public good depends on whether a district is or is not in the winning coalition.

It is interesting to note that this result is maintained, although mitigated, even in the case of a cooperative process in the legislature. This process is characterized by a utilitarian bargaining solution, which aims to maximize the joint surplus of the legislators. Thus, the local public good provision in each locality depends on the preferences of all legislators. If the median voter of each district were elected as its legislator, the cooperative legislative solution would replicate the first-best outcome. But as voters know that the allocation of the public goods depends on the type of legislators, they may act strategically and the election may not reflect the median voter's preference. Let us suppose that the median voter in a particular district has a stronger preference for public goods than the median voters of all other districts. Then, voters know that if every locality decides for the allocation that corresponds to their median voter, the total public good provision will be below their ideal level, because his preferences towards public goods are much higher than the average.

Thus, acting in his best interest, he will vote for a delegate with an even higher preference for public goods. Median voters from other districts will act in a similar way, but in the opposite direction. Thus, the cooperative system does not achieve the Pareto optimal result because, in spite of avoiding outcome uncertainty and misallocation which arise in the minimum winning coalition context, it raises a new problem: the strategic delegation problem.

Other studies also use the tools of public choice analysis in order to compare the centralized versus decentralized provision of public goods, some of them finding quite distinct results from those obtained by Besley and Coate (2003). For example, Person and Tabellini (1996) design a model in which risk-sharing arrangements between districts may increase each individual district's propensity to adopt riskier policies. This paper examines which constitutional designs exacerbate (or mitigate) this moral hazard problem. The political economy outcome is greatly influenced by the collective decision process and this paper analyzes several of such processes to determine the outcomess under different fiscal constitutions. In this context, centralization may be a good way of ruling out the moral hazard problem, even if no factor mobility is allowed in the model. Furthermore, delegation may mean a higher degree of commitment toward a primarily non-stable second best. In short, the effects of centralization and delegation here are just the opposite from those found in Besley and Coate (2003).

Turning to the application of the Principal-Agent problem in the context of fiscal federalism, one should note that it goes one step further than its use in other public finance situations. Traditionally, the application of the Principal-Agent prob-

lem in public finance is done by supposing that the public official (agent) who is responsible by delegation for the management of public affairs, may have his own motivations that are not necessarily coincident with the interests of the constituents (principals). But in a federation, it may be the case that some government levels can delegate responsibility to some other government level. In this situation, the relation between principal and agent occurs with governments and not with individual agents[4]. For example, in the model developed in Chapter 4 (as well as in Goodspeed 2002, Levaggi 2002 or Keen 1997, among others) the federation works as follows: states (principals) delegate some decision power to the central government (agent) in the hope that the latter will act on their behalf.

From a different perspective, Qian and Weingast (1997) suggest that decentralization would be an efficient way of addressing the Principal-Agent problem that arises in certain kinds of government delegation situations. If the government is totally centralized, its citizens will have neither comparison parameters to judge its quality nor the option of "voting with their feet". In other words, there will be no competition between governments and, in the absence of effective mechanisms through which the citizens could control the government, the latter would have a free hand to extract resources from the former beyond the desired level. If the government is decentralized, the existence of a number of different jurisdictions will constrain taxation by the self-interested government since the mobility of the residents will punish those governments that impose excessive taxes. This idea was first

[4]Naturally, this kind of the new application of the Principal-Agent problem does not exclude the possibility of its use in a more traditional sense and a fair amount of work within this framework has been done.

formulated by Brennan and Bucanan (1980), as mentined before, but these authors did not place it in a Principal-Agent context.

Another example of the application of the Principal-Agent approach to the federation context can be found in Levaggi (2002). The article in question tries to verify if, within the context of asymmetry of information, the central government (principal, in this model) is better off transferring earmarked grants or open-ended grants to local governments (agents). When Central Government transfers earmarked grants, it is said that the public sector operates under the "double budget constraint". Under this rule, Central Government defines not only the size of the total budget but also its distribution among the various expenditure functions. The paper shows that, contrary to the established budgetary wisdom, the "double budget constraint" may attenuate the Principal-Agent problem that arises when the objectives of the two government tiers are very different.

The theory of contracts has been utilized within the context of the SGT to explain federation relationships. Crémer, Estache and Seabright (1996) use this theory to explore asymmetric information between levels of government. In their view, lower level governments have more information than their higher-level counterparts because they obtain more benefits from gathering information about the preferences of their constituents. The level of accountability to which each government tier is submitted explains this endogeneity of information acquisition: the lower the government tier, the greater the probability of replacement if the government does not follow the preferences of the constituents.

The authors also point out the advantages of decentralization in the presence

of incomplete contracts. If the government has to decide on an issue, which is not specified in the federation constitution (which is the relevant contract in this case), the greater accountability of lower level governments will favor a better solution to the citizens of the jurisdiction than the measure that would be adopted by a higher-level, but less accountable, government.

The renegotiation of contracts is another source of problems in the federation context. Let us suppose that during the execution of a contract, it is observed that a modification in the contract may increase the utility of both parties involved. In this case there will be a strong tendency for the renegotiation of the initial terms of the contract. The problem here is that, if the parties can foresee renegotiation, they can modify their behavior in the previous periods in order to gain advantage in the renegotiation process. Thus, the moral hazard problem associated with the renegotiation possibility might lead the contract to be sub-optimal. This effect would help to clarify the "soft budget constraint" phenomenon as will be seen later.

2.3 Non-Credible Threats and Promises

It has been suggested that the distinction between threats and promises is merely semantic. Thus a promise of doing something would be equivalent to a threat of not doing that thing and vice-versa[5]. But, in order to be precise, one must recognize that there is a conceptual difference between the two ideas.

[5] "... the distinction between a threat and a promise depends only on what you call the status quo... A compellent threat is just like a deterrent promise with a change of the status quo; likewise, a deterrent threat and a compellent promise differ only in their status quo." (Dixit and Nalebuff 1991, pages 125–126).

Threats and promises are both strategic statements in which one player commits himself to an action that he may have no incentive to adopt. The distinction between the two concepts is that in a threat there is the prospect of punishment to the other party if he does not cooperate, while in the promise there is the prospect of reward for cooperation (Dixit and Nalebuff 1991, page 125). The concepts are not interchangeable because the agent has well defined preferences over the actions.

Thus, to follow the Dixit and Nalebuff (1991) example, if a mugger says to his victim "I will shoot you if you do not give me your wallet", this is a threat because the criminal would be acting against his *ex post* interests if he shoots the victim. It is a different situation if he says "I promise I will not hurt you if you give me your wallet." On the one hand, this is not a promise in the game theory sense but rather it is merely an assurance in which the player is trying to communicate his payoff function to the other party. On the other hand, it is not clear if the bandit will hurt the victim in the case of not receiving the wallet.

Both threats and promises are associated with credibility problems because the commitment of one agent to a strategy which is not preferred by him may not be believed by the other party, since he might always break his word and act according to his *a posteriori* interests when the chance appears. The lack of credibility of a commitment will undermine its desired effect because it will fail in changing the expectation of the other party about the response.

There are several ways in which the credibility of a commitment might be enhanced such as the reputation of the committed party and the adoption of formal or informal contracts. These two items are not infallible ways of assuring the

commitment since sometimes, as described by Bulow and Rogoff (1989), reputation might be built only to be advantageously broken in the future and contracts cannot cover all possible cases even when they are formally available.

Kidland and Prescott (1977) incorporated the literature of non-credible promises into macroeconomics. In this seminal work, the authors developed the concept of time inconsistency, which can be viewed as a non-credible promise. They use a monetary policy example: the monetary authority may produce inflation in order to promote an increase in GDP because there is in the model a Phillips curve which associates higher than expected inflation with increased output. Thus, only surprise inflation can raise GDP. The agents, knowing that the monetary authority has an incentive to deliver higher than expected inflation, will tend to increase their inflation expectations and thus decrease their monetary holdings below what would be optimal for them. This situation is inefficient. On the one hand, the equilibrium inflation will be higher than zero, and on the other hand there will be no gain in GDP since this higher inflation will not surprise anyone.

This perverse equilibrium will occur if agents do not believe in the promise of the monetary authority not to produce surprise inflation. Once agents have formulated their inflation expectation equal to zero, the non production of surprise inflation is against the immediate interests of the monetary authority and thus the commitment may lack credibility.

The analysis of threat credibility and consequences has been extensively studied in several contexts. Dixit (1979) utilizes the idea to analyze the effects of potential competition on a monopolist. He describes a situation in which an established

firm threatens a potential entrant with a predatory output increase and consequently a severe fall in sale prices should the prospective competitor effectively enter the market. In this example, now a classical textbook example, the author associates the credibility conditions of the threat with the monopolist's excess production capacity.

Lindbeck and Weibull (1988) apply the notion of non-credible threats in the context of intergenerational relationships and derive a justification for the adoption of compulsory social security systems as social welfare enhancers. The model is built on Gary Becker's famous "Rotten Kid Theorem" but the results are quite distinct.

In this model there are two overlapping generations, parents and children, who live for two periods. The parents derive utility from their own consumption and from the utility obtained by their children. This fact, which is known to the children, leads to an inefficient outcome. The children will overspend in the first period expecting to be helped by the parents in the second period, since their underconsumption in the second period will affect their parents. In this case the parents' threat of not helping in case of overspending (and consequently undersaving) in the first period is not credible. Even if the parents make the threat in the first period, the children know that they will have reasons to go back on their word and be tempted to help when the situation actually happens. Summarizing, the parents will have incentives not to enforce their threat when faced with the *fait accompli* of lower than optimum savings.

In this context, the savings generated by a compulsory social security system will tend to avoid the problem since the saving decision would be out of the hands of the second generation. It is worthwhile noting that Paul Samuelson (1958), in his

pathbreaking paper, arrives at the same conclusion but for the opposite reason. In his model there is no altruism, the source of inefficiency is the overaccumulation in the first period in order to assure the appropriate level of consumption in the second period. The introduction of a compulsory 'pay-as-you-go' social security system in this context would guarantee resources for the second period, and consequently would decrease the necessity of saving in the first period.

2.4 The Soft Budget Constraint in Federation Relationships

The concept of non-credible threats is an essential part of the *Soft Budget Constraint* (SBC). This phenomenon, first described by Kornai (1980, 1986), is characterized by a situation in which "the strict relationship between expenditures and earnings has been relaxed, because excess expenditure over earnings will be paid by some other institution, typically by the State" (Kornai 1986, page 4). It was first utilized to describe the behavior of state-owned enterprises in socialist economies. In this context, the SBC arises from the fact that these firms do not take as credible the government no-helping threat in case they get into economic or financial troubles. The managers of state-owned firms know that the job loss caused by an eventual closing will hurt the political interests of the government, and thus the bailout is consistent with government interests.

A series of papers in this line followed János Kornai. One could cite Pun (1995), Prell (1996), Li and Liang (1997), Maskin (1999), Qian (1994), and Qian and Roland (1998). In this last paper, the SBC principle is extended to settings

outside the socialist world. The concept is used to compare federative arrangements with different levels of centralization and includes the possibility of monetary decentralization. The innovative feature of this paper in relation to others that use the SBC concept is that the SBC is considered in a public budget environment and not limited to enterprise bailout situations.

Qian and Roland (1998) utilize a three tier hierarchy model (federal government, local governments and enterprises that can be state or foreign owned) and develop a sequential bailout game in which enterprises decide their action first and the local government decides whether to bail them out or not. Local governments compete for mobile foreign owned enterprises and play a sequential game competing with the Union for grants. Decentralization plus capital mobility may harden budget constraints but may also lead to allocative distortions. If there are federal grants, both of the above effects may be amplified. Even if the grants come from monetary *seignioriage*, the hardening effect over the budget constraint persists.

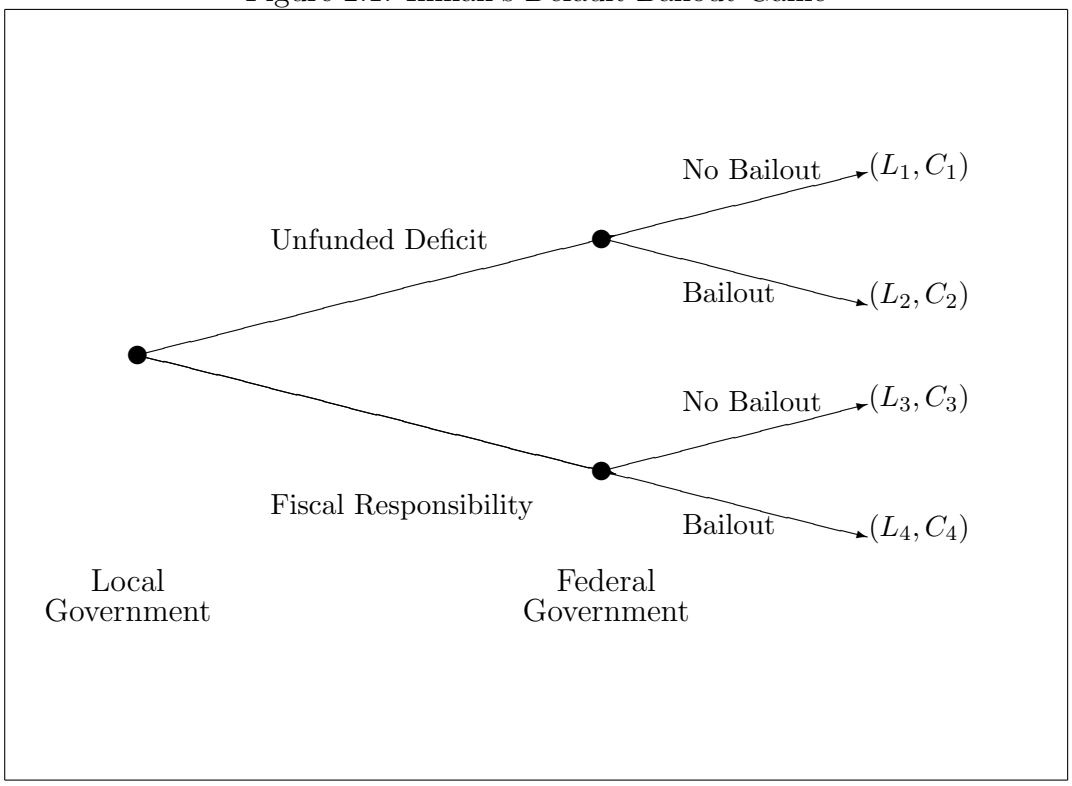
This generalization of the SBC idea in order to encompass federative relationships has been explored in the fiscal federalism literature. Inman (2004) has developed an intuitive explanation for this application in the federative context. In this sequential game, local governments choose their action in the first period. They can either choose responsible fiscal behavior or the generation of unfunded fiscal deficits. In the second period, the federal government, after having observed the chosen strategy of the local government, chooses between the financial rescue of the local government or allowing default. This Default-Bailout game is graphically shown in Figure 2.1. L represents the payoffs of the local government and C

represents the payoffs of the central or federal government.

One of the main questions that arises from this simple game is related to the credibility conditions for the non-bailout threat of the federal government. The problem is that if C_2 is greater than C_1, i.e., if the central government payoff increases when it bails out a troubled local government, the local government will have the incentive to adopt irresponsible fiscal polices even if $L_3 > L_1$ provided that $L_2 > L_3$. These local government payoff conditions are likely to be met, since when a local government adopts irresponsible fiscal polices it increases, in general, the disposable income of its constituents by increasing payments to persons or by reducing taxation. The cost of these policies comes when the local government has to adjust its accounts to repay the spent resources. As in most situations, this kind of cost overwhelms the initial benefits and it is probable that $L_3 > L_1$. But, if the central government helps the local government, the latter will have the initial benefits without bearing full costs, and thus $L_2 > L_3$ is a strong possibility.

On the side of the federal government, the payoffs are less direct. On the one hand, it is more or less obvious that C_3 is greater than C_2, i.e., the best situation from the point-of-view of the federal government is that in which the local government adopts responsible fiscal polices and the central government does not suffer pressure for bailouts. On the other hand, several factors may determine whether C_1 is greater than C_2 or not. In a once-for-all game, the possibility that $C_1 < C_2$ is greater because it is probable that events that affect local government negatively have also a negative effect over the central government. Thus, political pressures, the media, the complaints of voters and so on, may lead the central government to a financial

Figure 2.1: Inman's Default-Bailout Game



bailout of a troubled local government. But if the game is repeated, the federal government might consider the reputation effect of a non-bailout strategy even if the state had chosen irresponsible polices. In this case, a reputation for not helping poorly administrated jurisdictions may avoid poor administration in the first place.

Other authors also explored the concept of SBC in the relationship of distinct government tiers. Wildsin (1997) develops a model in which the probability of help from the central government to local government is influenced by the size of the latter. Thus, larger jurisdictions would have a greater chance of being bailed out. This happens in his model because of the existence of externalities. The federal government helps the larger jurisdictions not only because of its concern with the wellbeing of the residents of those localities but also because of the negative impact

on the other jurisdictions. This is the "too big to fail" case.

The model developed in Goodspeed (2002) is in the same spirit but used for a politically motivated federal government. In this model, the regional governments decide first (and simultaneously) how much they will spend and borrow. Afterwards, the central government will distribute grants in order to maximize the probability of being reelected. As first movers, regional governments use backward induction in order to maximize their own individual welfare. In this process, regional governments must determine the reaction function of the central government in order to take advantage of the situation. As the regional governments move simultaneously, the result is a sub-optimal Nash equilibrium in which the overspending and overborrowing of the regional government will be financed by an increase in the federal tax rate and a distortion between public good consumption (too high) and private good consumption (too low).

All these studies of the SBC have at least one common point. The SBC generates an inefficient outcome. Thus, the research agenda in this field seems to be based on three lines of action. First, the empirical methods used to detect the existence of the SBC in distinct situations must be improved. This line of research is needed since the mere existence of a theoretical *rationale* for the SBC does not imply its presence in real situations. Second, federations are institutions themselves; moreover their functioning is guided by institutional rules. Thus, it is necessary to identify which institutional mechanisms facilitate the existence of the SBC in federation relationships. Third, once the presence of the SBC has been detected in a federation and its source has been established, it would be desirable

in most of cases to reform the system. Thus, the design of institutional mechanisms that embody a harder budget constraint is another important point in the research agenda of this field.

Chapter 3

Economic Aspects of Brazilian Federalism

3.1 Overview

The purpose of this chapter is to give a brief overview of Brazilian federalist institutions and processes and to connect them to the theoretical model of the next chapter. Every theoretical model is a simplification of reality, but when one is trying to analyze the particular situation of a country the assumptions made must be compatible with the peculiarities of the studied country. For example, if someone is studying the US presidential elections, he must recognize that in this country the electoral votes come from the states and not from the individual voters and that implies that voters in different states have different voting weights.

Brazil is an interesting country for a number of reasons. First of all, the country is not yet in an institutional equilibrium, which means that a substantial number of institutional changes have yet to be made. Furthermore, some of the existing institutions generate so many economic distortions that the task of understanding why they actually exist is a challenging one.

In this chapter, four broad issues of Brazilian federalism are discussed: the Brazilian revenue system, the sharing of federal resources among states and municipalities, the evolution of the Brazilian state debt, and the political process of the Brazilian legislative power. Of course, there is no intention of discussing all aspects

of these subjects. The goal here is to present information about the Brazilian case sufficient to enable the reader to follow the theoretical modelling strategy and the empirical estimation of the next two chapters.

3.2 Expenditure Functions by Government Layer

The division of expenditure functions by government layer in Brazil has followed closely the political environment of the country. During the military regime, which was established in 1964 and lasted until 1986, the central government was responsible not only for all expenditure planning but also for most of the implementation. States and municipalities played a secondary role during this period and most of them could be considered mere local branches of the federal government.

The total dominance of the federal government was reflected in both political and economic spheres. On the political side, the federal government had a major weight in the election of the state governors. The electoral law allowed the central government to impeach opposition candidates if they were considered too leftist. Besides, most of the major Brazilian cities were considered "national security areas" and their mayors were appointed by the central government.

On the economic side, states and municipalities were completely dependent on resources from the federal government. Both low levels of local taxation and expenditure autonomy created a situation in which the role of the local government was restricted to elementary education (municipalities) and public security (states).

With the end of the military regime, devolution movements accompanied the

pressure for more political liberty. The 1988 Brazilian Constitution somehow satisfied both demands. On the political front the new Constitution reestablished democracy while in the economic sphere it created new local taxes as well as increasing the participation of the states and municipalities in the federal tax collection[1]. This increase in resources available to local governments was not followed by a corresponding increase in their expenditure responsibilities. On the contrary, federal government expenditure functions were increased in relation to local functions, since most of the new humanitarian rights recognized by the new Constitution were placed under federal responsibility.

This situation, which could be considered by local governments as an opportunity to consolidate their autonomy from the central government, was clearly missed. Instead of taking over expenditure areas in which the Constitution was indefinite or ambiguous, local governments rushed to increase their payrolls. In most cases the hiring of new civil servants was unnecessary; it was done on a massive scale in order to consolidate political spheres of influence.

Brazilian government payrolls are very inflexible. Public servants cannot be dismissed, and their wages have a steady rate of growth which is not correlated with their performance. Thus, this massive hiring of public servants had a great impact on local government finances and consequently on their expenditure capacity when, for a number of reasons, local government revenues began to shrink.

Among the various reasons for this fall in local revenues, two deserve to be

[1]For a complete description of the changes in the tax structure promoted by the 1988 Brazilian Constitution see Rezende (1995).

mentioned. First, the recession that hit Brazil in the beginning of the 1990's led to a sharp decline in local government revenues as well as in the federal revenue to be shared with states and municipalities. Second, the federal government began to implement a strategy of collecting revenues which were not constitutionally shared with states and municipalities, thus reducing the participation in shared revenues.

The issue of debt temporarily accommodated the financial difficulties of the states and municipalities, but in the long run it restricted even more the expenditure capacity of the local governments. Furthermore, as most of the local debt is held by the federal government, it has tried to control local government expenditures for the sake of the debt service. Naturally, this whole process implies less autonomy for local governments.

In spite of the financial restrictions on local governments, their political power combined with decentralization needs in the provision of some public goods and services have allowed some room for local government expenditure. Nowadays, they are concentrated in projects with high electoral visibility and in programs in which there are matching grants from the federal government like health and education.

The final configuration of the expenditure assignments by government layer that emerges from the process described above may be summarized as follows. First, in spite of the financial problems faced by local governments, the political pressure for devolution that occurred after the fall of the military regime succeeded in increasing the expenditure role of states and municipalities. In year 2002 local governments were responsible for some 40% of the total government expenditure (municipalities 13% and states 27%).

Second, as the process has evolved in a non-coordinated way, most of the expenditures are overlapping. Table 3.1 shows the expenditure by function at the federal level. It is worthwhile to notice that Brazilian budgetary classification has 28 functions here aggregated into only 10.

