Textos para Discussão FEE N°21

Secretaria do Planejamento e Gestão
Fundação de Economia e Estatística Siegfried Emanuel Heuser

Evaluating regional tax competition and the role of central government in Brazil

Alexandre A. Porsse

Eduardo A. Haddad

Eduardo P. Ribeiro

Porto Alegre, novembro de 2007

GOVERNO DO ESTADO
RIO GRANDE DO SUL

SECRETARIA DO PLANEJAMENTO E GESTÃO

Secretário: Ariosto Antunes Culau

Fundação de Economia e Estatística

TEXTOS PARA DISCUSSÃO

Publicação cujo objetivo é divulgar resultados de estudos direta ou indiretamente desenvolvidos pela FEE, os quais, por sua relevância, levam informações para profissionais especializados e estabelecem um espaço para sugestões. As opiniões emitidas nesta publicação são de exclusiva e de inteira responsabilidade do(s) autor(es), não exprimindo, necessariamente, o ponto de vista da Fundação de Economia e Estatística.

www.fee.tche.br

Evaluating regional tax competition and the role of central government in Brazil

Alexandre A. Porsse — *Foundation of Economics and Statistics Siegfried Emanuel Heuser, R. Duque de Caxias, 1691, 90010-283, Porto Alegre, Brazil.*
e-mail: porsse@fee.tche.br

Eduardo A. Haddad — *Department of Economics, University of São Paulo, Av. Prof. Luciano Gualberto, 908, Butantã, 05508-900, São Paulo, Brazil.*
e-mail: ehaddad@usp.br

Eduardo P. Ribeiro — *Economics Institute, Federal University of Rio de Janeiro, CNPq researcher and Department of Economics, Federal University of Rio Grande do Sul, Av. João Pessoa 52, 90040-000, Porto Alegre, Brazil.*
e-mail: eribeiro@ie.ufrj.br

Abstract

This paper analyses if income tax policy of central government does matter for the equilibrium of regional tax competition in Brazil due its potential effects on fiscal budget of regional governments. An interregional CGE model calibrated for the Brazilian economy is used to evaluate an experimental tax competition game where regional governments use indirect tax rate as strategies to attract investments and expect to guarantee fiscal solvency by transfers from central government and central government adjusts its income tax policy as reaction of this tax competition game. The results show that Nash equilibrium is race-to-the-top and welfare improving because the optimum strategy of central government is to reduce the income tax rate. This forces regional governments to raise tax rate to achieve the fiscal solvency rule. The central government behavior works as a fiscal compensation for the households, but the welfare gain is a fiscal illusion because it is accomplished by reductions in GDP and employment at the equilibrium.

Keywords: regional tax competition, fiscal federalism, interregional CGE model

Classification JEL: H39, H73, R13

1 Introduction

This paper reports some experimental results of a CGE analysis carried out for evaluate the welfare effects of a regional tax competition game taking account that also central (Federal) government is an active player in the game. Theoretical issues on horizontal tax competition usually are concerned on the welfare effects of strategic interactions between governments at the same level (Mintz and Tulkens, 1986; Zodrow and Mieszkowski, 1986; Wildasin, 1988). While these approaches can be appropriated for analysis of tax competition between national governments, they not necessarily take account all aspects of a horizontal tax competition among sub-national governments, such as states or municipalities. In a federal system where vertical linkages play an important role for the budget revenue of regional governments, the tax policy of central government can influence the tax policy of regional governments and therefore the result of regional tax competition. In fact, Wellisch (2000) has argued that the social cost of reduction in regional provision of public goods would be reduced if the transfers received by regional government from central government were conditioned by the results of the regional tax collection. Here, we aim to analyze if vertical linkages of Brazilian federalism could be an endogenous mechanism to refrain regional tax competition when the income tax policy of central governments is conditioned to the tax competition behavior of regional governments.

The Brazilian case is very interesting because its complex fiscal federalism system, with hard vertical linkages imposed by constitutional rules. Part of the income tax revenue collected by Federal government should be transferred for regional governments, but the level of income tax rate is exclusively defined by Federal government. Looking for the Federal government revenues at last decades, the contributions receipts have grown more than income tax receipts since the first one don't imply transfers to regional governments. In addition, many Brazilian states have used fiscal instruments to attract business investments and the increase in tax revenues of regional governments has not followed the social demand for public goods. As a result, regional governments recurrently claim for more transfers from Federal government. In this sense, this paper aims to investigate if the policy decision of Federal government on its income tax rate can affect the results of a tax competition game between regional governments. In special, we are interested in analyses if an active reaction of Federal government conditional to regional tax competition can reduce or eliminate the incentives for the called "fiscal war" in Brazil.