Table 3.1:

Federal Expenditure by Category in Millions of Dollars: Brazil 2002

Category	Value	% Federal	% Category
Debt Service	68,167	45.3	78.17
Social Security	47,321	31.5	83.93
Health	8,708	5.8	41.09
Administration	6,825	4.5	31.00
Infrastructure	5,917	3.9	50.48
Defense	4,774	3.2	99.81
Education	4,700	3.1	18.49
Agriculture	2,789	1.9	58.81
Public Welfare	895	0.6	10.96
Housing	243	0.2	3.51
Total	150,340	100	60.48

Source: Federal Treasury Secretariat.

The function "Administration" includes the three branches of the government (executive, legislative and judiciary) in each level. It can be seen as a measure of

government efficiency: the smaller its participation in the total expenditure, the more efficient the government. Note also that federal outlays account for more than 60% of the total government expenditure[2].

Due to the huge National debt, financial expenditure (Debt Service) consumes 45% of the federal resources. The second largest item is "Social Security" which takes 31.5% of the federal resources. In the other functions, excluding "Public Welfare" and "Housing", the federal government expenditure is a significant part of the total despite the lower weight they have in the federal expenditure. This profile indicates that, although federal government resources are largely consumed by debt service and social security payments, they still are important in financing other functions.

Table 3.2 describes the state expenditures (26.73% of the total by functions). Although "Debt Service" is also the principal component of state expenditure, it can be seen that states have a more equalized pattern of expenditure than the central government. Their role is relevant in all functions but "Defense", and it is of fundamental importance in such functions as "Education", "Public Welfare" (which includes public security) and "Infrastructure".

Table 3.3 provides a profile of municipality expenditure. It represented 12.78% of the total government expenditure in 2002 and was very concentrated in "Education," "Health" and "Housing" while having important participation in "Infrastructure" and "Agriculture".

[2] All amounts in this text will be converted from Brazilian Reais to US dollars by the annual average selling rate provided by the Brazilian Central Bank.

Table 3.2:

State Expenditure by Category in Millions of Dollars: Brazil 2002

Category	Value	% State	% Category
Debt Services	17,599	26.5	20.18
Education	12,440	18.7	48.95
Administration	9,611	14.5	43.66
Public Welfare	7,056	10.6	86.40
Social Security	6,435	9.7	11.41
Health	5,936	8.9	28.01
Infrastructure	4,393	6.6	37.47
Housing	1,590	2.4	22.92
Agriculture	1,391	2.1	29.32
Defense	0	0.0	0.00
Total	66,450	100.0	26.73

Source: Federal Treasury Secretariat.

3.3 Revenue Matters

The Brazilian revenue system is composed of federal, state and municipal taxes which totaled almost 130 billion dollars in 2002. The share of each level of government has been stable in recent years with federal taxes accounting for approximately 63% of the total national tax revenue in that year, state taxes for

Table 3.3:

Municipality Expenditure by Category in Millions of Dollars: Brazil 2002

Category	Value	% Municipal	% Category
Education	8,275	26.0	32.56
Health	6,550	20.6	30.90
Administration	5,579	17.6	25.34
Housing	5,105	16.1	73.57
Social Security	2,622	8.3	4.65
Debt Services	1,440	4.5	1.65
Infrastructure	1,412	4.4	12.05
Agriculture	563	1.8	11.87
Public Welfare	216	0.7	2.64
Defense	9	0.0	0.19
Total	31,771	100.0	12.78

Source: Federal Treasury Secretariat.

32% and municipal taxes for 5% of the total. Table 3.4 shows the temporal pattern of the Brazilian tax revenue by government level.

Table 3.4:

Tax Revenue in Billions of Dollars by Government Layer and by Year: Brazil 1998 to 2002

	Federal		State		Municipality		
Year	Revenue	(%)	Revenue	(%)	Revenue	(%)	Total
1998	114.75	63.7	56.43	31.3	8.86	4.9	180.04
1999	83.48	62.5	44.08	33.0	5.98	4.5	133.54
2000	96.69	63.4	47.75	31.3	8.09	5.3	152.52
2001	83.68	62.6	43.31	32.4	6.75	5.0	133.74
2002	83.20	64.0	40.29	31.0	6.44	5.0	129.93

Source: Federal Revenue and Customs Secretariat and National Treasury Secretariat.

At the federal level, as can be seen in Table 3.5, 40.15% of the total tax revenue came from income taxes in 2003 (personal or corporate), 28.13% from corporate gross revenues, 12.92% from consumption, 10.06% from financial transactions and 8.74% from other sources including property taxes and delayed tax payments.

Thus, a big share of Brazilian tax revenues is income based or related to bases that are proportional to income, as in the case of financial transactions and corporate revenues[3]. Consumption taxes account for 11.91% of the total collection. As there

[3] As strange as it may seem the CSLL and the COFINS are not specifically utilized for the

Table 3.5:

Federal Tax Revenue in Millions of Dollars and Economic Incidence by Type of Tax: Brazil 2003

Tax	Source	Revenue	% Total
Income Tax (IR)	Personal and corporate income	30,225	34.03
Social Security Contribution over Net Profit (CSLL)	Corporate income	5,442	6.13
Contributions for Special Programs (PIS/PASEP)	Gross revenue	5,633	6.34
Social Security Financing Contribution (COFINS)	Corporate gross revenue	19,355	21.79
Industrialized Product Tax (IPI)	Consumption	6,393	7.20
Imports Tax	Consumption	2,646	2.98
Tax over Petroleum Derivatives (CIDE)	Fuel consumption	2,436	2.74
Financial Transaction Tax (CPMF)	Financial transactions	7,489	8.43
Credit Operation Tax (IOF)	Credit operations	1,446	1.63
Tax over Rural Property (ITR)	Property	95	0.11
Contribution for the Public Servant Social Security Plan	Various	1,447	1.63
Contribution for Enhancement of Fiscal Performance (FUNDAP)	Various	105	0.12
Other Revenues	Various	6,113	6.88
Total Tax Revenue		88,825	100.00

Source: Federal Revenue and Customs Secretariat.

will be no savings in the model of the next chapter, consumption will be considered proportional to income and thus, consumption tax collection will depend on income. As property taxation is negligible at the federal level, it will be assumed that income is the only tax base available to the federal government.

In the case of states, consumption taxes play a major role (see Table 3.6). In 2003 more than 80% of the total state tax revenue came from the state consumption tax (ICMS). This tax is a value added tax and it is origin based. This means that the producer state collects the tax independently from where the good is going to be consumed. Thus, when a retailer from Amazonas buys something from a São Paulo wholesaler, the tax is collected by the São Paulo state government, in general, 18% of the sale value. Amazonas state government will only collect the tax over the difference between the retailer buying and selling price[4].

This system causes various types of inefficiencies in the national economy. First, producer states have an incentive to raise the tax over the efficient level, because they underestimate the marginal cost of doing so, since another state's consumers will pay the bill. Second, consumer states have an incentive to decrease the ICMS tax rate in order to attract business. This process, known in Brazil as "Fiscal War", is in part possible because states expect to be helped by the Federal government. In this case, the soft budget constraint faced by state governments is directly linked to the fiscal war. Administrative inefficiencies are also important in

Social Security system financing as may appear in table 3.3. This table does not include the "true" Social Security financing tax.

[4] One of the few exceptions to this rule is the petroleum derivative products, for which a federal law requires that the consumption tax be charged in the destination state.

this system; each state must keep checking posts in their borders to make sure that the out-of-state merchandize has paid taxes.

Table 3.6:

Aggregated States Revenue in Millions of Dollars and Economic Incidence by Type of Tax: Brazil 2002

Tax	Source	Revenue	% Total
Tax over Consumption (ICMS)	Consumption	32,877.4	81.6
Income Tax	Income	1,170.2	2.9
Tax over Automobiles (IPVA)	Property	2,217.8	5.5
Benefit Taxes	Various	3,866.5	9.6
Bequest Tax	Property	162.8	0.4
Total Tax Revenue		40,294.8	100.00

Source: National Treasury Secretariat.

In light of these data, states' taxes will be assumed to be proportional to consumption. One difficulty that arises within this approach is that, as the state consumption tax is origin based, tax collection in a given state depends on the consumption of all other states. Thus, in order to correctly endogenize state tax collection, one must establish a state tax revenue function which would be dependent on all other states income.

The municipal tax base is much more diversified. As Table 3.7 shows, in year 2002, 40.4% of the total municipal tax revenue came from property taxes, while

39.1% came from the consumption tax, 11.9% from taxes levied on business and 8.7% from income tax.

Table 3.7:

Aggregated Municipalities Revenue in Millions of Dollars and Economic Incidence by Type of Tax: Brazil 2002

Tax	Source	Revenue	% Total
Tax over Services (ISS)	Consumption	2,521.8	39.14
Tax over Urban Property (IPTU)	Property	2,125.5	32.99
Income Tax	Income	558.1	8.66
Municipal Service Contribution	Business tax	548.7	8.52
Bequest Tax	Property	456.3	7.08
Contribution to Police Department	Business tax	209.9	3.26
City Improvement Contribution	Property	22.0	0.34
Total Tax Revenue		6,442.3	100.00

Source: National Treasury Secretariat.

This diversity in the municipal tax base would require a much more complex approach for municipal tax revenues. In particular, municipal budget constraints would have to include several elements in order to capture the diversity of tax bases. But, since total municipal tax revenue is quite small in relation to other government level collections, the former is going to be neglected in the model of the next chapter.

3.4 Grants to States and Budgetary Execution

Regional disparities in Brazil are one of the greatest problems in the country and have been described as one of the greatest in the entire world [see Rodden (2003) and UNPD (2003)]. This undesirable situation and the policies that should be adopted to solve it have been one of main themes in Brazilian politics during the last decades.

The proposed policies to solve, or at least to reduce the problem, range from measures to increase the competitiveness of the poorest states, like increased autonomy in setting their preferred tax levels, to direct redistribution of resources made through the constitutional participation (equalization) funds.

The equalization funds have been a central feature of Brazilian federalism, but unfortunately their success in decreasing regional disparities in Brazil is very limited [see Rodden (2003)]. One of the central questions of this work is why? Our hypothesis is that the federal government offsets the effects of the equalization funds by compensating states and municipalities that are net contributors to those funds with voluntary grants and discretionary resources.

The two main funds are the Participation Fund of the States (FPE) and the Participation Fund of the Municipalities (FPM). The main financing sources of these funds are the Federal Income Tax (IR) and the Federal Tax over Industrialized Products (IPI): 22% of the total collection of these taxes goes to the FPE and 22.5% goes to the FPM. As these shares are stipulated by the Constitution, the amounts received by states and municipalities may be regarded as exogenous, since

the federal government has no discretionary power over them. Because of this, in the next chapter these equalization funds will be aggregated and treated as exogenous. It will be also assumed that the budgets for these funds are always balanced. This eliminates the need for writing an equation for them.

The FPE was conceived to reduce both state and regional[5] inequalities. In order to tackle the latter, 85% of the total amount of the fund is split among the states of the poorer regions (Midwest, Northeast and North), which embrace 20 states, and the remaining 15% among the 7 states of the richer regions (South and Southeast).

The other sharing criteria are the reciprocal of the state per capita income, the total population of the state and the state geographical area, since big states are supposed to have more expensive infrastructure needs.

In the year 2001, FPE distributed more than 6 billion dollars to Brazilian states, which accounts for 1.2% of the country's GDP. The recipients of the largest transfers were Bahia (US$ 573 millions), Ceará (US$ 447 millions), Maranhão (US$ 440 millions) and Pernambuco (US$ 421 millions), all of them from the Northeast (poorest) region.

A statistical evaluation of the FPE for year 2001[6] is described by the estimated regression equation below, where FPE_i is the total amount in dollars received by state i from the fund in 2001, $PCYS_i$ is per capita income of state i in that year also

[5] Brazilian territory is formed by 27 federative units (26 states and the Federal District, which contains the National capital) and 5 regions (South, Southeast, Midwest, Northeast and North).

[6] The utilization of data from 2001 is due to the fact that this is the last year to which information about states GDP is available.

measured in millions of dollars, $FPOP_i$ is a population factor[7] related to state i in 2001, which is measured in terms of percentage of the total population, $AREA_i$ is the state's geographical area in square kilometers and $REGIO_i$ is a dummy variable equal to 1 if state i is in region North, Northeast or Midwest and zero otherwise. The equation shows the t-statistics below the estimated coefficients.

$$FPE_i = \underset{(1.6)}{124.8} - \underset{(4.4)}{58.9}\ PCYS_i + \underset{(4.3)}{33.9}\ FPOP_i - \underset{(-0.1)}{3.33}\ AREA_i + \underset{(3.0)}{155.3}\ REGIO_i$$

$R^2 = 0.71$

With the exception of the criterion related to the geographical area, the distribution of the fund follows the original spirit of the law. The FPE amount received by a state is negatively related to its per capita income; more precisely, each additional dollar in a state per capita income costs 58.9 thousand dollars in FPE funds. This means that, if the per capita income of some state grows by 100 dollars, its revenue from FPE decreases 5.89 millon dollars, according to the sharing criteria.

In the case of the population the relation is positive. The equation above says that each percentage point in the total country's population earns more than 33 million dollars for a state. Thus, each 1% of the total population entitles the state to receive 0.55% of the funds' money.

The geographical area was included in the equation because it was one of the

[7] The distribution of the FPE is not meant to be strictly proportional to the population itself; states with less that 2% of the total population of the country receive more than their population share, while states with more than 5% of the total population receive less. In the case of the FPM the same principle is applied and there is also a differentiation between states' capitals and other municipalities.

criteria established in the original fund law. Nonetheless, as can be seen in the estimated equation above, it is not statistically significant in the sharing of the FPE resources. The FPE has an interregional distributive role, though. A 155 million dollar bonus was given to states of the poorest regions (North, Northeast and Midwest).

The FPM is the municipal version of the FPE. In the year 2001 it distributed 5.251 billion dollars to 4,601 municipalities[8], which accounts for a little more than 1% of Brazil's GDP.

Some modifications are needed in order to perform an evaluation of the FPM in year 2001. First, the FPM is legally structured to give an extra benefit to capitals. This feature is accommodated by the introduction of a dummy variable (CAP), which assumes a value of one if the data refer to a capital city and zero otherwise. Second, as the variable $AREA$ has no legal role in the distribution of the fund, it was removed from the equation. The estimated equation is shown below:

$$FPM_i = \underset{(-0.8)}{-36.5} - \underset{(-4.3)}{157.67}\ PCYM_i + \underset{(58.9)}{1.2}\ FPOP_i + \underset{(117.2)}{22.9}\ CAP_i + \underset{(0.2)}{6.8}\ REGIO_i$$

$R^2 = 0.79$

The regression analysis shows that the FPM does not redistribute regionally or it does so in a very weak way, since the $REGIO$ variable, defined in the same way as above, is not significant at the 5% level. But the FPM does redistribute to the poorer cities as indicated by the negative coefficient associated with the variable

[8] Actually, there were 5,506 municipalities in Brazil at that year, but some of them did not receive their share in the FPM because they had some irregularity in their fiscal accounts.

$PCYM$ (per capita municipal income). Each additional dollar in municipal per capita income costs that city 157.67 dollars in FPM funds. This means that an increase of 100 dollars in the per capita income of some city will reduce its FPM revenue in by 1.58 thousand dollars, everything else constant.

The population factor is relevant in the distribution of the FPM since the coefficient related two $FPOP$ is significant and greater than zero. Furthermore, the dummy variable CAP shows that capital cities have a 22.9 million dollars bonus.

The regression equations have a high degree of explanative power which suggests that the funds have been distributed roughly in accordance with the legal parameters. As the fund is fulfilling its role, the possible explanation for the persistence of regional and state inequality must come from elsewhere[9]. One could argue that the funds are not well designed since they create the wrong incentives for poor states and municipalities; once they have a guaranteed funding source, they may not choose the appropriate tax policies which could provide the necessary infrastructure for local development.

Another possible reason is that there is no point in creating an equalization fund if the federal government compensates the net donors of such funds by using other types of transfers. At first one could argue that the voluntary transfers are not large enough to play this anti-redistributive role, since they sum up to 1.6 billion dollars in 2003 which corresponds to only a little more than 13% of the 12.3 billion dollars of the FPE and FPM together. Furthermore, these voluntary

[9] Although the FPM does not have a direct regional redistribution effect, it has a local income redistributive effect, which should help to reduce regional disparities since the poorest cities are in general located in the poorest regions.

transfers made by the federal government to states and municipalities also have had an income redistributive character since poor states receive a big share of them. For example, North, Northeast and Midwest states had in 2003 approximately 43% of the total Brazilian population but received more than 61% of the total federal voluntary transfers[10].

The problem with this line of argument is what are called voluntary transfers. The figures computed above include only what is officially denominated "Voluntary Federal Transfers to States and Municipalities", but these transfers are only a small part of the resources that may be discretionally transferred from the federal government to lower layer governments.

Indeed the main source of voluntary federal resource transfers is directly linked to the liberation of funds of the federal budget. The Brazilian spending process allows the executive branch to make rescissions and deferrals of budgetary resources without the approval of the parliament. This means that magnitudes indicated in the budget are upper limits to federal government spending, but the central government is not required to spend all the subscribed amounts. Table 3.8 compares the actual expenditure with the amounts previously budgeted.

Often rescissions are made according to policy objectives. For example, if the central government and the International Monetary Fund make an agreement for a new and greater target for the primary surplus, the federal government may cut parts of the budget without consulting the congress in order to obtain the new level of surplus.

[10] Source: National Treasury Secretariat.

Table 3.8:

Federal Budget by Object Class. Outlays in Billions of Dollars: Brazil - 1995 to 2003

	Object Class							
	Personnel Services and Benefits		Contractual Services and Supplies		Acquisition of Capital Assets		Interest, Dividends and Debt Repayment	
Year	Outlays	%Budget	Outlays	%Budget	Outlays	%Budget	Outlays	%Budget
1995	41.37	96.01	84.84	85.85	12.51	49.59	122.98	60.63
1996	40.73	97.25	92.01	81.97	19.08	67.78	135.71	92.07
1997	41.34	96.51	98.18	89.08	67.49	57.98	156.03	65.78
1998	41.34	97.90	103.81	93.08	68.72	89.21	217.27	79.99
1999	27.93	97.45	69.66	92.93	18.41	48.36	188.21	90.33
2000	31.21	96.80	79.13	92.18	7.76	44.57	209.38	48.66
2001	27.13	96.65	71.90	93.07	8.62	41.98	139.06	47.92
2002	25.24	97.85	68.80	92.90	7.99	48.65	122.84	97.12
2003	25.50	98.98	74.21	93.04	5.71	31.59	169.52	72.50
2004	30.22	97.89	91.30	94.16	8.10	32.92	174.05	47.99

Source: Federal Budget Secretariat.

The resource liberation power is also often used for leverage in parliamentary negotiations. A typical situation in Brazilian political life is the governor of a state, or some of its representatives, asking the federal treasury secretary or the finance ministry to underwrite some federal project that benefits that particular state.

It is true that not all budgetary items are so vulnerable to political influence.

For example, "Personnel Services and Benefits" is mandatory. Public servants in Brazil have a constitutional guarantee that they will not be laid off or have their wages reduced. In this way the budget must be observed precisely with respect to this class of spending. This means that, from the point of view of the federal government, wages and benefits to public servants are fixed and compulsory. From the point of view of the states, they are federal transfers since some states have many more federal personnel than others[11]. In the empirical exercise in Chapter 5, this item will be added to the constitutional funds in order to form what will be called "Compulsory Transfers".

The items "Contractual Services and Supplies" and "Acquisition of Capital Assets" are different since the process of execution of the budget gives to the federal government complete discretion over these types of spending. Because of this, they will compose, together with the "Voluntary Grants", the "Discretionary Resource Transfers" which will be the federal government reaction function in the model in Chapter 4 and the endogenous variable in the estimation in Chapter 5.

The "Interest, Dividends and Debt Repayment" will be considered neither in the modeling chapter nor in the estimation since it is virtually impossible to assign the regional distribution of this item.

The approach utilized in this work is somewhat different from that found in Rodden and Arreteche (2003). They used total transfers and total discretionary transfers as endogenous variables, but in both cases they did not consider the com-

[11] For example, in the year 2001 the spending with federal personnel in Rio de Janeiro State is 1.8 billions dollars, while in São Paulo State it is 0.7 billions dollars, although São Paulo has more than two times Rio de Janeiro population.

pulsory transfers as an exogenous variable. By not doing so, they are not able to disentangle the adjustment process made by the federal government in the transfer system.

3.5 State Debts and Bailouts

The management of the state and municipal debts has been a major problem not only for the proper functioning of Brazilian federalism, but also for the stabilization of the National economy as a whole. The successive bailouts and an eventual open default have hurt both Brazilian federalism and the economy through at least two main effects.

First, they create a negative incentive for states and municipalities because they encourage them to take on more debt and to default. Second, as the federal government has issued bonds in order to buy back state debt, the central government will have to pay this new debt service with its own resources which implies an additional burden for the federal government if states default.

Brazilian federative unit debts are very peculiar in a number of aspects. First of all, they are primarily composed of intergovernmental debt. The federal government holds 84% of the total state and municipality liabilities which have reached around 130 billion dollars in 2003, which corresponds to 25% of that year's National GDP. The central government became their main creditor because it switched state and municipality debt for its own bonds in order to preserve private investors from state debt default.

A second aspect of the intergovernmental debt in Brazil is that it is highly concentrated. The four greatest debtors, coincidentally or not, the four largest states, accumulate more than 65% of the total debt, which is proportional to state GNP but not to their populations.

Another interesting fact about the intergovernmental debt in Brazil is that it grows basically because defaulting states are able, in general, to attach the unpaid services to the principal. As observed by Rodden (2004), Dillinger (1997) and Afonso e de Melo (2000), the efforts of the Cardoso[12] administration to prevent new borrowing by state governments were partially successful. The legislation has evolved in order to make it more difficult for states and municipalities to have access to new money.

The first step in this direction was the prohibition for states to contract debt from their own banks in 1992. This law was issued after a debt crisis in which the states ceased paying the loans contracted from their own banks. As the default could hurt the private sector, since the states banks needed those payments in order to honor their own obligations, the federal government was compelled to act. After this episode, the central government has issued more rules in an attempt to prevent new debt and to combat the bad incentives states and municipalities face. This effort has culminated with the adoption of the "Fiscal Responsibility Law,"[13] which may seriously penalize gubernatorial and other executive officers at state and municipal levels if they violate the law.

[12] Fernando Henrique Cardoso, former Brazilian president. Elected for his first term in 1995, reelected for more four years in 1999.

[13] Supplementary Law 101, edited on May 04, 2000.

It is interesting to notice that the set of laws and regulations to discipline state and municipality debt activities has had little effect on the already existing debt which in most cases has been renegotiated in favor of the debtors. This observation leads to the last point to be highlighted about Brazilian intergovernmental debt. Most Brazilians, including some Federal and state officials and legislators, consider the debt impossible to pay. The state debts alone add up to 100 billion dollars[14] which corresponds to 179% of their net current revenues. The situation is worse for the major debtors, São Paulo, Rio de Janeiro, Minas Gerais and Rio Grande do Sul, where this proportion is greater than 200%. Moreover, these four state capitals own more than 15 billion dollars of debt alone.

This belief that the intergovernmental debt is not payable changes the nature of the debt. One can view it as a perpetuity in which the principal will never be repaid. From this perspective, renegotiations and bailouts of the state and municipality debt are indeed negotiations that have the explicit objective of increasing the spending resources to these federation units.

The modeling strategy in this case will be to consider only service payments in state budget constraints, since the principal will not be repaid and will be considered a perpetuity. Under this approach, any reduction in the debt service payments or interest capitalization corresponds to a reduction of the implicit interest rate over the state debt. There are two advantages of this approach: empirically, it does not require the use of data about each government debt which would be very hard to obtain in the case of the municipalities, and theoretically it avoids an intertemporal

[14] Brazilian Treasury Secretariat, December 2003.

model which may not produce clearly testable hypotheses.

3.6 Political and Legislative Issues

Brazil is a presidential republic in which the legislature is divided into two houses. The lower house, the "Câmara dos Deputados", is equivalent to the US "House of Representatives" and performs a similar role, with 513 representatives from the 26 states and from the Federal District. Each one of them has a four year term; and there are no term limits. One of the characteristics of the lower house is that the number of deputies by state is not meant to be proportional to the population; less populated states have proportionally more representatives than the more populated states.

For example, São Paulo State has a population of nearly 39 million people, which are represented by 70 deputies. This means that each deputy from that state represents around 553 thousand citizens (or 367 thousand voters from that state). The situation of the Northern state of Roraima is quite different. In that state 357 thousand citizens are represented by 8 deputies which produces a ratio of one representative for less than 45 thousand people (or 26 thousand voters).

The sub-representation problem is aggravated still further in the upper house, the "Senado Federal". In this chamber, each state has three seats independently of its population. There are two types of senators, which only differ from one another by the length of their term. Two thirds of them have an eight year term, while the remaining one third have a shorter four year term.

Senators have, in general, important links with their origin state's executive branch. As observed by Samuels (2000, 2003) the majority of the senators in Brazil were (or wished to be) state governors and many of them helped to elect their successor before becoming congressmen. As pointed out by Rodden (2004) this intimate relationship of the senators with the state governments creates an environment in which the Senate has major obstacles in performing its constitutional function of supervising state and municipality debt.

An important characteristic of the Brazilian legislature is that congressmen, both deputies and senators, have a lower level of party fidelity. They tend to be more loyal to their own state's interests or to their direct voters than to ideology or party decisions [see Rodden and Arreteche (2003)]. This pattern of political behavior has been explained by historical circumstances [Schwartzman (1982)] and by the analysis of the Brazilian electoral legislation, which favors this type of behavior since there is no penalty for voting against party orientation or for party switching even after elections.

The relationship of the Congress with the executive branch is quite tight in Brazil. On the one hand, the executive may punish or reward individuals or groups of congressmen by authorizing or withholding expenditures in their interest, or by hiring or rejecting their political allies for public positions. On the other hand, Congressmen may vote for or against the government's proposals.

Because of these facts, governance in Brazil is a difficult process. Even if the party of the president has a robust majority in the Congress, which is an unlikely situation, the executive does not have automatic control of the legislative process,

since it has to build coalitions with regional representatives in order to approve its bills.

For most of the projects the executive needs a simple majority for approval. However, constitutional amendments need a super-majority of two thirds and must be voted in two rounds by both houses. The executive branch has expended much effort on changing the Constitution in order to improve economic performance since some of its articles lead to economic distortions. Thus, although Brazil is not a parliamentary country, the Brazilian president may become very weak if he does not satisfy the appetite of the congressmen for regional programs.

If the federal government needs the votes of the states' representatives, it may try to co-opt them by distributing discretionary resources. As congressmen tend to vote in groups by state, this distribution of resources may be related to the decisiveness of each state in this process. This feature will be dealt with in the next chapter's model by the introduction of pivotal probabilities [see Seabright (1996)].

The pivotal probability of each state is a measure of how likely the support of its congressmen will be decisive to obtain parliamentary approvals; i.e. what is the probability that the federal government will regret not having the support of a given state. Conceptually, the pivotal probability of a given state is the difference between the probability that the central government obtains a congressional majority with the support of the state in question and the probability that it obtains a majority even without the support of that state.

Brazil has 27 federation units (including the Federal District) and each of them may vote for or against the federal government. In order to calculate the pivotal

probability of a state, it is necessary to enumerate each possible combination of states votes (there are $2^{27} = 134,217,728$) and to count those combinations in which the federal government obtains a victory with the state support and those combinations in which the federal government wins in spite of the state opposition. Subtracting the latter from the former and dividing the result by the total number of possible combinations, one obtains the pivotal probability of the state. Of course each state has a different number of representatives and voters and this difference must be considered when calculating the winner combinations. The algorithm for calculating Brazilian states pivotal probabilities is described in Appendix A, while Table 3.9 shows the political representation and power of each Brazilian state, including the pivotal probabilities as a measure of state representative decisiveness.

In the calculation of the pivotal probabilities , it is assumed that states have no ideological preferences, i.e., their vote is totally based on the satisfaction of their own preferences for goods and services. It is clear that if the federal government takes into consideration state pivotal probability when deciding about resource redistribution, it is acting not as a purely benevolent central planner, but as a self-interested agent. If the government is self-interested, principal-agent problems may arise. In the econometric exercise of Chapter 5, the self-interested government hypothesis will be tested. In Chapter 4 we will examine the consequences of a principal-agent problem in this context.

Table 3.9:

Population, Voters and Seats in Congress by State: Brazil 2002

State	Population in Thousands	Voters in Thousands	Seats in Congress	Inhabitants by Seat	Voters by Seat	Pivotal Probability
São Paulo	38,178	25,656	73	522,983	351,446	0.2222
Minas Gerais	18,344	12,681	56	327,563	226,439	0.1606
Rio de Janeiro	14,724	10,214	49	300,499	208,439	0.1389
Bahia	13,323	8,569	42	317,219	204,014	0.1175
Rio Grande do Sul	10,409	7,352	34	306,134	216,239	0.0943
Paraná	9,798	6,663	33	296,909	201,921	0.0914
Pernambuco	8,085	5,397	28	288,738	192,738	0.0773
Ceará	7,655	4,805	25	306,181	192,210	0.0687
Pará	6,454	3,818	20	322,684	190,899	0.0548
Maranhão	5,803	3,569	21	276,344	169,968	0.0576
Santa Catarina	5,528	3,392	19	290,932	178,517	0.0520
Goiás	5,210	3,366	20	260,517	168,292	0.0548
Paraíba	3,495	2,322	15	232,993	154,805	0.0409
Espírito Santo	3,202	2,146	13	246,286	165,110	0.0355
Amazonas	2,962	1,917	11	269,255	174,307	0.0300
Piauí	2,898	1,848	13	222,940	142,176	0.0355
Alagoas	2,888	1,730	12	240,628	144,169	0.0328
Rio Grande do Norte	2,853	1,600	11	259,344	145,463	0.0300
Mato Grosso	2,605	1,525	11	236,795	138,612	0.0300
Distrito Federal	2,146	1,518	11	195,076	138,040	0.0300
Mato Grosso do Sul	2,141	1,412	11	194,602	128,343	0.0300
Sergipe	1,846	1,148	11	167,822	104,358	0.0300
Rondônia	1,432	883	11	130,162	80,231	0.0300
Tocantins	1,207	785	11	109,729	71,400	0.0300
Acre	587	370	11	53,358	33,617	0.0300
Amapá	517	290	11	46,956	26,373	0.0300
Rorâima	347	209	11	31,534	18,957	0.0300
Total	174,633	115,184	594	293,995	193,913	

Source: Federal Electoral Court.

Chapter 4

Discretionary Resources in the Brazilian Federation: A Theoretical Model

4.1 Models of Federative Resource Redistribution

Federative relationships among different government tiers have been a central source of economic problems, as well as an obstacle to the their solution, not only in Brazil but also in other federative Latin America countries. Conflicts between municipal, state and federal governments[1] are present in a number of aspects of these federations: which government layer is assigned to collect (or appropriate) tax revenues; how the money from privatization of state-owned enterprises should be divided between local and federal governments; what the criteria should be for voluntary grants distribution, and so on.

This chapter investigates, at a theoretical level, some of the major institutions that comprise the Brazilian federalism. In particular, it focuses on the consequences of the distribution of discretionary resources from the federal government. Discretionary resources are defined as those resources from the central government that are applied within the limits of a state or municipality without any legal or federative

[1] Throughout this chapter state and municipal governments will be aggregated as local governments. Thus, it will be assumed that all the municipalities within a state, as well as the state government, act as if they were an integrated federative unit. This assumption allows us to use a two layer government model.

obligation, i.e., those resources that are settled exclusively by federal government will. The definition of discretionary resources includes the Voluntary Grants which are cash transfers to local governments to be used at their discretion as well as all other direct application of resources made at the discretion of the federal government in the state territory.

This work is primarily concerned with the determination of the distribution of discretionary resources, in particular with the possibility that local governments may induce, by economic and political means, the federal government to increase their grants. A related question is whether or not the institutional design of the Brazilian federalism provides the right incentives to states and municipalities to be fiscally responsible. For example, do local governments face the true social benefits and costs of reducing their tax burdens? Do they have incentives to adopt a responsible debt policy?

The impact of the existing compulsory equalization grants on the allocation of discretionary resources is also a relationship to be studied in this chapter. The point here is to determine if discretionary transfers have an offsetting effect relative to the equalization grants as legally defined.

This study approaches some questions of great interest for the Brazilian federative structure. For instance, if the federal government can be induced to compensate local governments, the latter will face an SBC, since bad fiscal performance will lead to federal bailouts under the form of increased federal resource transfers. The existence of an SBC for local governments may have practical consequences for the operation of the fiscal federation. The first of them would be a low level of fiscal

responsibility. For example, if greater debt service payments by local governments are followed by greater discretionary resources transfers to them, there is a clear incentive to issue debt over what would be efficient.

In the context of the Brazilian federalism, the SBC may create benefits to states from forgoing local taxation. If the federal government compensates local governments when their tax collection decreases, the opportunity cost of an additional unit of private consumption faced by states, measured by the forgone tax collection, will be smaller than the real (collective) opportunity cost. As a consequence of this process states have an incentive to cut their tax rate even if it leads to a decline in tax collection. This process is known in Brazil as the "fiscal war" among states.

Another concern is related to the functioning of the equalization grants, which are supposed to reduce inter-regional disparities and may be seriously affected in the presence of compensatory discretionary transfers. If states that receive lower levels of constitutional (compulsory) grants are able to extract a compensatory amount from the federal government, the intended effect of those compulsory grants will be reduced.

The last objective of this chapter is to explore the existence of principal-agent problems that may arise where the interests of the federal government are not coincident with those of the federate units. Even if one accepts the existence of this kind of problem, can it explain the inefficiencies associated with the distribution of the discretionary resources among the federative units?

Thus, it is also necessary to determine if the existence of SBCs and other fiscal

inefficiencies are due to delegation problems or if they result from the design of resource transfer mechanisms. This diagnostic is important because the appropriate policies for dealing with a principal-agent problem emanating from some delegation system are quite different from those necessary to remedy a situation in which the mechanism for federal resource reallocation is not efficient.

If the federal government pursues its own interests, it will try to maximize a function that is not directly related to the states' well-being. For example, the federal government may maximize its chances of re-election or the probability of obtaining a congressional majority.

At this point a $principal - agent$ problem may arise. The federal government is supposed to use its power on behalf of the well-being of the states, but it may have its own agenda. In this case, the states (principals) delegate some decision power to the federal government (agent), but the latter may have objectives that differ from those of the former. It is necessary to examine the consequences of this federal government self-interested behavior, the magnitude of its effects over the states' well-being, and if it is a major source of inefficiencies in the model.

The existence of a principal-agent problem is to be detected by empirical investigation (chapter 5), but its consequences and its importance may be inferred at a theoretical level. Do all inefficiencies associated with a principal-agent problem vanish when a benevolent federal government replaces a self-interested one, or will such inefficiencies come from somewhere else and are merely aggravated by the principal-agent effect? The answer to this question may be used to determine the appropriate policies to improve the performance of the Brazilian federation, since

if the major inefficiency problem comes from a principal-agent problem, the better measures to deal with it (improvement of the states' control over the federal government, increase of the federal government accountability, etc.) are quite different from those necessary to correct a badly conceived federation design.

4.2 Structure of the Model

In this section, I will develop a model of the distribution of federal resources, inspired by Goodspeed (2002), in which the federal government taxes the entire population of the country and redistributes the resources accordingly to a rule that maximizes a concave sum of the utilities of the federate units. This altruistic central government is instituted because it has better information about the situation of the other units than any unit in particular. The main objective is to derive the reaction function of the federal government as well as its derivatives with respect to variables controlled by local governments.

A second model will be developed in the next section using the concept of accountability [Seabright (1996)] in order to describe the behavior of a self-interested, vote-seeking government. After obtaining the reaction function of such a government, it will be contrasted with the altruistic-government's function to determine the consequences of a principal-agent problem and their importance to the states' well-being.

The model developed in this chapter is similar to that found in Goodspeed (2002), but it has at least two important differences. First of all, it considers a

one-period problem while Goodspeed's is a two-period model. Secondly, this model specifies the reelection mechanism through which the federal government is chosen or defeated. In order to describe such a process the concept of pivotal probability is utilized [Seabright (1996)]. Pivotal probability is defined as the probability that one particular state is decisive in the electoral process.

The modifications of Goodspeed's model are driven by two main reasons: to establish a closed-form solution for the federal government discretionary grants reaction function and to define specifically the electoral process for the federal government.

There are m localities, each one inhabited by η_i $(i = 1, 2, ..., m)$ individuals with homogeneous tastes[2]. Each state has a representative agent's additive utility function, which depends on the consumption of a public and a private good and on an idiosyncratic shock, as in the equation (4.1) below, where C_i is the per capita consumption of the private good in region i, G_i is the per capita consumption of the public good in region i and $e_i \sim F[0; \sigma_i]$ is the idiosyncratic shock that occurs in region i.

$$U_i(C_i, G_i) = u_i(C_i) + z_i(G_i) + e_i \tag{4.1}$$

where $u_i', z_i' > 0$ and $u_i'', z_i'' < 0, \forall i = 1, 2, \ldots, m$.

The idiosyncratic shocks may be interpreted as a judgment made by the popu-

[2]It is assumed here that the "Tiebout process" of grouping individuals with similar tastes into communities has been already in effect. This assumption allows the utilization of the representative agent for each region.

lation over non-economic aspects of the government (for example, its foreign affairs performance or the perceived level of corruption[3]).

States do not have perfect information about the real situation of the other states. In particular, they cannot observe the realization of the shock e in the other states. Thus, they must delegate power to the federal government in order to redistribute income across states. The central government might have its own motivation and may not act in the interest of the federation, as will be seen in a later section of this chapter.

In this version, externalities are allowed neither in the public nor in the private good. Although their importance has been recognized in allocative government decisions[4], they would make the model much more complex without a corresponding gain in intuition.

Both local and federal governments provide local public goods. Federal provision is a perfect substitute for local provision[5]. The sources to finance local public good expenditures (G_i) are three: local tax collection T_i^C, compulsory grants gc_i and discretionary resource transfers gv_i from the federal government. This last category includes direct federal local public good expenditures. These sources are used not only to finance the public good provision, but also to service S_i, local perpetual debt. Taking this relation in per capita terms, one could write down the state government budget constraint as:

[3]In Brazil we humorously say that the chances of re-election of an incumbent government increase if the national soccer team performs well.

[4]See for example Wildasin (1997).

[5] This is an assumption that is not too strong for the Brazilian case, since there is a substantial overlapping of functions between government tiers in that country. See Chapter 3 for details.

$$G_i = T_i^C + gc_i + gv_i - S_i \tag{4.2}$$

Since in Brazil the main local tax is a consumption, origin based tax, per capita local tax collection in locality i, T_i^C, depends on all other states' income (besides the own state income). Let α_{ij} be the proportion of state i income that is spent on products and services produced in state j[6]. Then, state i per capita tax collection may be described as:

$$T_i^C = \frac{\tau_i}{\eta_i} \sum_{k=1}^{m} \eta_k \alpha_{ki} Y_k \tag{4.3}$$

where τ_i is the local tax rate and Y_k is the state k per capita income.

States' per capita income, Y_i are random. Each state knows its own value before acting, but it does not possess exact information about other states' income. The federal government knows the per capita income realization of all states. Thus, the federal government could operate a regional insurance system in which transfers go from the states with better income realizations to those with poorer ones.

Another constraint in the model is the one faced by private consumers in each locality. The private consumption in each locality must be equal to private income after federal and local taxes. Federal government taxes income and each state taxes consumption at a different tax rate. As there is no private savings in this model, private consumption will equal to disposable income. In this case, one could write down the following constraint for private consumption:

[6]The supposition that α_{ij} is fixed implies a perfectly inelastic consumption. This means that the consumers will bear the whole tax burden.

$$C_i = (1 - \tau_c)Y_i - T_i^p \tag{4.4}$$

where τ_c is the federal income tax rate and T_i^p is the per capita tax payments made by state i citizens to local governments. Notice that T_i^p is, in general, different from T_i^C; net exporter states will have $T_i^C > T_i^p$, while net importers will have the inverse situation.

Per capita local tax payments depend on a combination of different states' tax rates and on how much one state consumes from the others, thus:

$$T_i^p = \sum_{k=1}^{m} \tau_k \alpha_{ik} Y_i \tag{4.5}$$

The last equation to be considered is the federal government budget constraint. It establishes that, in absolute terms, the total sum of the discretionary transfers of resources must be equal to the total federal tax collection, thus:

$$\sum_{k=1}^{m} \eta_k \tau_c Y_k = \sum_{k=1}^{m} \eta_k g v_k \tag{4.6}$$

It is worth noting that there is no constraint for the compulsory grants gc_k . This is so because, as in Goodspeed (2002), they are treated as exogenous and their financing is provided by a separate fund over which neither the federal nor the state government has any control; the distribution of these funds is legally established.

4.3 Benevolent Central Planner Solution

In this section the federal government is supposed to act in accordance with the state collective will, i.e., federal government uses all available information from the localities to maximize their collective welfare. In this case, there is no principal-agent problem involved. The federal government (agent) uses all available information from the states (principals) to maximize their collective welfare.

In order to establish the first-best solution to the model, one may derive the behavior of a benevolent central planner who coordinates the actions of the federal government with those of the states. In this case, the federal government observes the realizations of each state income and chooses the values of the local tax rates (τ_i), federal tax rate (τ_c) and federal resources voluntary transfers (gv_i). This benevolent planner would solve the following problem:

$$\begin{cases} \underset{\{gv_k,\tau_k\}}{Max} : U_T = E\sum_{k=1}^{m}\eta_k[u_k(C_k) + z_k(G_k) + e_k] \\ S.t. : (4.2),\ (4.3),\ (4.4),\ (4.5)\ and\ (4.6) \end{cases} \qquad \text{(P1)}$$

The Lagrangean for this problem is:

$$\Gamma = \sum_{j=1}^{m}\eta_j\{u_j[(1-\tau_c-\sum_{k=1}^{m}\tau_k\alpha_{jk})Y_j] + z_j[gc_j + gv_j + \frac{\tau_j}{\eta_j}\sum_{k=1}^{m}\eta_k\alpha_{kj}Y_k - S_j] + e_j\} \quad (4.7)$$

Maximization produces the following set of first order conditions, $\forall i = 1, ..., m$:

$$\eta_i z_i' = \sum_{k=1}^{m}\eta_k u_k' Y_k \frac{\partial t_c}{\partial gv_i} \quad (4.8)$$

and

$$z_i' = \frac{\sum_{k=1}^{m} \eta_k \alpha_{ki} u_k' Y_k}{\sum_{k=1}^{m} \eta_k \alpha_{ki} Y_k} \tag{4.9}$$

But as, from (4.6):

$$\frac{\partial t_c}{\partial g v_i} = \frac{\eta_i}{\Upsilon} \tag{4.10}$$

where $\Upsilon = \sum_{k=1}^{m} \eta_k Y_k$, thus plugging (4.10) into (4.8):

$$z_i' = \sum_{k=1}^{m} u_k' \Upsilon_k \tag{4.11}$$

for all $i = 1, ..., m$ and where $\Upsilon_i = \frac{\eta_i Y_i}{\sum_{k=1}^{m} \eta_k Y_k}$ is the share of state i income in the national income.

This formula resembles Samuelson's condition for efficient provision of public goods, but its interpretation is somewhat different. First, observe that the public goods here are local and thus they do not preserve the characteristic of being non-rival across states; consumption in one state precludes the consumption of others. The Samuelson condition is derived from the fact that one more unit of a public good benefits all consumers and as a consequence its marginal utility must equal the sum of the marginal utilities of the private consumption good across consumers. In our model, the additional provision of the local public good z_i does not benefit any consumer outside state i. Because of this, despite the resemblance equation (4.11) is not the Samuelson condition for efficient public good provision[7].

From the system of $2m$ equations comprised of the set of equations (4.9) and

[7]As will be seen in the next section equation (4.11) holds even when the provision is not efficient.

(4.11) it is possible to determine the values for gv_i and τ_i ($2m$ values). From constraint (4.6) the federal tax rate t_c is obtained. Besides from equations (4.11) one gets, $\forall i, j = 1, ..., m$:

$$z'_i = z'_j = z' \tag{4.12}$$

We use this result to obtain a parametric solution for the set of equations (4.9). Notice that, at this point, this set of equations has m equations and m variables (the u's). This guarantees a unique solution, provided that the equations are not linearly dependent. It is easy to see that the solution to this system is:

$$u'_i = u'_j = z' \tag{4.13}$$

The conclusion is that in the totally centralized solution the benevolent central planner will equalize the marginal utilities of the consumption of the public and the private good across states, i.e., $u'_1 = u'_2 = \ldots = u'_m = z'_1 = z'_2 = \ldots = z'_m$. Given the concavity of the functions $u(\bullet)$ and $z(\bullet)$ and given the total distributive power of the central government this result is to be expected. In this case, the benevolent central government promotes a totally egalitarian federation, which maximizes the concave sum of states' utilities.

4.4 Decentralized Federation

In a decentralized federation local governments have autonomy to decide about some fiscal issues that affect their constituents. In the model of this section we

assume that local governments establish the local tax rate (τ_i) and use the revenues to supply the local public good (G_i). The federal government keeps its prerogative of national taxation and can also supply a complementary amount of the local public good. In this setup, the federal government does not have total distributive power anymore since it must tax income at the same rate across states.

The whole process may be described as follows. First, local governments, knowing the realization of their own income, decide about the per capita local tax rate (τ_i), and possibly about the per capita debt services payment (S_i). Per capita compulsory grants for each locality (gc_i) are public information and are known before state and individual decisions.

Central government observes their actions, as well as each state per capita incomes (Y_i), and chooses the federal income tax rate (τ_c) and the amount and distribution of the per capita discretionary resources (gv_i). Then individuals in each locality decide about gross per capita consumption spending (C_i). Finally the idiosyncratic shock (e_i) occurs.

This is a sequential game in which states act first and must foresee the actions of the federal government, which plays after having observed state moves. States must apply backward induction while formulating their policies.

Thus, states know that the federal government problem is:

$$\begin{cases} \underset{\{gv_k\}}{Max} : U_T = E \sum_{k=1}^{m} \eta_k [u_k(C_k) + z_k(G_k) + e_k] \\ S.t. : (4.2),\ (4.3),\ (4.4),\ (4.5)\ and\ (4.6) \end{cases} \tag{P2}$$

which produces the following set of first order conditions, $\forall i = 1, ..., m$:

$$z_i' = \sum_{k=1}^{m} u_k' \Upsilon_k \tag{4.14}$$

As the set of equation (4.14) shows, the federal government will try to equalize the marginal utilities in the consumption of the public goods across states, but now it has only the voluntary transfers as instruments to do so. Furthermore, in order to increase the voluntary transfers to a state, the federal government must increase its tax rate, which causes a decrease in private consumption in all states, including the state to be benefited. This reduces the distributive power of the central government because it can not control each state's private consumption anymore, although it retains the control over aggregate private consumption.

With this set of equations in hand, it is possible to evaluate the impact of the variables with regard to the propensity of the central government in supplying discretionary resource transfers to state governments. The main question here is how the federal government will react in the distribution of the discretionary resources when states change their choice variables. With this analysis, one could evaluate which specific policies of the federal government are consistent. For example, Brazilian federal government has been engaged in policies to stop economic wars among federate units. One pertinent question in this context would be: what is the real opportunity cost for the states in lowering their tax burden? If they are partially compensated by an increase in discretionary resource transfers when they reduce their tributary burden, the local social cost expressed by a reduction in public goods provision will be also lowered.

Thus, the main objective of this section is to evaluate the properties of the federal discretionary transfer reaction function, with special interest in its behavior in relation to the states' control variables.

As a first exercise one might examine the impact of the state tax rate on the federal discretionary resource allocation. Differentiating equation (4.12) in relation to τ_i:

$$z_i''(\frac{\partial gv_i}{\partial \tau_i} + \frac{1}{\eta_i}\sum_{k=1}^{m}\eta_k\alpha_{ki}Y_k) = z_j''\frac{\partial gv_j}{\partial \tau_i} \tag{4.15}$$

Supposing that all states have the same preferences, i.e., $u_i = u_j$ and $z_i = z_j$ for all $i, j = 1, ..., m$, then $z_i' = z_j'$ implies necessarily $z_i'' = z_j''$, thus:

$$\frac{\partial gv_j}{\partial \tau_i} = \frac{\partial gv_i}{\partial \tau_i} + \frac{1}{\eta_i}\sum_{k=1}^{m}\eta_k\alpha_{ki}Y_k \tag{4.16}$$

Now notice that:

$$\frac{\partial t_c}{\partial \tau_i} = \sum_{k=1}^{m}\frac{\eta_k}{\Upsilon}\frac{\partial gv_k}{\partial \tau_i} \Rightarrow$$

$$\frac{\partial t_c}{\partial \tau_i} = \frac{\eta_i}{\Upsilon}\frac{\partial gv_i}{\partial \tau_i} + \sum_{k\neq i}^{m}\frac{\eta_k}{\Upsilon}\frac{\partial gv_k}{\partial \tau_i} + \sum_{k\neq i}^{m}\frac{\eta_k}{\Upsilon\eta_i}\sum_{j=1}^{m}\alpha_{ji}\eta_j Y_j \Rightarrow$$

$$\frac{\partial t_c}{\partial \tau_i} = \frac{N}{\Upsilon}\frac{\partial gv_i}{\partial \tau_i} + \frac{N-\eta_i}{\Upsilon\eta_i}\sum_{k=1}^{m}\alpha_{ki}\eta_k Y_k \tag{4.17}$$

Differentiating equation (4.11) in relation to τ_i one obtains:

$$z_i''(\frac{\partial gv_i}{\partial \tau_i} + \frac{1}{\eta_i}\sum_{k=1}^{m}\eta_k\alpha_{ki}Y_k) = -\Upsilon_i u_i''(Y_i\frac{\partial t_c}{\partial \tau_i} + \alpha_{ii}Y_i) - \sum_{k\neq i}^{m}\Upsilon_k u_k''Y_k\frac{\partial t_c}{\partial \tau_i}$$

Plugging in equation (4.17) one obtains:

$$\frac{\partial gv_i}{\partial \tau_i} = -\frac{(z_i'' + \frac{N-\eta_i}{\Upsilon}\sum_{k=1}^{m}\Upsilon_k u_k'' Y_k)\frac{1}{\eta_i}\sum_{k=1}^{m}\eta_k\alpha_{ki}Y_k + \alpha_{ii}u_i''Y_i\Upsilon_i}{z_i'' + \frac{N}{\Upsilon}\sum_{k=1}^{m}\Upsilon_k u_k'' Y_k} \tag{4.18}$$

Observe that $z_i'' < 0$, $\frac{N-\eta_i}{\Upsilon} > 0$ since $N > \eta_i$ and $\Upsilon > 0$, $\sum_{k=1}^{m}\Upsilon_k u_k'' Y_k < 0$ since it is a summation of negative numbers, $\sum_{k=1}^{m}\eta_k\alpha_{ki}Y_k > 0$ and $\alpha_{ii}u_i''Y_i\Upsilon_i < 0$.

This implies that $\partial gv_i/\partial\tau_i < 0$, which means that decreases in the tax rate by a state will lead to increases in federal discretionary transfers to that state. Whether it will be greater or smaller than -1 depends on, among other things, the population of the state η_i. Curiously, the smaller its population, the larger the increase in per capita federal discretionary resource transfers promoted by a decrease in state taxes. This happens because it is relatively cheap to compensate small states. Furthermore, the smaller the state, the less it participates in the financing of its own supplementary funds. If a high population state cuts its tax collection, a big part of the compensation must come from the state itself, unless the federal government is willing to place a greater burden on the other states.

It is worth noting that there are constraints that force the federal government to increase discretionary transfers to a state when the latter decreases its tax rate. In this model, when a state cuts its tax rate, the state tax burden decreases since the states' income are supposed to be exogenous. A decrease in the state tax burden leads, on one hand, to more disposable income and to more private consumption. On the other hand, this diminishing tax collection constrains the provision of the local public good. This imbalance between private consumption and local public good

consumption reduces the state's level of utility. The federal government increases discretionary transfers to that state in order to restore, at least partially, the ideal proportion between public and private good consumptions. The federal government realizes that if it taxes all states a little more, there will be imbalances in the other states too, but the reduction in the imbalance in the receiving state will produce a compensatory increase in the federation welfare. At the end of such a process, the state in question obtains more private consumption, since it has reduced its tax burden, and it is at least partially compensated by the decrease in the local public good provision. Summarizing, there is time inconsistency in the solution of the problem: ex-ante it is better for the federation if the federal government does not act in order to restore the proportion between private and public good consumption, but ex-post, when the federal government faces a such imbalances as a *fait accompli*, as defined by Lindbeck and Weibull (1988), the federation as a whole will be better off if the federal government tries to correct the problem.

Applied to the Brazilian case, this result may help to explain the aversion of the more populated states to fiscal wars. When state taxation declines, federal grants to the state increase but they increase more in per capita terms in the less populated states. As the financing of the grants are to be shared equally among all states in per capita terms, those states which receive less are indeed losing resources.

Similar exercises will produce the following results in relation to the impact of per capita debt services, S_i, and the per capita compulsory grants, gc_i , respectively:

$$\frac{\partial gv_i}{\partial S_i} = \frac{z_i'' + \frac{N-\eta_i}{\Upsilon}\sum_{k=1}^{m}\Upsilon_k u_k'' Y_k}{z_i'' + \frac{N}{\Upsilon}\sum_{k=1}^{m}\Upsilon_k u_k'' Y_k} \tag{4.19}$$

$$\frac{\partial gv_i}{\partial gc_i} = -\frac{z_i'' + \frac{N-\eta_i}{\Upsilon}\sum_{k=1}^{m}\Upsilon_k u_k'' Y_k}{z_i'' + \frac{N}{\Upsilon}\sum_{k=1}^{m}\Upsilon_k u_k'' Y_k} \tag{4.20}$$

First note that $\frac{\partial gv_i}{\partial S_i} = -\frac{\partial gv_i}{\partial gc_i}$. This equality reflects the fact that the central government reaction function is equally affected by an increase of the compulsory transfers or by a similar decrease in debt service payments.

Equation (4.19) shows that $0 < \partial gv_i/\partial S_i < 1$. This means that reductions in the debt service payments will lead to less than proportional decreases in discretionary resource transfers from the federal government. Besides, the larger the population of the state, the smaller the decrease. Thus, Brazilian state debt restructuring programs, in which states must adopt a number of fiscal disciplinary measures in order to obtain more favorable interest rates over their debt, seem to make sense since the big owners are also the more populated states. The reduction in debt service payments will not be totally offset by a proportional reduction in discretionary resource transfers from the federal government. Such programs may have negative distributive effects, since resources will be attracted by the most populated states in per capita terms.

A negative relationship between compulsory grants and discretionary transfers is detected in equation (4.20). It implies that, even in the case of a benevolent government, *a priori* redistributive schemes will be somewhat offset by the distribution of discretionary transfers.

The last part of this section examines the effects of this federal government behavior over the decisions of the local governments. As said before, local governments act before the federal government, but they internalize the reaction function of the latter in their decisions. As each local government tries to maximize its own utility function, its problem may be described as below :

$$\begin{cases} \underset{\{\tau_i\}}{Max} : U_i = E[u_i(C_i) + z_i(G_i) + e_i] \\ S.t. : C_i = (1 - \tau_c - \sum_{k=1}^{m} \tau_k \alpha_{ik}) Y_i \\ \qquad G_i = \frac{\tau_i}{\eta_i} \sum_{k=1}^{m} \eta_k \alpha_{ki} Y_k + gv_i + gc_i - S_i \end{cases} \tag{P3}$$

The Lagrangean for this problem is:

$$\Gamma = u_i[(1 - \tau_c - \sum_{k=1}^{m} \tau_k \alpha_{ik}) Y_i] + z_i[\frac{\tau_i}{\eta_i} \sum_{k=1}^{m} \eta_k \alpha_{ki} Y_k + gv_i + gc_i - S_i] + e_i\} \tag{4.21}$$

Which produces the following set of first order conditions, $\forall i = 1, ..., m$:

$$z_i' = u_i' \frac{\left(\alpha_{ii} + \frac{\partial \tau_c}{\partial \tau_i}\right) Y_i}{\frac{1}{\eta_i} \sum_{k=1}^{m} \eta_k \alpha_{ki} Y_k + \frac{\partial g v_i}{\partial \tau_i}} \tag{4.22}$$

Equation (4.22) says that, in general, the decentralized solution will not equalize the marginal utilities from the private and from the public good consumption and thus the decentralized solution will meet the first-best conditions only in special cases. This divergence of the decentralized solution in relation to the first best solution comes from two sources. First, there is the reaction function of the federal government, which indicates that the federal government will help the localities with insufficient provision of the local public good, even if this shortage is provoked by a

deliberate reduction in the local tax collection.

Second, there is the problem of tax exports, which induces the exporter localities to increase their tax rates, since a good part of the burden will be levied on other localities' citizens.

In order to isolate the first effect, one could examine a situation in which there are no local tax exports, in this case the elements of the matrix α would be such that:

$$\alpha_{ij} = \begin{cases} 0 \text{ if } i \neq j \\ \\ 1 \text{ if } i = j \end{cases}$$

In this case, equation (4.22) becomes:

$$z_i' = u_i' \frac{Y_i + \frac{\partial \tau_c}{\partial \tau_i} Y_i}{Y_i + \frac{\partial g v_i}{\partial \tau_i}} \tag{4.23}$$

First notice that, if $\frac{\partial \tau_c}{\partial \tau_i} Y_i = \frac{\partial g v_i}{\partial \tau_i}$ the solution of the decentralized problem becomes equivalent to the centralized one. In this case $u_i = u_j = z_i = z_j$, for all $i, j = 1, 2, \ldots, m$.

The most plausible case in which this equality can occur is when both derivatives are equal to zero. This means that the reaction function of the federal government is totally insensitive to the states' tax rate. In this case (with no tax exports) the decentralized solution would be equal to the centralized, first-best solution.

This is a strong result because it implies that the achievement of the first-best solution may be a question of credible commitment. If the federal government can credibly commit to not help local governments when they reduce their tax rate, the latter have no incentive for doing so since a decrease in the tax collection

and a consequent reduction in the provision of the local public good would not be compensated by a higher level of voluntary resource transfers. At the end of the day the local population would obtain a sub-optimal bundle of public and private consumption goods.

In the case in which $\frac{\partial \tau_c}{\partial \tau_i} Y_i, \frac{\partial g v_i}{\partial \tau_i} \neq 0$, the relation between the marginal utilities from the consumption of the private and of the public goods depend essentially on whether $\frac{\partial \tau_c}{\partial \tau_i} Y_i$, the variation in the federal tax collection in state i caused by an increase in the state tax rate, is greater or smaller than $\frac{\partial g v_i}{\partial \tau_i}$, the reduction in the federal voluntary transfers to state i when the latter increases its taxes.

If $\frac{\partial \tau_c}{\partial \tau_i} Y_i > \frac{\partial g v_i}{\partial \tau_i}$ then $z_i' > u_i'$, which means that locality i consumes too much of the private good and too little of the public good relative to the first-best outcome. The interpretation goes as follows: on the one hand, if an additional increase in the local tax rate provokes a reduction in the federal voluntary transfers which is greater than the reduction in the federal tax collection within the locality, local government will fall short in the local tax rate and in the provision of the local public good. On the other hand, the smaller local tax rate implies more disposable income and thus, more private consumption.

But what is the profile of the locality in which this case is most likely to happen? First observe that, in the case of no local tax exports, from equation (4.17) it is possible to see that:

$$\frac{\partial \tau_c}{\partial \tau_i} Y_i = \frac{N Y_i}{\Upsilon} \frac{\partial g v_i}{\partial \tau_i} + \frac{(N - \eta_i) Y_i^2}{\Upsilon} \tag{4.24}$$

This implies that:

$$\frac{\partial \tau_c}{\partial \tau_i} Y_i > \frac{\partial g v_i}{\partial \tau_i} \Leftrightarrow \frac{N Y_i}{\Upsilon} \frac{\partial g v_i}{\partial \tau_i} + \frac{(N - \eta_i) Y_i^2}{\Upsilon} > \frac{\partial g v_i}{\partial \tau_i} \Leftrightarrow (\Upsilon - N Y_i) \frac{\partial g v_i}{\partial \tau_i} < (N - \eta_i) Y_i^2$$

But equation (4.18), adapted to the no tax-exports case, says that:

$$\frac{\partial g v_i}{\partial \tau_i} = - \frac{(z_i'' + \frac{N - \eta_i}{\Upsilon} \sum_{k=1}^{m} \Upsilon_k u_k'' Y_k) Y_i + u_i'' Y_i \Upsilon_i}{z_i'' + \frac{N}{\Upsilon} \sum_{k=1}^{m} \Upsilon_k u_k'' Y_k}$$

This implies that:

$$\frac{\partial \tau_c}{\partial \tau_i} Y_i > \frac{\partial g v_i}{\partial \tau_i} \Leftrightarrow \; - (\Upsilon - N Y_i) \frac{(z_i'' + \frac{N - \eta_i}{\Upsilon} \sum_{k=1}^{m} \Upsilon_k u_k'' Y_k) Y_i + u_i'' Y_i \Upsilon_i}{z_i'' + \frac{N}{\Upsilon} \sum_{k=1}^{m} \Upsilon_k u_k'' Y_k} < (N - \eta_i) Y_i^2$$

as $z_i'' + \frac{N}{\Upsilon} \sum_{k=1}^{m} \Upsilon_k u_k'' Y_k < 0$, since it is a summation of negative terms, thus:

$$\frac{\partial \tau_c}{\partial \tau_i} Y_i > \frac{\partial g v_i}{\partial \tau_i} \Leftrightarrow$$

$$(N Y_i - \Upsilon) \left[\left(z_i'' + \frac{N - \eta_i}{\Upsilon} \sum_{k=1}^{m} \Upsilon_k u_k'' Y_k \right) Y_i + u_i'' Y_i \Upsilon_i \right] > (N - \eta_i) Y_i^2 \left(z_i'' + \frac{N}{\Upsilon} \sum_{k=1}^{m} \Upsilon_k u_k'' Y_k \right) \Rightarrow$$

$$\frac{\partial \tau_c}{\partial \tau_i} Y_i > \frac{\partial g v_i}{\partial \tau_i} \Leftrightarrow (N Y_i - \Upsilon) u_i'' \Upsilon_i > (\Upsilon - \eta_i Y_i) z_i'' + (N - \eta_i) \sum_{k=1}^{m} \Upsilon_k u_k'' Y_k$$

Notice that:

$\Upsilon = \sum_{k=1}^{m} \eta_k Y_k > \eta_i Y_i \Rightarrow \Upsilon - \eta_i Y_i > 0$, and

$N = \sum_{k=1}^{m} \eta_k > \eta_i \Rightarrow N - \eta_i > 0.$

As u_i'' and z_i'' are both negative, then:

$(\Upsilon - \eta_i Y_i) z_i'' + (N - \eta_i) \sum_{k=1}^{m} \Upsilon_k u_k'' Y_k < 0.$

Thus a sufficient condition for $\frac{\partial \tau_c}{\partial \tau_i} Y_i > \frac{\partial g v_i}{\partial \tau_i}$ is that $N Y_i < \Upsilon$, since in this case

$(NY_i - \Upsilon)u_i''\Upsilon_i > 0$, and consequently, $> (\Upsilon - \eta_i Y_i)z_i'' + (N - \eta_i)\sum_{k=1}^{m} \Upsilon_k u_k'' Y_k$.

States with per capita income above the average will consume too much public good (in relation to the first-best solution). To see this, notice that the average per capita income is:

$$\bar{Y} = \frac{\sum_{k=1}^{m} \eta_k Y_k}{N} = \frac{\Upsilon}{N} \Rightarrow N\bar{Y} = \Upsilon$$

thus, if $Y_i > \bar{Y} \Rightarrow NY_i > \Upsilon \Rightarrow (NY_i - \Upsilon)u_i''\Upsilon_i < 0$.

The conclusion of all this is that the greater the per capita income of a locality, the greater its public good consumption and the smaller its private good consumption in relation to the first-best optimum.

4.5 Vote-Seeking Central Government

And if the federal government is not a benevolent one? Suppose, for example, that it is election-motivated, what would the difference be in its reaction functions expressed by equations (4.18), (4.19) and (4.20)? What kind of inefficiencies would arise from this principal-agent problem? Do these inefficiencies alter qualitatively the results?

In order to answer these questions, one must first specify the objective function of such a self-interested government. On one hand, in the Brazilian case, as discussed in the last chapter, the federal government always needs support from states and municipalities' representatives in order to approve its legislative bills. In the last instance, the federal government must maintain a winning coalitions in order to remain in office. Thus, it is quite reasonable that the federal government's objective

is keeping a parliamentary majority in the congress, because without such a majority the central government cannot satisfy the minimum governance condition.

On the other hand, as a democratic republican country, the incumbent federal government is periodically subject to presidential elections. Thus another possible objective of the federal government is to be re-elected or to have its candidate elected.

In both cases, there is a principal-agent problem, since these objectives are not directly coincident with the federation objective, which is the maximization of the sum of the total utility of the federated localities. In this situation, the federal government uses its voluntary resources transfer powers to co-opt localities' votes.

Suppose that, as in Seabright (1996), there is a utility "cut level", Q, in each locality. If this minimum level is not achieved the locality is going to vote against the federal government. In order to achieve its objectives (re-election or congressional majority), the central government needs a simple majority. Each locality has a different number of votes and they cast all of them in favor or against the federal government; thus what is truly necessary for federal government to achieve its objective is a combination of satisfied localities that accounts for more than one half of the votes.

Some observations regarding the electoral process are worthwhile at this point. First observe that, as said above, in this model the voting rules are well defined. If a locality reaches at least its reservation utility level, it will vote in favor of the government; otherwise it will vote against it. There is also a notable difference between this model and Seabright's, because in the latter it is implicitly assumed that

all states have the same electoral weight. This fact becomes clear in the assumption that to be re-elected the incumbent government needs the votes of at least K states (any K states). Here, differences in the electoral power of the localities are allowed.

Furthermore, in Seabright's model the policy implementation is costly to the central government, while in this paper the implementation (or the expansion) of a policy has no direct effect in the central government's objective function. It only affects central government because it changes its success probability[8].

Thus, if the central government has its own objectives, which are not necessarily coincident with its constituents' aspirations, there is a principal-agent problem. Localities (principal) cannot directly control the central government's (agent) actions a priori, but they can replace it if they are not satisfied. There is also an incomplete contract problem. As the idiosyncratic shock is not verifiable, it is not possible to write down a contingent contract for every realization of e and thus no pre-determined penalty against a government that frustrates the population can be enforced.

The model is as follows. Let R represent the event in which the federal government obtains the majority of the votes and let R_i and $\overline{R}_i$ represent the events in which locality i votes in favor of and against the incumbent government, respectively. Thus, the Problem of the Central Government may be described as follows:

[8] Indeed, the assumption that policy implementation is costly seems to be in opposition to most of the literature. An increased level of central government intervention generally implies a larger budget, which is usually regarded favorably by politicians.

$$\begin{cases} \underset{\{gv_k\}}{Max} : Prob(Federal\ Government\ Approval) = P(R) \\ S.t. : (4.2),\ (4.3),\ (4.4),\ (4.5)\ and\ (4.6) \end{cases} \tag{P2}$$

The first order conditions of this problem may be expressed in the following way:

$$\frac{\partial P(R)}{\partial g_{vi}} = 0, \forall i = 1, ..., m \tag{4.25}$$

It is possible to show that[9]:

$$\frac{\partial P(R)}{\partial gv_i} = \sum_{k=1}^{m} \Phi_k \frac{\partial P(R_k)}{\partial gv_i} \tag{4.26}$$

where $\Phi_k = P(R/R_k) - P(R/\overline{R_k})$.

The variable Φ_k above measures the probability that the votes from locality k are decisive or pivotal for the federal government success and is obtained by the difference between the probabilities of winning the ballot with and without locality k's votes.

Locality k will vote in favor of the federal government if, and only if, they achieve at least the utility reservation level Q; thus the event R_k may be defined as:

$$R_k = \{e_k/u_k(C_k) + z_k(C_k) + e_k > Q\} \tag{4.27}$$

or alternatively:

[9] Details in Seabright (1996), Appendix I.

$$R_k = \{e_k / e_k > Q - u_k(C_k) - z_k(C_k)\} \tag{4.28}$$

Thus the probability of approval of the central government by locality k, $P(R_k)$, may be expressed as:

$$P(R_k) = \int_{Q-u_k(C_k)-z_k(C_k)}^{e_k\,\max} f(e_k)de_k \tag{4.29}$$

$$\Rightarrow \; P(R_k) = 1 - F[Q - u_k(C_k) - z_k(C_k)] \tag{4.30}$$

From (4.40) it is possible to define:

$$\frac{\partial P(R_k)}{\partial gv_i} = -f_k u_k' Y_k \frac{\partial t_c}{\partial gv_i} \qquad fork \neq i \tag{4.31}$$

$$\frac{\partial P(R_i)}{\partial gv_i} = -f_i u_i' Y_i \frac{\partial t_c}{\partial gv_i} + f_i z_i' \qquad fork = i \tag{4.32}$$

From equation (4.6) it is possible to obtain:

$$\frac{\partial t_c}{\partial gv_i} = \frac{\eta_i}{\Upsilon} \tag{4.33}$$

and thus, plugging equation (4.33) into equations (4.41) and (4.32):

$$\frac{\partial P(R_k)}{\partial gv_i} = -\frac{\eta_k Y_k f_k u_k'}{\Upsilon} \tag{4.34}$$

$$\frac{\partial P(R_i)}{\partial gv_i} = -\frac{\eta_i Y_i f_i u_i'}{\Upsilon} + f_i z_i' \tag{4.35}$$

From equations (4.34) and (4.35) it is possible to obtain:

$$\sum_{k=1}^{m} \Phi_k \frac{\partial P(R_k)}{\partial g v_i} = \Phi_i f_i z_i' - \frac{\eta_i}{\Upsilon} \sum_{k=1}^{m} \Phi_k Y_k f_k u_k' \tag{4.36}$$

Plugging equation (4.36) into equation (4.26) and then substituting into equation (4.25) one obtains:

$$\frac{\Upsilon \Phi_i f_i z_i'}{\eta_i} = \sum_{k=1}^{m} \Phi_k Y_k f_k u_k' \tag{4.37}$$

As equation (4.37) holds for all $i = 1, ..., m$, it implies that:

$$\phi_i f_i z_i' = \phi_j f_j z_j' \tag{4.38}$$

for all $i, j = 1, ..., m$ and where ϕ_i is the locality's i per capita pivotal probability index.

Equation (4.38) is in sharp contrast to its analogue in the benevolent central planner case (equation 4.12). Supposing homogeneous preferences across states, equation (4.12) says that in the latter case, the federal government will try to equalize the per capita provision of the public good across states. Equation (4.38) indicates, in contrast, that even if preferences are homogeneous, the federal government will try, in general, to establish a larger provision of the public good in localities where the per capita pivotal probability index is greater.[10]

The behavior of the reaction functions of the federal government to changes in

[10] Of course the relation between public good provision and pivotal probability depends on the shape of the probability function f, but as there is no *a priori* reason to assume that the function value be greater in state i than in state j, the proposition is still fairly general.

the exogenous parameters may be calculated in a way that is similar to the procedures used in the last section. Thus, supposing that the idiosyncratic shocks in all states have the same uniform distribution, one can obtain the following derivatives:

$$\frac{\partial gv_i}{\partial \tau_i} = -\frac{\frac{\phi_i z_i''}{\eta_i^2}(\sum_{k=1}^{m} \eta_k \alpha_{ki} Y_k)[(\sum_{j=1}^{m} \phi_j Y_j^2 u_j'')(\sum_{j\neq i}^{m} \frac{\eta_j^2}{\phi_j z_j''})\frac{1}{\Upsilon} + \Upsilon] + \sum_{j=1}^{m} \alpha_{ji}\phi_j Y_j^2 u_j''}{\frac{\phi_i z_i''}{\eta_i^2}[(\sum_{j=1}^{m} \phi_j Y_j^2 u_j'')(\sum_{j=1}^{m} \frac{\eta_j^2}{\phi_j z_j''})\frac{1}{\Upsilon} + \Upsilon]} \tag{4.39}$$

$$\frac{\partial gv_i}{\partial S_i} = \frac{\Upsilon\phi_i z_i'' + \sum_{k=1}^{m} \Phi_k {Y_k}^2 u_k'' \sum_{j\neq i}^{m} \frac{{\eta_j}^2 \phi_i z_i''}{\Upsilon \phi_j z_j''}}{\Upsilon\phi_i z_i'' + \sum_{k=1}^{m} \Phi_k {Y_k}^2 u_k'' \sum_{j=1}^{m} \frac{{\eta_j}^2 \phi_i z_i''}{\Upsilon \phi_j z_j''}} \tag{4.40}$$

$$\frac{\partial gv_i}{\partial gc_i} = -\frac{\Upsilon\phi_i z_i'' + \sum_{k=1}^{m} \Phi_k {Y_k}^2 u_k'' \sum_{j\neq i}^{m} \frac{{\eta_j}^2 \phi_i z_i''}{\Upsilon \phi_j z_j''}}{\Upsilon\phi_i z_i'' + \sum_{k=1}^{m} \Phi_k {Y_k}^2 u_k'' \sum_{j=1}^{m} \frac{{\eta_j}^2 \phi_i z_i''}{\Upsilon \phi_j z_j''}} \tag{4.41}$$

In the cases of equations (4.40) and (4.41), the results are quite straightforward. Both derivatives are, in absolute terms, smaller than one. However, the former is positive while the latter is negative. Both also have in common the fact that the greater the population of the state (η_i), the smaller the magnitude in absolute terms. These results are consistent with the central planner case (see equations (4.19) and (4.20) above), but there is an interesting difference. In spite of the fact that the discretionary transfers reaction function intensity is decreasing in the population of the state, it is increasing in its per capita pivotal probability, ϕ_i[11]. As ϕ_i has a concave relationship with the population (see Chapter 5 for details), it is not clear that less populated states would face a weaker reaction function than others.

[11] To be sure ϕ_i appears in both numerator and denominator of equations (4.40) and (4.41), but as in these equations the numerators are smaller than the denominators an increase in ϕ_i will cause a proportionally greater increase in the numerators.

This fact is still stronger in equation (4.39), in which the per capita pivotal probability appears again in the numerator. In this case the magnitude of the reaction function could be indeed greater than unity in absolute value. It could happen in states with a high per capita pivotal probability and a small population. States with large populations will tend to be adverse to economic wars, since they will be subjected to a lesser reduction in federal discretionary resource transfers when they increase their taxes.

These results depend on the shape of the probability density function, but the problem becomes virtually impossible to deal with if one considers other functions besides the uniform distribution.

4.6 Delegation vs. Institutional Design Problem

As can be seen in the last two sections, the behavior of the central government, benevolent or self-interested, only affects the results of the model to the extent that it takes into account the electoral weight of the states. The signs of the derivatives of the federal discretionary transfers reaction functions remain the same, but their magnitudes vary when pivotal probabilities are introduced. This means that, in any case, the existence of discretionary resource transfers in the Brazilian federation (at least in the way they exist at the moment) will always be regarded by the states as a compensatory mechanism in the provision of public goods.

Thus, the principal-agent problem that arises when the federal government is self-interested aggravates the inefficiencies associated with the distribution of federal

discretionary transfers, since the reaction functions of the benevolent central-planner and those of the self-interested government differ from each other. Nonetheless, the previous analysis finds that the differences between the reaction functions of the two types of government are quantitative rather than qualitative, since the signs of their derivatives remain the same. Even in the case of a benevolent central government, there are incentives for states to over-borrow and to decrease their tax rates bellow the appropriate level.

The quite obvious corollary from equations (4.39) to (4.41) is that reaction functions will tend to be stronger in localities with greater political decisiveness (i.e. pivotal probability) when the government is vote-seeking. This argument implies that any eventual principal-agent problem emanating from an imperfect delegation system is not the main cause of the distributional inefficiencies in the Brazilian federation; the high level of discretion will generate such inefficiencies even when the delegation problem is absent.

In practice, the theoretical differences between the actions of a self-interested government and an altruistic one may be detected by empirical tests. In order to perform such tests, one must specify the equation in which the federal voluntary resource transfer amount to each state is the endogenous variable and include the pivotal probability of each state among the exogenous variables. If the latter is not significant, it means that the federal government is not self-interested since it does not account for the political influence of the states when setting transfers.

But this chapter shows that whatever is the objective function of the central government, the existence of federal discretionary resources will generate an SBC

for local governments. It happens because local governments know that the federal government has available a help mechanism. Thus, if local governments face fiscal problems they may expect some kind of rescue from the central government either because the latter is concerned with a fall in local populations' wellbeing, or because it knows that this fall would hurt its reelection probability. In either case, local government could expect a relaxing in their budget constraint, which characterize the existence of the SBC.

Chapter 5

Discretionary Resources in the Brazilian Federation: Empirical Tests

This chapter aims to test the theoretical model developed in the Chapter 4. In order to do this, a simplified linear federal government reaction function will be estimated and the direction of its responses to a number of exogenous variables will be checked.

In the theoretical model, the federal behavior was obtained in a way in which the direction of its reactions could be unambiguously determined. In this chapter, the econometric procedures will try to see if this behavior can be observed empirically within the Brazilian federation.

5.1 Strategic Interactions between Governments: Empirical Issues

The existence of strategic behavior in the relationship among governments has been tested in a number of studies including Case, Rosen and Hines (1993), Kelejian and Robinson (1993), Keen (1997), Besley and Rosen (1998), Goodspeed (2000) and Esteller-More and Sole-Olle (2001). Nonetheless, the focus of those papers is quite distinct both because they deal with different types of fiscal externalities and because they consider distinct levels of government interactions[1].

[1] Case, Rosen and Hines (1993), for example, use a model in which the endogenous variable is the per capita expenditure of each state. Thus they are investigating horizontal fiscal interactions,

The typology of the fiscal externalities is done according to what is affected by the government action. If a fiscal policy of a jurisdictional government impacts directly the utility functions of the residents of others jurisdictions (e.g. pollution abatement), this fiscal externality is said to be *direct*. But if it only affects other governments' budget constraints (e.g. tax competition), it is called an *indirect* externality[2].

An important feature of this classification is that, in spite of the conceptual distinction, both models generate similar jurisdictional reaction functions and the estimating process to be applied, and its difficulties, are quite the same.

Fiscal externalities can also be classified accordingly to the layers of government that produce them. If the externality created by a jurisdictional government affects governments of the same level, it is said to be a *horizontal externality*. If instead, the externality impacts other government layers then it is classified as a *vertical externality*.

As an example of a vertical fiscal externality, consider what happens when the federal government raises its tax rate on a commodity, which is also taxed by the states. Among other things, this increase in the federal tax will likely increase the consumer price of the commodity in question. Higher consumer prices will reduce the total unit sales of the good and, consequently, will reduce state tax collections.

while the central point of this dissertation is related to vertical fiscal interactions. Furthermore, their model has spatial correlation in both the errors and the endogenous variable, while in this dissertation the model to be estimated will deal only with residuals' spatial dependence.

[2] This nomenclature is compatible with Brueckner (2003) 'spillover' or 'resource flow' taxonomy. Some authors, as Browning (1999) do not consider indirect externalities as genuine; they prefer to classify them as "pecuniary" externalities.

Thus, an increase in the federal tax rate will drive down state revenues.

Notice that all vertical externalities are indirect. This is because the federal government cannot impact directly the utility functions of other same level jurisdictions' residents since by definition everybody in the country is under federal jurisdiction. Of course, there may be international spillovers, but in this case they would be classified as horizontal externalities since from the international perspective, federal governments play the role of state governments within the national economy.

A point that is common to all of these models is that they are utilized to estimate the reaction functions of the jurisdictions that interact as Cournot competitors. Thus, in the case of the horizontal models, local government interaction generates a Nash equilibrium in a simultaneous game. In a vertical interactions model, local government takes the actions of the central government as given and interact with each other in a Cournot fashion.

The model estimated in this chapter is quite distinct; we analyze the reaction function of the federal government in a Stackelberg game in which the central government is the follower. As it will be seen below, most of the problems of the Cournot-type models are also present in the estimation of this class of models.

The first of these empirical complexities is related to the endogeneity problem. When modelling local government behavior, one must consider that the decisions made by them take into account the decisions of the other governments. Thus, a system of equations is needed and the variable in the LHS of one equation may

appear on the RHS of many other equations[3]. In order to deal with this econometric issue two approaches are frequently suggested: the use of instrumental variables in a two-stage least squares procedure or the application of maximum likelihood methods.

In the case of the model estimated in this chapter, simultaneity is still a complication but for other reasons. In a Stackelberg-type game, the leader plays first but she foresees the move of the follower. Because of this, it would not be wrong to consider that the follower's action causes the leader's choice, if retrospectively. Of course, the leader's move also helps to define what the follower will do. Thus, in spite of the chronology in which they are made, the actions of both players influence the decisions of the other. Because of this simultaneity, endogeneity problems need to be taken into account.

For example, suppose the federal government (follower) aims to aid states that have low taxation power. States (leaders, in this game) will take into consideration this federal government motivation and may reduce local taxation expecting to get more help from the central government. Thus, in the estimation of the federal government aid reaction function, a simultaneity problem may appear: the federal aid to a low taxation state is large because its taxation is low, or its taxation is low because the local government counts on the federal aid.

Another source of inefficiency in OLS estimation may come from spatial correlation in the residuals. In this case, the OLS estimators are still consistent but not efficient. There are a number of possible channels through which the spatial

[3] See Brueckner (2003) for a detailed discussion about this point.

correlation might be transmitted to the equation errors. First, the residuals generating process may be the cause. In this model, known as the *Spatial Errors Model* (SEM), all the correlation is due to a peculiar disturbance generating process[4].

The spatial dependency may also come from the endogenous variables of other spatial units. Thus the criminality index in one county, for example, depends not only on that county's income, but also on the neighboring counties' income (*Spatial Durbin Model*). It can still be treated in a *Spatial Autoregressive Model* (SAR) in which the values of some other spatial units' endogenous variables appear as explanatory variables in one unit's equation.

Another possible channel through which the spatial correlation may be present in the data occurs when the cross-sectional fixed effects show spatial dependence. Suppose that spatial correlation appears neither in the residuals nor in the variables, but the state intercepts are spatially dependent. In this case the fixed effect panel estimation will produce residuals that are not spatially correlated, in spite of the existence of some spatial dependence in the data.

In Appendix C these two effects are shown: first, if there is interest in detecting spatial dependence and the estimation process is "Least Squares Dummy Variables" (LSDV), it is necessary to test the spatial correlation of the intercepts, since this correlation may not be present in the residuals. Secondly, if there is spatial dependence in the intercepts and the model is estimated with OLS, this dependence will appear in the residuals.

Heteroscedasticity is also a possible issue to be addressed in these estimations.

[4] For a detailed discussion about spatial econometric and its applications, see LeSage (1999).

It may arise from the fact that Brazilian states are heterogeneous in several aspects as income, population, size of the public sector in proportion to the private sector, etc. Furthermore, as the data will be utilized in per capita terms, the variance of the residuals associated with the smaller states is expected to be greater than those of the larger states, because small variations in the federal resources transferred to the former may cause large variation in their per capita values.

As these sources of estimation inefficiencies, endogeneity, spatial dependence and heteroscedasticity, are likely to appear in the data, section 5.3 summarizes the procedures utilized to deal with them.

5.2 Data Set and Variables

Brazilian data collection and dissemination have evolved enormously in the last decade. This evolution has two sources. First, the end of the very high inflation rates allows analysts to be more confident about their precision. Second, the spread of computers has made it easier to organize, disseminate and utilize the data.

One of the more interesting data sets that has been made available in this process is the "Regionalization of the Public Sector Transactions" produced by the Brazilian Institute of Geography and Statistics - IBGE. Although this data set dates back to 1970, it used to be of very limited value since the regional appropriations were contaminated by errors due to inflation and by the lack of operational capability of processing the information.

This data set contains data on federal government expenditures and payments

and by state. Thus, it is possible, with the proper aggregation of variables, to estimate the reaction functions that rule the federal government distribution of voluntary resources among the federated states.

In spite of the utility of this data set, some limitations still remain. The most important among them is the fact that the expenditures assigned to the Federal District [5] are inflated because most of the federal expenditures for which the proper location cannot be precisely determined are appropriated in the Federal District. This aggregation procedure produces problems of inconsistency in the data and the solution for that, as will be seen in the next section, was the deletion of the observations associated with the Federal District.

The aggregation of the original variables was done in order to group them according to their nature and it did not necessarily respect the classification established in the Brazilian public accounts. For example, the two sub items "Participation Fund of the States" and "Capital Transfers" are both under the item "Intergovernmental Transfers" but the former is a mandatory transfer and the latter is voluntary in most cases. Thus, they were used to compose distinct variables in spite of the fact that both belong to the same item in the official accounts. In the following paragraphs we describe the variables assembled to estimate the model; a complete and detailed description of the variables can be found in Table 5.1.

The per capita "Discretionary Federal Resources Transfers" (DFT) includes all discretionary expenditures and transfers made by the federal government to each

[5]The Federal District (Distrito Federal) is the federative unit which contains Brasilia, the Brazilian capital. The Federal District is somewhat analogous to the District of Columbia in the US.

Table 5.1:

Variable Composition for Model Estimation

Acronym	Variable	Composition
FRT	Federal Revenue Total	Federal Tax Collection by State + Federal Social Security Tax Collection by State + Federal Civil Servant Social Security Tax Collection by State + Federal Patrimonial Revenues by State + Repayment of Debt Loaned from the Federal Government by State
SR	State Revenue	State Tax Collection + State Social Security Tax Collection + State Civil Servant Social Security Tax Collection + State Patrimonial Revenues + State Revenues from Sales of Goods + State Revenues from Services + State Alienation of Goods + Repayment of Debt Loaned from the State Government + State Credit Operations
MR	Municipal Revenue	Municipal Tax Collection by State + Municipal Social Security Tax Collection by State + Municipal Civil Servant Social Security Tax Collection by State + Municipal Patrimonial Revenues by State + Municipal Revenues from Sales of Goods by State + Municipal Revenues from Services by State + Municipal Alienation of Goods by State + Repayment of Debt Loaned from the Municipal Government by State + Municipal Credit Operations by State
LR	State + Municipal Revenue	SR + MR
FVT	Federal Voluntary Transfers	Other Federal Expenditures by State +Federal Fixed Capital Expenditures by State + Federal Other Transfers by State + Federal Capital Transfers by State + Federal Subsidies by State + Federal Financial Investments by State
FMT	Federal Mandatory Transfers	Federal Personnel Payments by State + Federal Public Debt Payments by State + Federal Social Security Payments by State + Federal Funds Transfers to State + Federal Funds Transfers to State's Municipalities + State Federal Matching Grant for State Education + Municipal Federal Matching Grant for State Education by State + State Participation in the Tax on Gold Transactions + Municipal Participation in the Tax on Gold Transactions by State + State Participation in the IPI over Exports + Municipal Participation in the Rural Property Tax by State + Reimbursement to State for Exports VAT Desoneration + Reimbursement to Municipalities for Exports VAT Desoneration by State + Federal Matching Grant for State Health Expenditures + Federal Matching Grant for Municipalities Health Expenditures by State
LDS	Local Debt Service	State Public Debt Payments + Municipal Public Debt Payments by State
POP	Population	State population
GDP	State Gross Domestic Product	State Gross Domestic Product
ISR	Non-agriculture Share of the State GDP	Non-agriculture Share of the State GDP
VPIV	State voters pivotal probability	State voters pivotal probability

of the states and municipalities within the states, i.e., its composition considers all those budgetary expenditures that are not compulsory or mandatory plus the voluntary monetary transfers. Thus, by summing up the budgetary items "Federal Capital Expenditures", "Capital Transfers", "Subsidies", "Financial Investments", "Other Transfers" and "Other Expenditures," one obtains the DFT. This variable, as well as all other monetary values have been deflated by the Brazilian General Price Index (IGP-DI), which includes the prices of a wide range of products from raw materials to final consumption goods. Notice that the constitutional funds FPM and FPE are not included in this variable.

The per capita "Local Government Own Revenues" (LR) is composed of the total revenues that both states and municipalities collect by themselves. It includes all state and municipalities' tax collections (including social security taxes), patrimonial revenues, revenues from sales of goods and services, repayment of loans and credit operations contracted with the federal government or with private institutions. The per capita "Local Government Debt Services" (LDS) is the sum of the per capita debt payment of a state and of the municipalities within the state.

In order to obtain the per capita "Net Mandatory Federal Resources Transfers" (NMFT) to states, we summed all the compulsory monetary transfers (FPE, FPM, federal matching grants for state education and for health services, state and municipal participation in the tax on gold transactions , state and municipal reimbursements for export tax exemptions and other state and municipal participation in federal tax collection[6]), and the direct payments that the federal government

[6]For example, states have rights over the federal IPI over exports, and municipalities over the

must compulsorily make within a state like federal personnel salaries, social security payments and public debt payments. From this sum we subtract the total federal tax collection within the state in order to obtain the net transfers.

Besides the use of the per capita "State Gross Domestic Product" (SGDP), we also use the sum of the per capita industrial and the service product of the states (ISSGDP) in the instrument estimation.

The last exogenous variable utilized in the estimations was the "State Voters Pivotal Probability" (SVPP) which measures the decisiveness of state voters in the reelection of an incumbent president.

5.3 Estimation Procedures

The first step in the estimation procedure was to fit the data with a *Dummy Variable Least Squares* (DVLS) model. The likely existence of both time and cross sectional effects suggested the utilization of a panel data model. The model utilized to fit the data is described by equation (5.1) below.

$$DFT_{it} = \alpha_i + \gamma_t + \beta_1 LR_{it} + \beta_2 NMFT_{it} + \beta_3 LDS_{it} + \beta_4 SGDP_{it} + \beta_5 SVPP_{it} + \epsilon_{it} \quad (5.1)$$

In (5.1) α_i is the cross-sectional effect of state i, γ_t the time effect of year t, the β_k's are the coefficient associated with each exogenous variable and ϵ_{it} is the true error associated with the tth observation of the ith cross-section unit.

The data set utilized in the estimation may be considered a 'typical panel' in the sense that the cross-section units greatly outnumber the time-series units.

federal rural property tax.

As such, most of the methods used to deal with serial autocorrelation have their powers strongly undermined. Because of this, we concentrated in the modelling on heterogeneity among the cross-section units and somewhat neglected the possible autocorrelation effects.

After the first DVLS estimation was done, some robustness tests were performed in order to detect the presence of influential observations. First, following the methodology suggested by Belsley, Kuh and Welsch (1980), the "Studentized" residuals were obtained from the DVLS residuals according to the following equation:

$$e_i^* = \frac{e_i}{s(i)\sqrt{1-h_i}}$$

where e_i^* is the ith "studentized" residual, e_i is the ith regression residual, $s(i)$ is the standard deviation of the residuals of the regression when the ith observation is deleted and h_i is the the ith term of the diagonal of the matrix $H = X(X'X)X'$.

Each one of the "studentized" residuals is distributed according to a t distribution with $n-k$ degrees of freedom, where n is the number of observations and k the number of endogenous variables utilized in the estimation. Following Belsley, Khu and Welsch (1980), residuals that lie outside of the two standard deviation range are possibly associated with influential observations.

The "studentized" residuals are shown in figure 5.1. As can be seen in this figure, there are six points that break the two standard deviation barrier and among them, four out of six come from observations associated with the Federal District (state number 53).

This evidence suggests that the observations from that federative unit have a large influence on the estimation. This influence may be explained by the fact that the Federal District appropriates all those expenditures to which there is no precise determination of the location where they effectively occurred. In order to test the hypothesis that Federal District data is driving the results, a "change of fit" test[7] was performed. This test consists of deleting all observations from one unit and calculating the following test statistics:

$$MDFFIT_m = [\mathbf{b} - \mathbf{b}(m)]' X(m)' X(m) [\mathbf{b} - \mathbf{b}(m)]$$

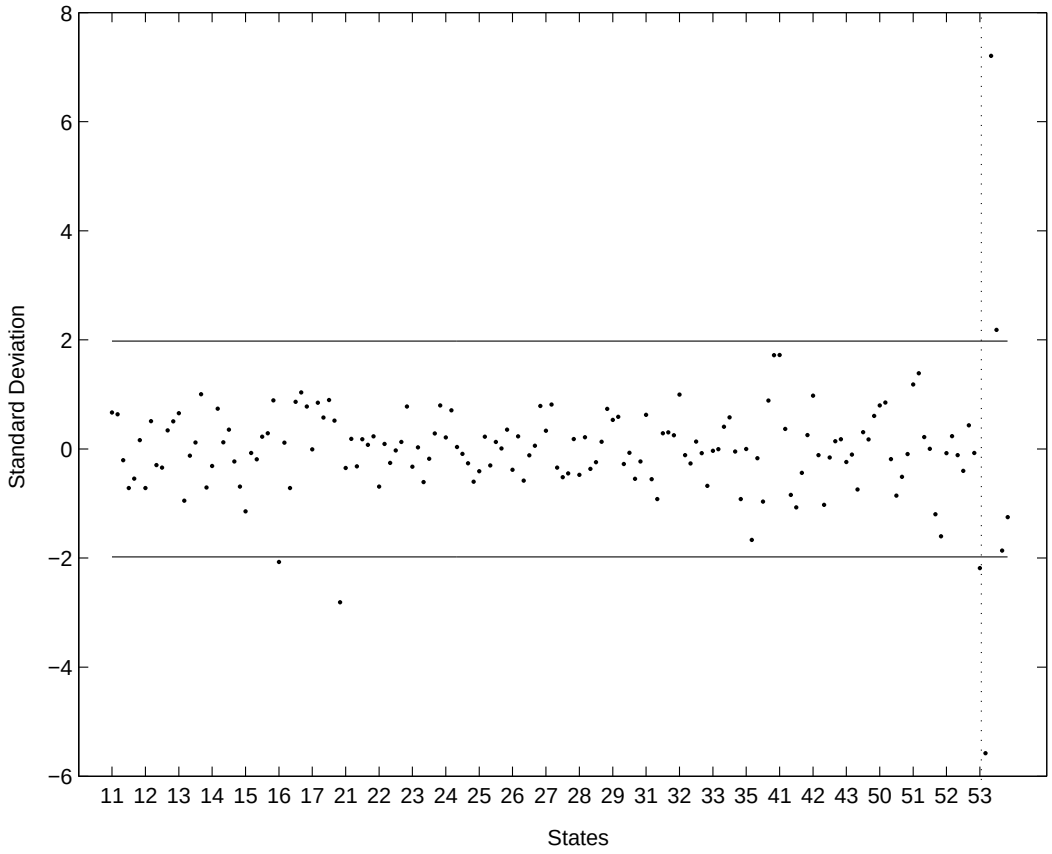
where $\mathbf{b}$ are the estimated coefficients of the original regression, $\mathbf{b}(m)$ are the estimated coefficients of the regression in which the m supposed influential observations were deleted. If the $MDFFIT_m$ is greater than $2\sqrt{k/n}$, the deleted observations may be considered influential with respect to the overall regression results.

In the case considered, in which $n = 162$ and $k = 37$ (considering all dummy variables), the critical value is 0.97402. There were four cases in which the $MDFFIT_m$ were greater than the critical value, among them the most notable was the Federal District where $MDFFIT_{DF} = 103.48$.

The next step was the calculation of the "studentized" residuals for the regression without the observations from the Federal District. The results of this procedure are shown in figure 5.2. As can be observed, there were no reduction in

[7] Belsley, Khu and Welsch (1980), pages 14 to 16.

Figure 5.1: "Studentized" Residuals of the DVLS Estimation.



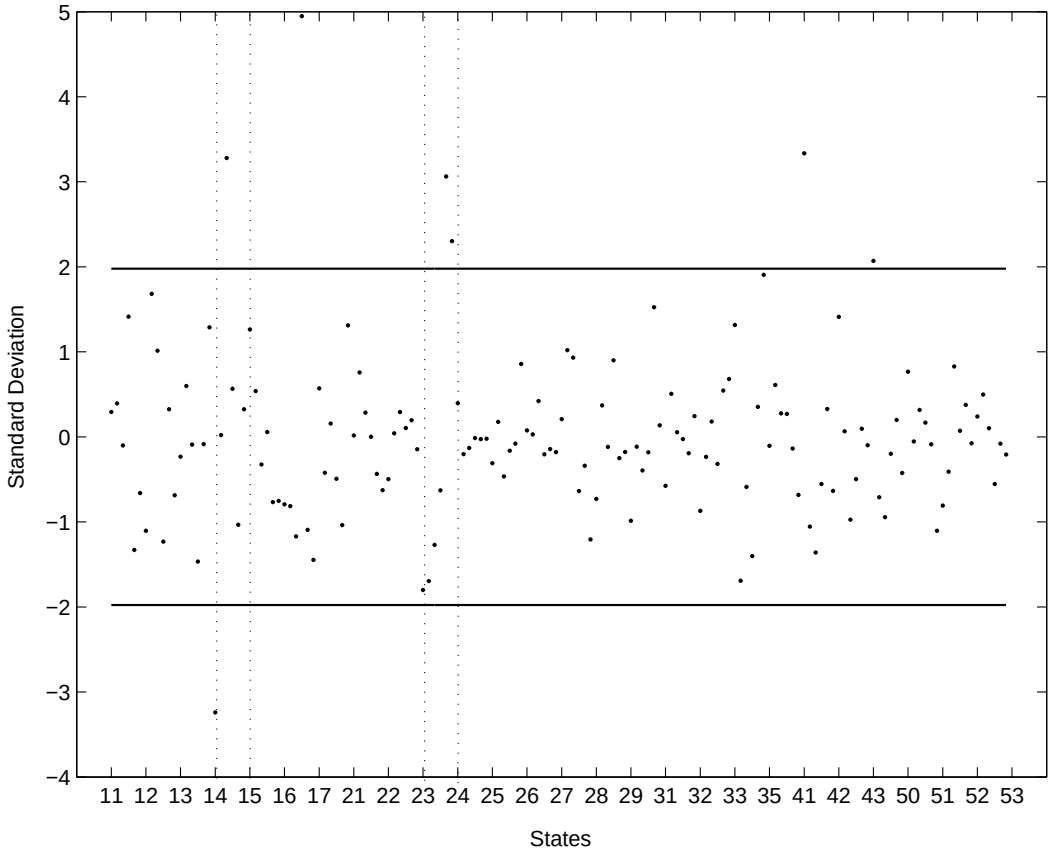
the number of possibly influential observations, but there was a reduction of the concentration of these points, although two states, Roraima (state 14) and Ceará (state 23), showed two of these points. At any rate, when one calculates the $MDFFIT$ statistics to this new set of observations there are no values above the new critical point (now with $n = 150$ and $k = 36$ the new critical value is 0.9798). This fact suggests that none of the remaining states have a disproportionate influence on the results.

Another experiment performed in order to test the robustness of the results was the calculation of the $MDFFIT$ statistics for the sample years. Thus, instead of sequentially deleting the observations associated with each state, the observations for each year of the sample were deleted and the respective $MDFFIT$ calculated. As the data from Federal District had already been deleted, the critical value for this experiment was 1.053, a number that comes from a sample size of 130 elements and 26 endogenous variables. None of the yearly $MDFFIT$ was greater than the critical value, which allows one to infer that no yearly observation is driving the results.

The results of the DVLS regression, after deleting of the data from the Federal District, as well as the other estimation procedures results are in tables 5.4 to 5.7 and will be discussed in the next section.

As the Brazilian states show large economic disparities, it is very likely that some degree of heteroscedasticity will be present in the data. Furthermore, as the

Figure 5.2: "Studentized" Residuals of the Estimation without the Federal District



sizes of the population of the states are very heterogeneous, changes in total amounts may have a larger impact on the per capita values of the less populated states, and this effect may imply a larger variance in per capita terms for these states.

In order to test for heteroscedasticity of the DVLS residuals, we followed a maximum likelihood test devised in Greene (1997) [8]. This procedure begins with the collection of the DVLS residuals after which the variance of the errors is calculated. The variance of the residuals of each state is calculated separately and then one can compute the following statistic:

$$H = n \ln \hat{\sigma}^2 - \sum_{i=1}^{m} n_i \ln \hat{\sigma_i}^2$$

where $\hat{\sigma}^2$ is the total variance of the DVLS residuals, $\hat{\sigma_i}^2$ is the variance of the residuals in state i, n is the total number of observations, n_i is the number of observations from state i (in this case $n_i = 6$, $\forall i$) and m is the number of states ($m = 26$).

The null hypothesis is the equality of the variance of the errors within the cross-section units, thus:

$$\begin{cases} H_0 : \sigma_1^2 = \sigma_2^2 = \ldots = \sigma_m^2 \\ H_a : \exists i, j : \sigma_i^2 \neq \sigma_j^2 \end{cases}$$ where σ_i^2 is the true variance of the errors of state i. Under the null hypothesis, H is asymptotically distributed as chi-square with $m-1$ degrees of freedom.

Using the residuals generated by the DVLS regression, we calculated the H statistics for the regional data. The obtained value, $H = 123.88$, is greater than the

[8] See Greene (1997), pages 553 and 554.

critical value $\chi_{0.01}(25) = 44.31$ and thus one can reject the null hypothesis that the error variances are homogeneous across groups.

Because of the rejection of the hypothesis of homoscedastic residuals, robust covariance estimators (White's variance estimators) were computed and are shown in the second column of Tables 5.4 to 5.7. The errors were then grouped according to their variance and an *Interactive Weighted Least Squares* (IWLS) estimator was constructed.

The clustering of the data in subgroups was done according to the following procedure: first, the states were sorted according to their residuals variance in ascending order as shown in Figure 5.3. Then the two smallest errors variance states were examined in order to test if the difference in their variances was significant using the H statistic described above. If this difference was not considered significant, the state with the next smallest variance was added to the test. This routine was repeated until the null hypothesis (equal population variance across the tested states) could be rejected. When this happened, the last state to be grouped was taken out of the group and utilized to begin the formation of another group. In our sample the first group was formed by 16, and the second by 10, states [9].

After the division of the states in two subgroups, the maximum likelihood test was applied to each subgroup in order to check if one could accept the hypothesis

[9] First group states: Rio Grande do Norte (RN), Pernambuco (PE), Piaui (PI), Goias (GO), Minas Gerais (MG), Sao Paulo (SP), Paraiba (PB), Maranhao (MA), Sergipe (SE), Mato Grosso (MT), Espirito Santo (ES), Mato Grosso do Sul (MS), Para (PA), Santa Catarina (SC), Tocantins (TO) and Bahia (BA). Second group states: Alagoas (AL), Amazonas (AM), Rondonia (RO), Rio Grande do Sul (RS), Acre (AC), Rio de Janeiro (RJ), Parana (PR), Roraima (RR), Ceara (CE) and Amapa (AP).

that the variances within subgroups are homogeneous. This procedure was utilized to ensure that the choice of the subgroups was consistent. The results of the tests are shown in Table 5.2. These results validate the utilized clustering, since they do not reject the hypothesis of homogeneous variance within groups.

The division of the sample in two groups was then utilized to estimate a new set of coefficients by IWLS; the results are shown in the third columns of Tables 5.4 to 5.7. The IWLS estimator is based in the *Weighted Least Square* (WLS) estimator:

$$\hat{\beta}_{WLS} = \left[\sum_{g=1}^{G} \frac{1}{\hat{\sigma}_g^2} X_g' X_g\right]^{-1} \left[\sum_{g=1}^{G} \frac{1}{\hat{\sigma}_g^2} X_g' Y_g\right]$$

where there are G groups, $\hat{\sigma}_g^2$'s are the within group variance, obtained from the OLS residuals, X_g are the matrices that contain the values of the exogenous variables of the observations of the group g and Y_g the vector with the values of the group's endogenous variables.

With the $\hat{\beta}_{WLS}$ in hand, one may calculate the residuals produced by the application of this estimator over the data by calculating:

$$\hat{e}_{WLS} = Y - X\hat{\beta}_{WLS}$$

where X and Y are the pooled values of the variables.

New within-group variances can be calculated from the vector $\hat{e}_{WLS}$ and these values may be utilized in order to recalculate $\hat{\beta}_{WLS}$. The IWLS estimator is obtained when this process converges to some value, i.e., when the estimator utilized in the

Figure 5.3: Variances of the DVLS Residuals.

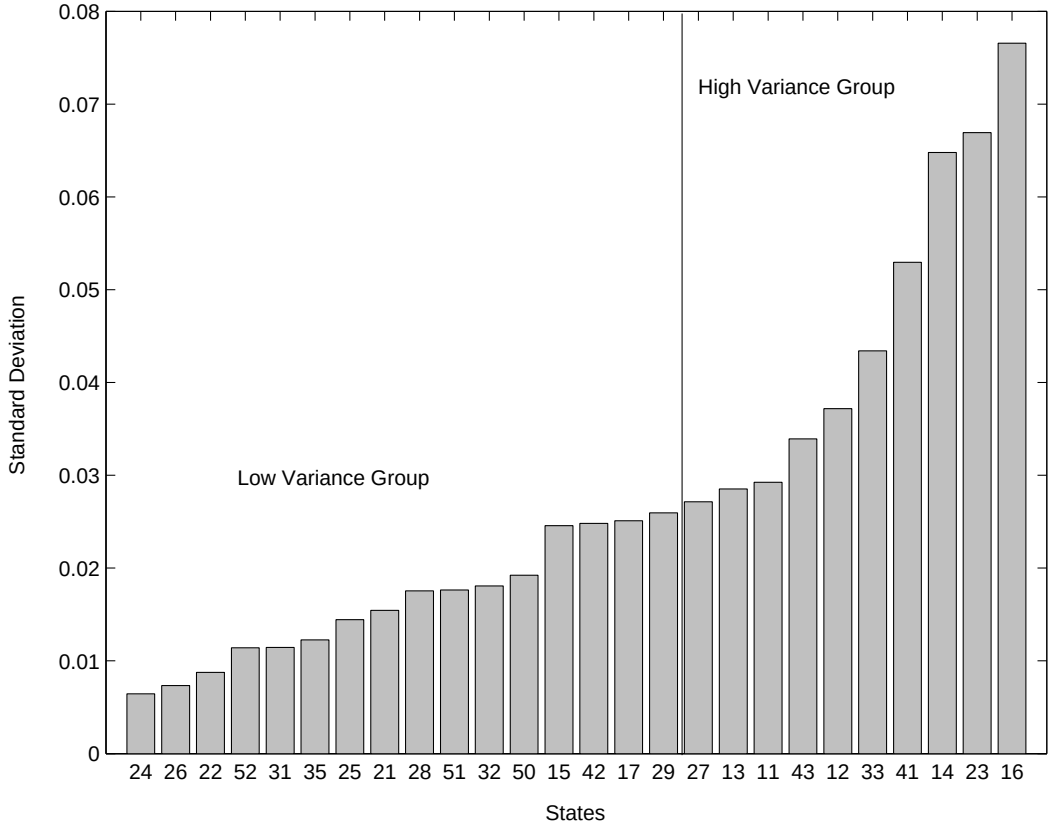


Table 5.2:

Maximum Likelihood Test for Homoscedasticity within Subgroups

OLS Residuals

Group	W Statistics	$\chi_{0.01}$	DF
First	29.43	30.58	15
Second	15.96	21.67	9
Total	123.89	44.31	25

residuals production is close enough to the estimator that arises when these errors are applied as weights.

In the calculations performed in this paper, the stop criterion for the interactions was the following:

$$\left/ \hat{\beta}_{WLS(t)} - \hat{\beta}_{WLS(t-1)} \right/ < 10^{-5}$$

where $\hat{\beta}_{WLS(t)}$ is the tth interaction of the WLS estimation and $/\bullet/$ is the cartesian distance operator.

As seen in section 5.1, one of the most frequent problems that occurs during the estimation of government reaction functions is the presence of simultaneity. In the present model, the source of endogeneity, if it is present, resides most likely in the interaction of the per capita "Discretionary Federal Resources Transfers" (DFT) and the per capita "State and Local Revenues" (LR). In principle, it would be hard to detect if a local government has low tax collections because it has received high voluntary resources transfers, or if these transfers are large because the local government has a low taxable capacity.

The other right-hand side variables are probably not subject to this problem because they do not depend on local government decisions. For example, the per capita "Local Government Debt Service" (LDS) reflect the stock of debt of a local government, and the decision of the former in the present period only affects this variable marginally.

Local government can only indirectly make decisions about the per capita "Net Mandatory Federal Resources Transfers" (NMFT) (which are mostly determined by

constitutional law), about the per capita "State Gross Domestic Product" (SGDP) and about the per capita "State Voters Pivotal Probability" (SVPP) and these decisions could hardly be related to the extraction of voluntary grants from the federal government. Because of these considerations there was no attempt to use other variables as instruments in the two stage procedures performed here.

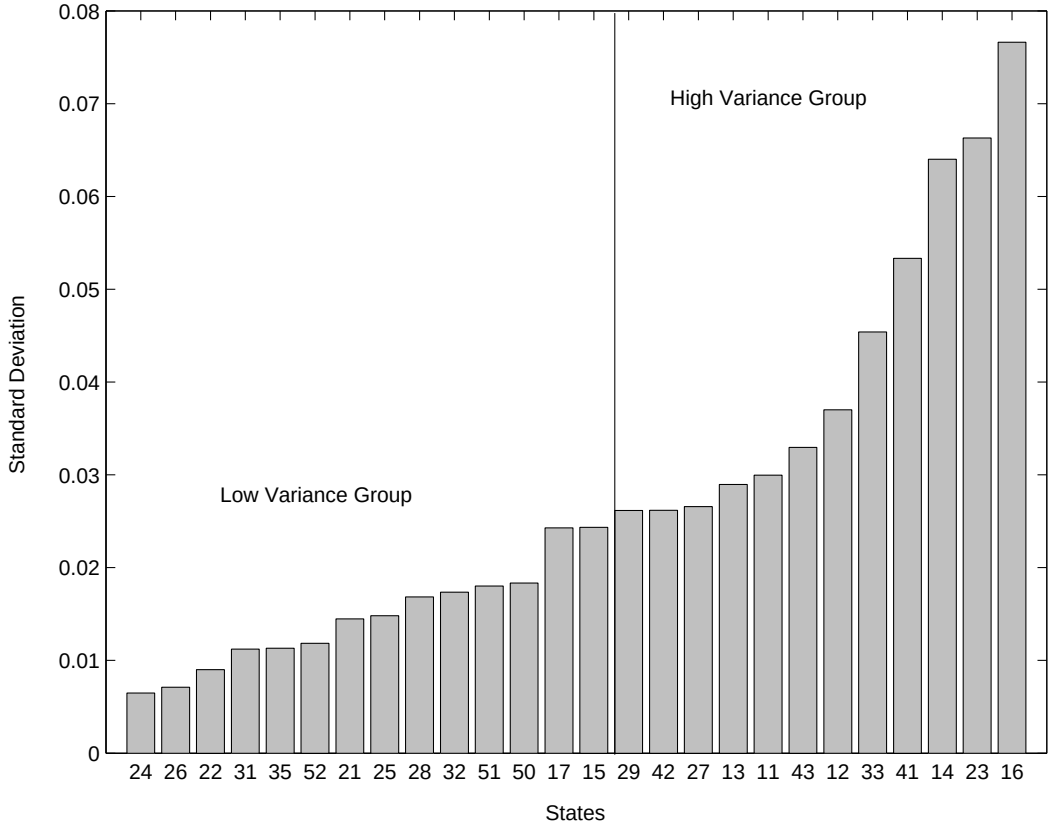
In order to model this situation, one must include an equation to explain the variations in the local governments collection of tax revenues. Chelliah, Baas and Kelly (1975) and Piancastelli, Miranda and Vasconcelos (2004) use, besides the per capita income, the participation of the agriculture, industrial and services sectors in total GDP to explain tax revenues. In this paper, we use a modified version of this equation, in which states' tax revenues (LR) depend on the state per capita income (SGDP), on the proportion of the non-agriculture GDP over the total GDP (ISSGDP) and on the per capita level of the voluntary resources transfers (DFT) as seen in equation 5.2:

$$LR_{it} = \theta_i + \phi_t + \varphi_1 DFT_{it} + \varphi_2 SGDP_{it} + \varphi_3 ISSGDP_{it} + \mu_{it} \qquad (5.2)$$

Thus, equations 5.1 and 5.2 compose a system of equations in which DFT_{it} and LR_{it} are simultaneously determined. In order to estimate equation 5.1 consistently, we utilize the *Two Stage Least Square* (2SLS) technique. First, the reduced form of equation 5.2 was estimated and the predicted values of LR_{it} were collected, These predicted values were then utilized as an instrumental variables in the estimation of equation 5.1. The results of this estimation are shown in the fourth column of Tables 5.4 to 5.7.

Naturally, these results may be influenced by the presence of heteroscedastic residuals. Because of this, the tables also show White's standard deviation of the estimators (fourth column). A *Two Stage Interactive Weighted Least Squares* estimator (2SIWLS) was also computed for the equation system and the results are reported in the fifth column of Tables 5.4 to 5.7. In this case, the clustering process described above also produced two groups, the first one with 14 states and the second with 12 states[10], as shown in Figure 5.4.

Figure 5.4: Variances of the 2SLS Residuals.



[10] First group states: Rio Grande do Norte (RN), Pernambuco (PE), Piaui (PI), Sao Paulo (SP), Minas Gerais (MG), Goias (GO), Paraiba (PB), Maranhao (MA), Sergipe (SE), Mato Grosso (MT), Espirito Santo (ES), Mato Grosso do Sul (MS), Para (PA) and Tocantins (TO). Second group states: Santa Catarina (SC), Bahia (BA), Alagoas (AL), Amazonas (AM), Rondonia (RO), Rio Grande do Sul (RS), Acre (AC), Rio de Janeiro (RJ), Parana (PR), Roraima (RR), Ceara (CE) and Amapa (AP).

The tests to verify the cluster choices are shown in Table 5.3. As can be seen there, the hypothesis of homoscedasticity within groups cannot be rejected at a 99% level of significance, but the test also shows that there is heteroscedasticity in the total sample.

Table 5.3:

Maximum Likelihood Test for Homoscedasticity within Subgroups

Simultaneous Equations Residuals

Group	W Statistics	Critical $\chi^2_{0.01}$	DF
First	25.83	27.69	13
Second	22.12	24.73	11
Total	127.93	44.31	25

With this group division in hand, the 2SIWLS estimators for the simultaneous equations model were estimated; the results are in the fifth column of Tables 5.4 to 5.7.

The last procedure performed was the test for residual spatial correlation. Spatial correlation may appear in the data for a number of reasons. For example, suppose that a severe drought affects some Northeast state. Possibly, the federal government will increase the transfers of discretionary resources to that state in order to alleviate the impact of the natural phenomenon. In this case, it is likely that the drought is also harming some of the neighboring states. Thus the federal government is expected to increase help for all those states affected by the drought.

All those states would appear as points above the regression line only because they are neighbors.

Before choosing the appropriate model to fit the data, one must see if spatial correlation is indeed relevant to the phenomenon to be studied. The simplest way to perform such verification is to fit the data by OLS and test for spatial dependence of the residuals using a spatial autoregressive model; if the errors show some degree of spatial correlation, one must be concerned about the best way of dealing with the problem.

In order to test for residuals spatial dependence, one may utilize a *First Order Spatial Autoregressive Model*(FAR), which is the simplest among the spatial autoregressive models and may be represented in the following way:

$$\epsilon = \rho W_s \epsilon + \upsilon$$

$$\upsilon \sim N(0, \sigma_\upsilon^2 I_n)$$

where ϵ are the OLS residuals, υ are the residuals innovation and W_s is the standardized state contiguity matrix.

The matrix W_s is a derivation of the simple contiguity state matrix W. Each column and line of W represents one of the 26 states. Suppose that state i is a neighbor of state j, then both elements W_{ij} and W_{ji} will be equal to one. If they are not neighbors, $W_{ij} = W_{ji} = 0$. By definition, all diagonal elements are equal to zero. W_s is obtained by dividing each element of W by the sum of its row. In this way, every row of W_s must sum up to one[11].

[11] This is the simplest specification of the contiguity matrix. One could make it more sophisticated by making each cell of the matrix proportional to the distance between the states' capitals,

The test for the presence of first-order autocorrelation is equivalent to the test for the significance of the estimator ρ, i.e., a simple t-test. If one cannot reject the null hypothesis that $\rho = 0$, he cannot accept the hypothesis of spatial autocorrelation. The complication with this estimation is that ordinary least squares will produce an estimator which is both biased and inconsistent. Thus, one must utilize a maximum likelihood estimator in order to compute $\hat{\rho}$.

In our exercise, as we are dealing with a panel data set, we will use a modified version of this model in order to test for spatial correlation:

$$E = \rho \Lambda E + \epsilon \tag{5.3}$$

E is a vector of the residuals to be tested for spatial correlation. Just to be as clear as possible, we are going to test four sets of regression residuals, one from each regression described in this section (DVLS, IWLS, 2SLS and 2SIWLS). Each set of residuals must be sorted first by state number, since the contiguity matrix is based on this classification[12] and then by year. The matrix Λ is the panel contiguity matrix and is obtained as follows:

or other distance measure. Another common specification is to put a value of one if states are neighbors and a value of one half if they are neighbors of the neighbors. The simplest specification for the contiguity matrix is the most utilized in the literature and is recommended whenever one does not have a strong reason to use a more complex one.

[12]Those are the Brazilian states names, codes and acronyms according to the Brazilian Institute of Geography and Statistics (IBGE): 11 - RONDÔNIA (RO); 12 - ACRE (AC); 13 - AMAZONAS (AM); 14 - RORAIMA (RR); 15 - PARÁ (PA); 16 - AMAPÁ (AP); 17 - TOCANTINS (TO); 21 - MARANHÃO (MA); 22 - PIAUÍ (PI); 23 - CEARÁ (CE); 24 - RIO GRANDE DO NORTE (RN); 25 - PARAÍBA (PB); 26 - PERNAMBUCO (PE); 27 - ALAGOAS (AL); 28 - SERGIPE (SE); 29 - BAHIA (BA); 31 - MINAS GERAIS (MG); 32 - ESPÍRITO SANTO (ES); 33 - RIO DE JANEIRO (RJ); 35 - SÃO PAULO (SP); 41 - PARANÁ (PR); 42 - SANTA CATARINA(SC); 43 - RIO GRANDE DO SUL (RS); 50 - MATO GROSSO DO SUL (MS); 51 - MATO GROSSO (MT); 52 - GOIÁS (GO); 53 -DISTRITO FEDERAL (DF).

$$\Lambda = I_{26} \otimes W_s \tag{5.4}$$

where I_{26} is the 26 by 26 identity matrix and $\otimes$ is the Kronecker operator. Thus Λ is a 26^2 by 26^2 block diagonal matrix in which the diagonal partitions are formed by W_s.

As it will be seen in the next section, spatial correlation was not found in any of the estimated models (see Tables 5.4 to5.7), and because of this there was no necessity to model it using a more sophisticated procedure.

As seen in Appendix C, the absence of spatial correlation in the residuals may occur even if there is spatial dependence in the intercepts. Because of this, we applied a FAR model using the intercepts as dependent variables in order to detect this type of spatial correlation.

5.4 Discussion of the Results

Table 5.4 shows the estimation results for the time-effects. As one can see, most of these effects are not statistically significant. Exceptions may exist for the coefficients associated with the years of 1997 and 1998. The parameter γ_{1997} is significant in the IWLS and in the 2SIWLS models and it is positive in all models except the DVLS. In the case of γ_{1998}, this coefficient is positive and significant in all models if one considers a 10% level in all cases.

This fact may be explained by the implementation of the 1997 *State Debt Renegotiation Act*, which was concluded in 1998 and resulted in massive transfers of

Table 5.4:

Results of the Estimations: Yearly Time Effects

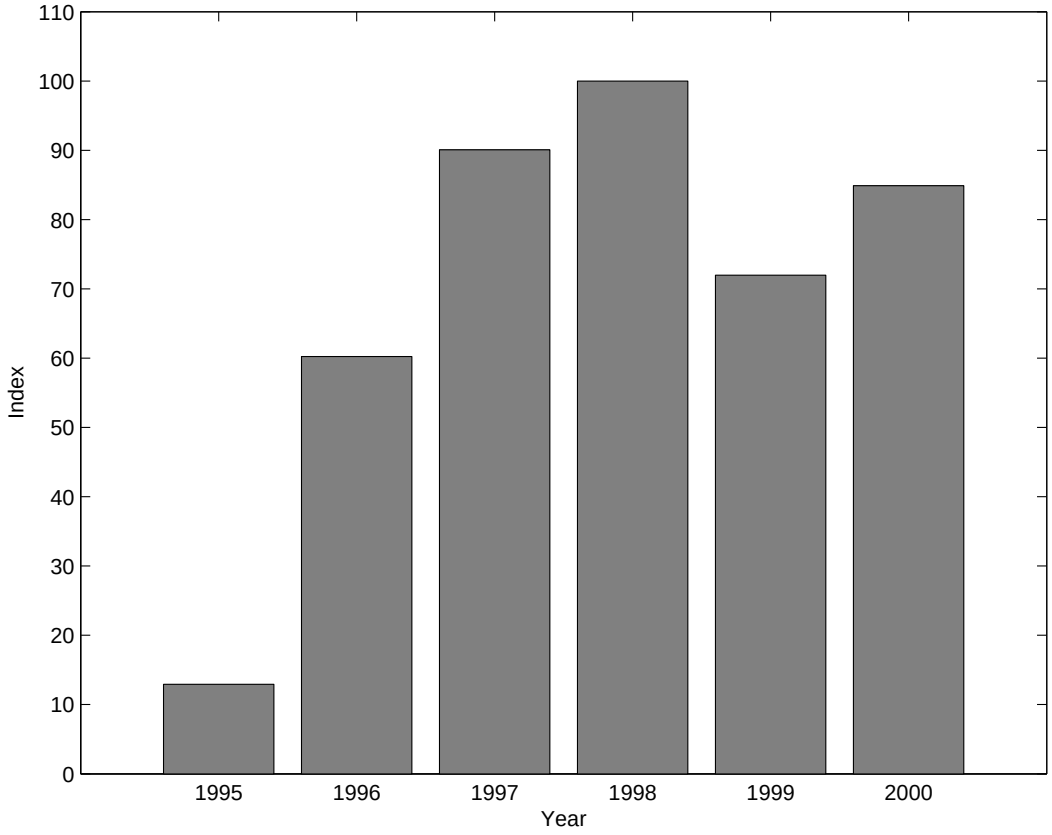
Model → Variable ↓	DVLS	IWLS	2SLS	2SIWLS
γ_{1995}	-0.03088**	-0.00548	-0.03027**	0.00395
	0.0168 W 0.0210	0.0061	0.0168 W 0.0211	0.0034
γ_{1996}	-0.02318	-0.00295	-0.02276	0.02101*
	0.0159 W 0.0168	0.0048	0.0168 W 0.0173	0.0040
γ_{1997}	-0.00004	0.01464*	0.00030	0.03348*
	0.0138 W 0.0127	0.0036	0.0139 W 0.0128	0.0063
γ_{1998}	0.02371*	0.02790*	0.02376**	0.00939**
	0.0115 W 0.0095	0.0027	0.0123 W 0.0105	0.0049
γ_{1999}	-0.00094	0.00773*	-0.0009	0.00346
	0.0113 W 0.0098	0.0028	0.0115 W 0.0097	0.0062

Standard errors and White standard errors (W) below estimates.
*Significant at 5% level.
**Significant at 10% level.

capital from the federal government to the indebted states. As these transfers are computed as "Discretionary Federal Resources Transfers", we might expect to find a shift in the intercept in that year. Figure 5.5 shows that the level of the "Capital Transfers" from the federal government to the states is unambiguously larger in 1997 and 1998.

In the case of the cross-sectional effects, most of them were independently significant (see Table 5.5) and furthermore, they showed spatial correlation when one

Figure 5.5: Yearly Capital Transfers from Federal to State Governments



considers the estimates obtained from the DVLS and 2SLS[13]. This spatial correlation can be appreciated in the maps of Figure 5.6. There, one can see that the states with high cross-sectional effects are those in the south and southeast region, while the low cross-sectional effects are mostly present in states of the northeast region. Most of the central states have a medium cross-sectional intercept.

It is interesting to notice that the spatial correlation was not detected in the residuals, as can be verified by the observation of the t-statistics in the fifth row of Table 5.7. This means that the spatial dependence is not present in the errors generating process.

[13] Asymptotic t-statistics of 3.253 and 3.444, respectively. The IWLS and 2SIWLS estimation did not produce spatially correlated intercepts.

Instead, this dependence appears in the generation of the intercepts, which can be viewed as an unconditional initial voluntary resource transfer endowment.

This pattern shows, beyond the spatial correlation, a positive relation with states' wealth. Probably, this effect is associated with the public capital stock, which is greater in southern states and requires resources for its maintenance and operation. It is also probably masking the influence of the state GDP over the distribution of voluntary resources (see the later discussion of the coefficient of SGDP).

Table 5.6 shows the estimates of the exogenous variables other than the dummy variables. One can see that the estimates for the effect of per capita local revenue (LR) and of per capital local debt service (LDS) were not significant in any of the estimation models. In the first case, this finding might result from the failure to consider the differences in states' potential tax collection. Since states and municipalities have distinct tax bases and economic development, it would be expected that, with the same fiscal effort, some states would collect more taxes than others. As the utilized variable only considers the absolute per capita value, this fact is not considered in the estimation.

The problem with the estimated coefficients associated with LDS may come from a number of factors, but the most important is the pattern of the compensation for localities with high levels of debt. Most of these payments do not come from regular, yearly transfers. Instead, they take the form of sporadic bailouts in the form of capital transfers. These transfers probably appear in the estimation as outliers and are not fully captured by the estimators. This pattern of compensation is likely hiding the expected positive relationship between the payment of debt services and

Table 5.5:

Results of the Estimations: State Cross-Sectional Effects

Model → / Variable ↓	DVLS	IWLS	2SLS	2SIWLS
α_{11}	0.04666**	0.10946*	0.04651	-0.05538*
	0.0277 W 0.0221	0.0366	0.0304 W 0.0247	0.0189
α_{12}	0.12512*	0.08302	0.12368*	0.03177
	0.0549 W 0.0488	0.0635	0.0574 W 0.0522	0.1411
α_{13}	0.32418*	-0.12274*	0.32366*	0.07694*
	0.0573 W 0.0755	0.0168	0.0578 W 0.0763	0.0183
α_{14}	0.36032*	0.00116**	0.35809*	0.23643*
	0.066 W 0.0698	0.0007	0.0673 W 0.0733	0.0318
α_{15}	-0.03197	0.21018*	-0.03287	0.01659
	0.0411 W 0.0346	0.0224	0.0425 W 0.0361	0.0141
α_{16}	0.21620*	-0.07432*	0.21407*	0.06746
	0.0657 W 0.0801	0.0175	0.0688 W 0.0835	0.0416
α_{17}	-0.07776	0.24852*	-0.07869	0.00888*
	0.0501 W 0.0525	0.0362	0.05 W 0.0520	0.0041
α_{21}	-0.17168*	0.03405**	-0.17292*	-0.06994*
	0.0591 W 0.0588	0.0189	0.06 W 0.0590	0.0085
α_{22}	-0.17759*	0.07014*	-0.17800*	-0.06562*
	0.0545 W 0.0621	0.0157	0.0553 W 0.0622	0.0084
α_{23}	-0.00722	0.20780*	-0.00762	-0.07126*
	0.0366 W 0.0419	0.0221	0.0369 W 0.0427	0.0248
α_{24}	-0.02002	0.04957	-0.02026	0.02501
	0.035 W 0.0298	0.1699	0.0357 W 0.0303	0.0155
α_{25}	-0.10430*	0.24753*	-0.10446*	-0.02888*
	0.0432 W 0.0449	0.0541	0.0454 W 0.0461	0.0031
α_{26}	-0.05305**	0.09584*	-0.05288	-0.00625*
	0.0319 W 0.0288	0.0112	0.032 W 0.0289	0.0006
α_{27}	-0.04669	0.24156*	-0.04845	-0.12178*
	0.0518 W 0.0424	0.052	0.0522 W 0.0431	0.0271
α_{28}	-0.02573	0.00426*	-0.02627	0.01002*
	0.0333 W 0.0270	0.0012	0.0334 W 0.0270	0.002
α_{29}	-0.06789*	0.07795*	-0.06793*	-0.15890*
	0.0262 W 0.0215	0.0272	0.0274 W 0.0223	0.0253
α_{31}	0.10025*	0.09464*	0.10114*	0.04100
	0.0388 W 0.0370	0.0125	0.041 W 0.0374	0.0442
α_{32}	0.1546*	0.20364*	0.15549*	0.06492**
	0.0474 W 0.0528	0.0173	0.0476 W 0.0522	0.036
α_{33}	0.53423*	0.00407*	0.53497*	0.24873*
	0.0866 W 0.1118	0.0017	0.0882 W 0.1121	0.0163
α_{35}	0.35405*	0.13211*	0.35831*	0.14142*
	0.1337 W 0.1344	0.0252	0.1341 W 0.1313	0.0542
α_{41}	0.21366*	0.23662*	0.21503*	-0.02457*
	0.0611 W 0.0781	0.0316	0.061 W 0.0769	0.0047
α_{42}	0.28791*	0.09829*	0.28906*	0.21732*
	0.0701 W 0.0814	0.0136	0.0716 W 0.0812	0.0634
α_{43}	0.34410*	-0.05755*	0.34505*	0.06431*
	0.0767 W 0.0912	0.0126	0.0769 W 0.0905	0.0114
α_{50}	0.18238*	0.16305*	0.18283*	0.11329*
	0.0384 W 0.0409	0.0295	0.0398 W 0.0412	0.0244
α_{51}	0.15017*	0.08411*	0.15034*	0.10453*
	0.0309 W 0.0276	0.0135	0.0309 W 0.0274	0.0202

Standard errors and White standard errors (W) below estimates.
*Significant at 5% level.
**Significant at 10% level.

Table 5.6:

Results of the Estimations: Exogenous Variables

Model → Variable ↓	DVLS	IWLS	2SLS	2SIWLS
LR	0.01249	-0.00313	0.01399	0.03426
	0.0374 W 0.0262	0.0065	0.1052 W 0.0819	0.0238
NMFT	-0.20057*	-0.09212*	-0.19895*	-0.13990*
	0.067 W 0.0806	0.0241	0.0674 W 0.0828	0.0234
LDS	0.00602	0.00637	0.01212	-0.03087
	0.0706 W 0.0442	0.0115	0.1017 W 0.0656	0.0195
SGDP	-67.32260*	-35.31520*	-67.67743*	-30.66019*
	17.055 W 20.631	6.028	17.975 W 20.823	6.143
SVPP	4.64293*	3.43204*	4.54061*	2.96644*
	2.1961 W 2.3304	0.6821	2.1716 W 2.3755	0.6918

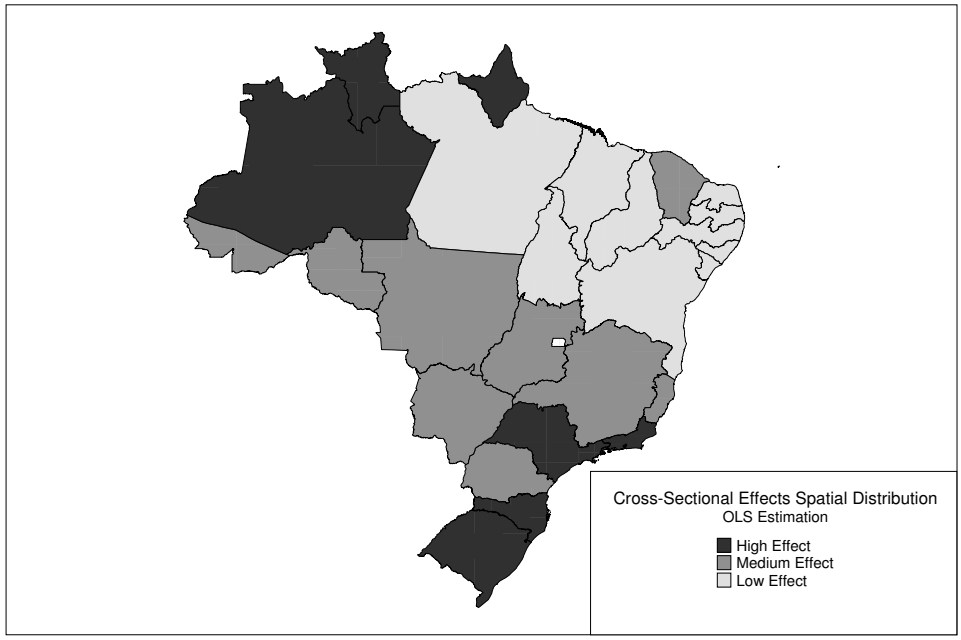
Standard errors and White standard errors (W) below estimates.
*Significant at 5% level.
**Significant at 10% level.

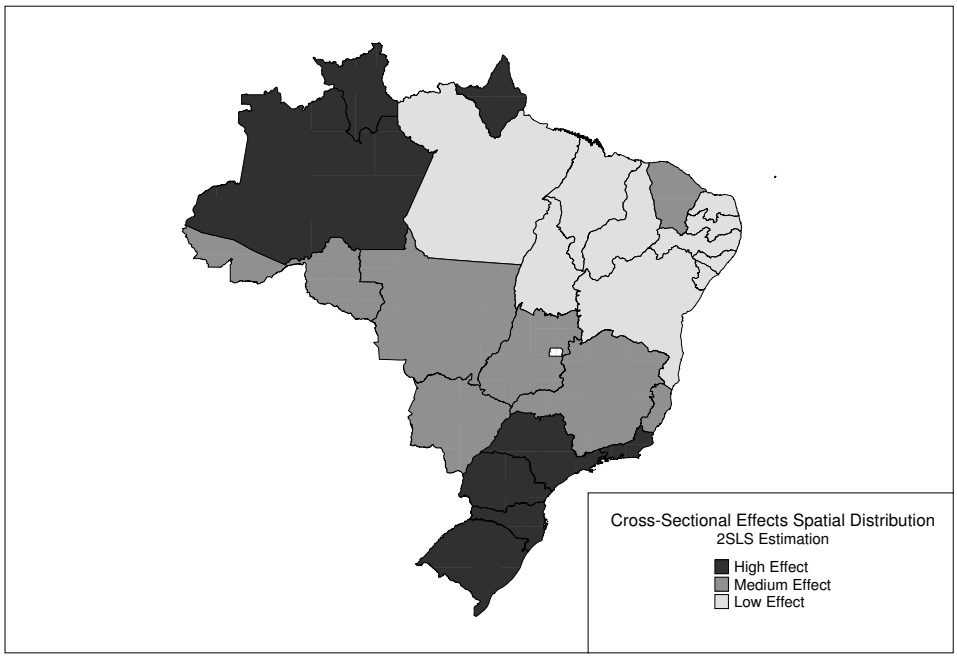
the federal voluntary transfers to states.

At any rate, these to results do not support the hypothesis of existence of *Soft Budget Constraint* in the relationship between Brazilian states and the federal government.

The coefficients associated with the per capita net mandatory federal resources transfers (NMFT) are significant and negative in all estimation models. This means

Figure 5.6: Cross-Sectional Effect Spatial Distribution.





that states that receive large amounts of compulsory transfers are somewhat neglected in the distribution of the discretionary resources.

The magnitude of the coefficients goes from negative 0.0921 to negative 0.2006, which means that for each dollar received as mandatory transfers, there is an average loss of discretionary resources in the range of 9 to 20 cents.

It is worthwhile noticing that the mandatory federal transfers include resources transferred to state and municipal governments, as well as, payments made directly by the federal government to a locality population. Thus, the estimation results show two parallel effects from discretionary resources compensation. The first one is related to the regional equalization scheme. Since states which receive more equalization transfers are neglected in the distribution of discretionary resources, the established redistribution system is somewhat undermined.

Furthermore, this compensation may have a dual effect on the ideal balance between public and private resources. On the one hand, when public resources are directly transferred to private pockets, they naturally lose their public character, i.e., they will be utilized for private consumption. On the other hand, in the presence of the compensation mechanism, this above-average level of payments or transfers to persons would lead to a decrease in the discretionary resources transfers, which are for public consumption.

Thus, from the standpoint of the federation, the central government may be spending an appropriate level of resources in that locality, but from the local population perspective, the level of public good consumption is too small. This phenomenon might explain the situation of some states, like Rio de Janeiro, in which

there is a clear contrast between the spending of the federal government in direct payments to persons (very high) and the level of the public goods and services consumption (very low).

The states gross domestic product (SGDP) has, in all four estimations, negative and significant effects. Their magnitude varies from negative 67.68 to negative 30.66, as SGDP is expressed in Reais millions and the discretionary federal transfers (DFT) in Reais thousands. These coefficients mean that each over-average Real in SGDP decreases the discretionary resource transfers in an amount between 3 and 7 cents.

The theoretical model predicted this negative effect although this result does not support the "too big to fail" effect. In this case the redistributive reason would be stronger than the externalities effects. But a careful interpretation of this result is needed. Observe that the intercept may be absorbing most of the correlation between the endogenous variable and the states' wealth. In fact, when the correlations between the intercepts and the states residential capital are calculated, the obtained values are significantly positive for three (DVLS, 2SLS and SIWLS) of the models considered[14]. Thus, although the coefficient directly associated with SGDP is showing a negative signal, indicating the presence of the distributive motive, one must take in consideration that, as the richer states have a large initial voluntary resource transfer endowment, the "too big to fail" effect can not be ruled out. The

[14] In order to calculate these correlations a series of total residential capital produced by the Brazilian Institute of Applied Economics (IPEA) was utilized. The values found were 0.457 for the DVLS model, 0.461 for the 2SLS model, 0.315 for the 2SIWLS and 0.021 for the IWLS model. The positive correlation hypothesis could not be rejected in the three first models.

effect would be associated in this case with the wealth of the state, not with its income.

Finally, the coefficients associated with the state voters pivotal probability (SVPP) were all positive and significant at the 5% level. These results are consistent with the view that the federal government takes into consideration the proportional political weight of the states when distributing discretionary resources. But one cannot infer from these results that the federal government is purely politically motivated, since the data cannot exclude the possibility of a two-argument (political self-interest and federation well-being) federal government objective function.

The comparison of the coefficients estimated by the DVLS model with those produced by the 2SLS model seems to imply that endogeneity is not present in the data, since the estimates produced by both models are very similar. Likewise, in the case of the heteroscedastic-corrective models (IWLS and 2SIWLS), there are no important discrepancies between the estimated coefficients. Observe that in almost all cases (except in the IWLS coefficient for LR), all the signals are the same for all four models, providing some support for the robustness of the estimations.

The test statistics and other parallel results of the estimated models can be found in Table 5.7. The coefficient of determination of the four models ranges from 0.7878 (2SIWLS model) to 0.8001 (DVLS model), while the adjusted coefficients go from 0.7259 to 0.7418. These numbers are not very high for a panel analysis, but they seem to be satisfactory, especially when one takes into consideration the quality of Brazilian data. The F-statistics are significant for all four models, suggesting the validity of the overall models in explaining the fiscal interaction.

Table 5.7:

Selected Test Statistics for the Estimated Models

Model → Statistics ↓	DVLS	IWLS	2SLS	2SIWLS
R-Square	0.8001	0.7900	0.7999	0.7878
Adj. R-Square	0.7418	0.7288	0.7416	0.7259
F-Statistics	13.723	12.899	13.710	12.730
Fix Effect Rel.	7.7700	6.9147	7.7300	6.7778
Spatial T-Test Residals	0.5733	0.9669	0.6510	1.1450
Spatial T-Test Intercepts	3.2530	-0.8898	3.4438	1.0248

In the fourth row of Table 5.7, one can see the results of the test for panel fixed effects. The statistics showed also have a significant F-statistic indicating that there is substantial gain in the use of the DVLS model instead of a simple cross-section OLS.

The fifth row of the Table 5.7 shows the t-statistics for error spatial dependence. As said before, based on these numbers one could reject the hypothesis of spatial correlation of the residuals, since their level of significance are higher than 25%. But when the intercepts spatial t-statistics are considered, the presence of spatial dependence is clear, at least in the DVLS and 2SLS models. This may imply that although a negative relation between the discretionary federal transfers and

the states GDP has been found in all the estimated models, there is at least a suspicion that these grants are positively related to states' wealth, since the spatial dependence would favor the regions where the richer states are.

Chapter 6

Conclusions

In this dissertation, we have studied the consequences of the Brazilian budgetary process for the functioning of the Brazilian federal system. At the institutional level, it was found that the central government's power of executing unilateral adjustments to budget items makes the distribution of federal resources pronouncedly discretionary. States and municipalities, knowing that the federal government may use this power, could potentially try to exploit it by adopting policies which are not compatible with their budget constraints but are beneficial to their own constituents since they expect the central government to rescue them from their fiscal difficulties.

The theoretical models explored two types of behavior for the central government. In the first, the federal government was benevolent, in the sense that its objective function reflected a weighted sum of the individual state utility functions. In the second model, a principal-agent problem appeared since the central government had a non-altruistic objective function. Namely, it aimed to maximize its reelection probability. Both models were compared with the first-best centralized solution.

In both cases, the reaction functions of the federal government showed some important properties. First of all, they exhibit a negative relationship between local

tax collection and discretionary grant disbursements. This indicates the presence of a soft budget constraint, since it could promote a relaxation in local tax collection efforts. States and municipalities may prefer to depend on transferred resources from the federal government rather than press their constituents for an adequate level of taxes.

The responses of the federal government to variations in debt service paid by local governments also suggest the existence of a soft budget constraint. The more a local government pays in debt service, the more it receives in discretionary transfers. This pattern would allow states and municipalities to overborrow, since the cost will be partially paid by the federation.

Another result of the theoretical model is related to the equalization mechanisms between the states of the Brazilian federation. This equalization is done mainly by compulsory, non-matching grants which transfer resources from richer localities to the poorer ones. The model indicates a negative relationship between this type of grant and the discretionary transfers, which suggests that the equalization mechanisms can be somewhat undermined by the federal government.

These hypotheses were empirically tested and the first two, the negative relation between discretionary grants and local tax collection and the positive relation between discretionary grants and local debt service payments were not supported by the results. Thus, the empirical analysis did not corroborate the hypothesis that Brazilian local governments exploit a soft budget constraint.

Nonetheless, the estimated coefficient of the influence of the compulsory federal transfers to states and municipalities was negative and significant, attesting to the

offsetting effect that discretionary transfers have on the equalization schemes in Brazil.

The empirical analysis also revealed an apparent paradox. Although the distribution of discretionary transfers is negatively correlated with local per capita income, the analysis of the cross-sectional fixed effects showed that higher intercepts are related to richer states. Thus, the "too big to fail" effect described by Wildasin (1997) was likely captured in the fixed effect parameters and only the marginal income effects were left to the per capita income coefficient.

The more important distinction between the two theoretical models concerns the relevance of state political power to federal decisions concerning discretionary transfers. In the altruistic central government model, this variable does not exert any influence over the allocation of federal resources; in contrast, it becomes a major determinant of these allocations when a vote-seeking government is considered. Thus, this political variable was included in the empirical tests in order to examine the real motivation of the Brazilian federal government. The coefficients associated with this variable were positive and significant in all four estimations, which suggests that the federal government in Brazil is not purely altruistic and has political survival concerns.

All these findings point to a number of problems generated by the budgetary system in Brazil. First, even in the case of a non-politically motivated federal government, the present system is likely to produce a non-optimal allocation of federal resources. One manifestation of this phenomenon would be an imbalance between private and public good consumption in favor of the former. This fact has been

observed in Brazil over the last decade. Most of the public budget has been allocated to direct transfers to persons and interest payments, while spending in health, education, investments and other public goods has had only modest increases, or even decreases, in some years.

The cause for this imbalance lies in the partial substitutability between the compulsory and the discretionary federal resource transfers, as detected in the empirical tests. If the federal payroll is large in a certain locality, the discretionary transfers to this jurisdiction will tend to be small. But payroll money will become private consumption, while the discretionary resource transfers take the form of public goods, in general.

As noted above, the sub-optimal proportion between public and private goods consumption may arise even if the federal government does not act politically. However, the empirical tests performed in this dissertation suggest that the Brazilian federal government acts, at least partially, in favor of its own interests.

In this case the budgetary process includes a political component that may cause additional harm to the system. First, it is possible that a marginalization process, as described in Seabright (1996), may occur. In this case, the states or municipalities that are out of the federal government coalition would receive little help from the central power.

Second, the bargaining for local support may result in unacceptable levels of corruption with the federal government buying the individual votes of congressional representatives with personal advantages, or more crudely, with public money. The root of these co-optation or corruption channels is the high discretionary power that

is in the hands of the federal government.

The reforms to confront this tendency toward potential opportunistic fiscal administration have mostly taken the form of tight controls over state and local government fiscal spending and borrowing. Several measures have been adopted in this regard since the first Cardoso administration (1995-1998). They culminated with the implementation of the 1997 Fiscal Responsibility Act that establishes limits for public servants' payroll and debt/revenue ratios, among several other parameters.

Several observations could be made about the 1997 Fiscal Responsibility Act. First, one could point out that it leads to a higher degree of centralization since it constrains state and municipal power over several fiscal decisions.

Second, the Fiscal Responsibility Act does not preclude bailouts. What it does, or tries to do, is to create conditions that make the need for a bailout less likely. However, there have been no changes in the credibility of the federal government no-bailout threat. Indeed, some people see the 1998 state debt renegotiation as a bailout, although its terms were not painless to the states.

Third, it is supposed to limit potential local governments' opportunistic behavior, but it does not intend to constrain federal government's opportunistic behavior.

A truly effective reform of the Brazilian budgetary system would have to include a decrease in this discretionary power. The key aspect is that the Brazilian budget is authoritative, which means that once it has been approved by the congress, the executive branch has the right of spending, but not the duty of spending, the budgeted sums. Thus, the executive is able to make unilateral rescissions without congressional approval. This feature allows the executive to spend discretionary

budgetary resources, creating a channel for local and state government free-rider behavior as well as for pork barrel spending.

The change from an authoritative to a mandatory budget is needed, but it is not a simple matter. There are several difficulties associated with this desirable transition. First, congressmen would have to commit themselves to more realistic revenue and spending forecasts. One of the arguments in favor of the authoritative budgetary system is that it is a flexible way to deal with decreases in estimated tax revenues, since if the estimates are not realized, the federal government may automatically adjust spending to actual tax revenue. However, this argument has lost weight in recent years as inflation rates have decreased to more modest levels in Brazil.

A second argument in favor of the authoritative budgetary system is that this is the only way through which the federal government could possibly generate a primary surplus in order to pay its huge interest bill. Taking into consideration the present political situation in Brazil, one could argue that it is not feasible to generate a primary surplus in the budget by congressional decision. Thus, the only mechanism for the federal government to achieve a surplus in its accounts is to use its discretionary power over the budget and unilaterally save resources to pay its debt service.

As can be seen, there is need for both empirical and theoretical research on these issues. Future research on this topic may include a better way of dealing with the local tax collection effort in the empirical estimations as well as an intertemporal version which would allow a more complete analysis of the impact of the SBC on

local debt administration. Mechanism design studies of the Brazilian budgetary process are also needed in order to improve the efficiency of federation resource use and to avoid the possibility of SBCs. These are only a few topics in the longer agenda needed to improve the operation of the evolving Brazilian fiscal federalism.

Appendix A

Appendix

A.1 MatLab Code for Calculating Pivotal Probabilities

```
        clear
n = 27; k = 17; j = n - k;
base = sparse(ff2n(k));
save BASE base
clear base
aux1 = ff2n(j);
for i = 1:2^j
comp = sparse(kron(aux1(i,:),ones(2^k,1)));
save(strcat('RES', num2str(i)),'comp');
end
clear aux1 comp
        stage = 1
load BASE
load W
[wr, wc] = size(w);
for i = 1:2^j
load(strcat('RES', num2str(i)));
aux2 = [comp base];
aux3 = round(aux2*w);
aux4 = [aux2 aux3];
clear aux2 aux3 comp
save(strcat('RES', num2str(i)),'aux4');
clear aux4
end
clear base w
        stage = 2
```

```
for i = 1:2^j
load(strcat('RES', num2str(i)));
for ii = 1:n
aux5 = sum(kron(aux4(:,ii),ones(1,wc)).*aux4(:,n+1:n+wc));
aux6 = sum((1-kron(aux4(:,ii),ones(1,wc))).*aux4(:,n+1:n+wc));
aux7(ii,:) = [aux5 aux6];
end
save(strcat('RES', num2str(i)),'aux7');
end
clear aux4 aux5 aux6 aux7
      stage = 3
fresa = sparse(zeros(wr,2*wc));
for i = 1:2^j
load(strcat('RES', num2str(i)));
fresa = fresa + aux7;
end
clear aux7

      stage = 4

fres = fresa(:,1:wc) - fresa(:,wc+1:2*wc);

clear fresa

fres=full(fres/(2^n));

save RESF fres;
```

A.2 Intercepts Spatial Dependence and Panel Data Estimation

The objective of this appendix is to show that the spatial correlation of the intercepts may be masked when one is fitting the data with a fixed effect panel data model. In order to detect this spatial dependence a test using the intercept values

is needed. Furthermore, the spatial correlation will be detected in the residuals if a simple cross-section regression is estimated utilizing data of one period only, while it will not appear in the complete panel data estimation.

Suppose the data are generated by the following random process:

$$y = D\alpha + X\beta + \epsilon \tag{A.1}$$

$$\alpha = \rho W\alpha + \mu \tag{A.2}$$

$$\epsilon \sim N(0, \sigma_\epsilon^2 I_{nT}) \tag{A.3}$$

$$\mu \sim N(0, \sigma_\mu^2 I_n) \tag{A.4}$$

$$E[\epsilon\mu'] = 0 \tag{A.5}$$

where y is the vector that contains the values of the endogenous variables, X is now a $nT \times k$ matrix that contains the values of the k exogenous variables for each of the n cross-section units across T periods, ϵ are the regression disturbances, W is the $n \times n$ contiguity matrix, α is the $n \times 1$ fixed effect vector, ρ is the spatial lag of the fixed effects, μ is the fixed effect spatial innovation, I is the identity matrix and D is a $nT \times n$ "dummy" variable matrix with the following structure:

$$D = \begin{pmatrix} \mathbf{i} & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & \mathbf{i} & \dots & \mathbf{0} \\ & & \vdots & \\ \mathbf{0} & \mathbf{0} & \dots & \mathbf{i} \end{pmatrix}$$

where $\mathbf{i}$ is $T \times 1$ collum vector of ones and $\mathbf{0}$ is $T \times 1$ collum vector of zeros.

In this case, one could rewrite equation A.2 in order to express the intercept vector α in the following way :

$$\alpha = (I_n - \rho W)^{-1}\mu = \Theta\mu \tag{A.6}$$

The matrix $\Theta_{n\times n}$ is symmetric, but not necessarily idempotent. From equation (A.6) is possible to compute the covariance matrix of the fixed effects:

$$\alpha\alpha' = \Theta\mu\mu'\Theta' \Rightarrow$$

$$E[\alpha\alpha'] = \Theta E[\mu\mu']\Theta' \Rightarrow$$

$$E[\alpha\alpha'] = \sigma_\mu^2\Theta^2 \tag{A.7}$$

Equation (A.1) may be expressed in another convenient form when equation (A.6) is applied into it:

$$y = [D\ X]\begin{bmatrix} \Theta\mu \\ \\ \beta \end{bmatrix} + \epsilon \tag{A.8}$$

Notice that if one applies the least square dummy variable model (LSDV) in the estimation of the data generated by the process described above, the residuals obtained will not show spatial dependence. In order to see that, first notice that the LSDV estimator is:

$$\begin{bmatrix} \widehat{\alpha} \\ \\ \beta \end{bmatrix} = \left[[D\ X]\begin{bmatrix} D' \\ \\ X' \end{bmatrix}\right]^{-1}\begin{bmatrix} D' \\ \\ X' \end{bmatrix} y \tag{A.9}$$

Thus the residual vector is:

$$\hat{e}_{LSDV} = y - [D\ X]\begin{bmatrix} \widehat{\alpha} \\ \\ \beta \end{bmatrix} \Rightarrow$$

$$\hat{e}_{LSDV} = y - [D\ X] \left[[D\ X] \begin{bmatrix} D' \\ X' \end{bmatrix} \right]^{-1} \begin{bmatrix} D' \\ X' \end{bmatrix} y \Rightarrow$$

$$\hat{e}_{LSDV} = M_z y \tag{A.10}$$

where

$$M_z = \left[I - [D\ X] \left[[D\ X] \begin{bmatrix} D' \\ X' \end{bmatrix} \right]^{-1} \begin{bmatrix} D' \\ X' \end{bmatrix} \right]$$

From equation (A.10) is possible to define the covariance matrix for the LSDV residuals:

$$E\left[\hat{e}_{LSDV}\hat{e}'_{LSDV}\right] = E\left[M_z y y' M_z\right]$$

but notice that, from equation (A.8):

$$M_z y = \left[I - [D\ X] \left[[D\ X] \begin{bmatrix} D' \\ X' \end{bmatrix} \right]^{-1} \begin{bmatrix} D' \\ X' \end{bmatrix} \right] \left[[D\ X] \begin{bmatrix} \Theta\mu \\ \beta \end{bmatrix} + \epsilon \right] \Rightarrow$$

$$M_z y = \epsilon - [D\ X] \left[[D\ X] \begin{bmatrix} D' \\ X' \end{bmatrix} \right]^{-1} \begin{bmatrix} D' \\ X' \end{bmatrix} \epsilon \Rightarrow$$

$$M_z y = M_z \epsilon$$

this also implies that:

$$y' M_z = \epsilon' M_z$$

and thus:

$$E\left[\hat{e}_{LSDV}\hat{e}'_{LSDV}\right] = E\left[M_z\epsilon\epsilon' M_z\right] \Rightarrow$$

$$E\left[\hat{e}_{LSDV}\hat{e}'_{LSDV}\right] = M_z E\left[\epsilon\epsilon'\right] M_z \Rightarrow$$

$$E\left[\hat{e}_{LSDV}\hat{e}'_{LSDV}\right] = \sigma_\epsilon^2 M_z \tag{A.11}$$

since M_z is an idempotent matrix.

Equation (A.11) shows that the covariance matrix does not exhibit spatial correlation. Thus, if there is spatial dependence in the cross-section intercepts the test of the LSDV residuals will not detect it.

It is interesting to notice that, if one estimates the same data set with the OLS model, i.e. without using the cross-section fixed effect dummies, the intercepts spatial dependence will spillover to the residuals. Consider the simple OLS estimator:

$$\beta_{OLS} = \left(X'X\right) X'y \tag{A.12}$$

Equation (A.12) implies that the OLS residuals are:

$$\hat{e}_{OLS} = y - X\beta_{OLS} = y - X\left(X'X\right) X'y \Rightarrow$$

$$\hat{e}_{OLS} = M_x y \tag{A.13}$$

where:

$$M_x = I - X\left(X'X\right) X'$$

Thus the covariance matrix of the OLS residuals is:

$$E\left[\hat{e}_{OLS}\hat{e}'_{OLS}\right] = E\left[M_x y y' M_x\right]$$

From equation (A.8):

$$M_x y = \left[I - X\left(X'X\right)X'\right]\left[D\Theta\mu + X\beta + \epsilon\right] = M_x\left[D\Theta\mu + \epsilon\right]$$

and thus:

$$y'M_x = \left[\mu'\Theta'D' + \epsilon'\right]M_x$$

This implies that:

$$\hat{e}_{OLS}\hat{e}'_{OLS} = M_x yy'M_x = M_x\left[D\Theta\mu + \epsilon\right]\left[\mu'\Theta'D' + \epsilon'\right]M_x \Rightarrow$$

$$\hat{e}_{OLS}\hat{e}'_{OLS} = M_x\left[D\Theta\mu\mu'\Theta'D' + D\Theta\mu\epsilon' + \epsilon\mu'\Theta'D' + \epsilon\epsilon'\right]M_x \Rightarrow$$

$$E\left[\hat{e}_{OLS}\hat{e}'_{OLS}\right] = E\left[M_x\left[D\Theta\mu\mu'\Theta'D' + D\Theta\mu\epsilon' + \epsilon\mu'\Theta'D' + \epsilon\epsilon'\right]M_x\right] \Rightarrow$$

$$E\left[\hat{e}_{OLS}\hat{e}'_{OLS}\right] = M_x\left[D\Theta E\left[\mu\mu'\right]\Theta'D' + D\Theta\left[\mu\epsilon'\right] + \left[\epsilon\mu'\right]\Theta'D' + \left[\epsilon\epsilon'\right]\right]M_x \Rightarrow$$

$$E\left[\hat{e}_{OLS}\hat{e}'_{OLS}\right] = \sigma^2_\mu M_x D\Theta^2 D M_x + \sigma^2_\epsilon M_x \tag{A.14}$$

Equation (A.14) shows that the OLS residuals covariance matrix depends on the fixed effect innovation variance σ^2_μ, as well as on the contiguity matrix W and on the fixed effects spatial lag ρ (since $\Theta = (I - \rho W)^{-1}$). This means that the fixed effect spatial dependence will manifest itself in over the OLS residuals when a simple OLS (without fixed effects) is utilized to fit the data.

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