The simulation results are based on B-MARIA-RS model, an interregional CGE model calibrated for two Brazilian regions, Rio Grande do Sul and Rest of Brazil. CGE models are interesting and promising tools to evaluate quantitatively tax competition as they incorporate important general equilibrium effects in the analysis and it can focus on actual welfare estimates instead of focusing on revenues or fiscal budgets only.

The remainder of the paper is organized in five sections. After this introduction, the next section presents a summary view of B-MARIA-RS model and its theoretical economic structure. Section 3 describes some important aspects of the public finance module and presents the modeling strategy

adopted to implement the simulation of a non-cooperative game between the regional governments. The main causal relationships of the tax competition game are discussed in section 5 and the simulation results are reported and analyzed in the following section. Final remarks follow in the last section in an attempt to evaluate our findings and put them in perspective, considering their extension and limitations. The Appendix in the end of the paper presents the equations, variables and parameters of the core module of B-MARIA-RS.

2 The B-MARIA-RS model

In order to evaluate the welfare and fiscal effects of regional tax competition in Brazil, an interregional CGE model was developed and implemented (B-MARIA-RS). The structure of the model follows the Brazilian Multisectoral and Regional/Interregional Analyses Model (B-MARIA), the first fully operational interregional CGE model for Brazil; full details of the model may be found in Haddad and Hewings (1997) and Haddad (1999) and will not be presented here in details. The functional forms of the main groups of equations of the CGE core are presented in the Appendix A together with the definition of the main groups of variables, parameters and coefficients. The interregional version of B-MARIA used in this research recognizes 2 Brazilian regions. The first one is Rio Grande do Sul, the fourth Brazilian state economy which has been an important player in the fiscal competition game in Brazil at last decade. The second one is Rest of Brazil, a region that encompasses all other 26 Brazilian states. The B-MARIA-RS model contains over 60,300 equations and 1,500 exogenous variables. Agents' behavior is modeled at the regional level, accommodating variations in the structure of regional economies. Results are based on a bottom-up approach – national results are obtained from aggregation of the regional results. The model identifies twenty five sectors in each region producing twenty five commodities, one representative household in each state, regional governments and Federal government, and a single foreign consumer who trades with each region. Special groups of equations define government finances, accumulation relations, and regional labor markets. The public finance module recognizes vertical linkages between regional governments and Federal government in accordance with the constitutional rules of Brazil. The model is calibrated for 1998 based on an input-output database of Rio Grande do Sul integrated with an input-output database estimated for the Brazilian economy (Porsse, Haddad and Ribeiro, 2004).

Previous analysis with the B-MARIA framework has suggested that interregional substitution is the key mechanism that drives the model's spatial results. In general, interregional linkages play an important role in the functioning of interregional CGE models. These linkages are driven by trade relations (commodity flows) and factor mobility (capital and labor migration). Both of them are crucial to evaluate the effects of regional tax competition because changes in tax rate imply changes in relative prices of goods and factors, and should conduct to changes in the regional trade balance and reallocations of the productive factors across regions. Interregional trade flows should be incorporated in the model, so interregional input-output databases are required to calibrate the model. Regional trade elasticities also play an important role in the adjustment process.

The closure rules define the characteristics of factor mobility. As is usual with CGE models, the number of unknowns exceeded the number of equations and short-run or long-run closure rules should be defined. In the long-run (steady-state) equilibrium closure, capital is mobile across regions and industries. Capital and investment are generally assumed to grow at the same rate. The main differences from the short-run are encountered in the labor market and the capital formation settings[1]. In the first case, aggregated employment is determined by population growth, labor force participation rates, and the natural rate of employment. The distribution of the labor force across regions and sectors is fully determined endogenously. Labor is attracted to more competitive industries in more favored areas. While in the same way, capital is oriented towards more attractive industries. This movement keeps rates of return at their initial levels. Since factor mobility is crucial for the regional tax competition process, only the results from long-run closure will be presented.

3 Modeling strategy: tax competition game

The public finance module in B-MARIA-RS has equations fully modeling the components of the government's budget at the regional and Federal levels. The vertical linkages also are modeled and represent a further development of the public finance module in B-MARIA. In accordance with the Brazilian constitutional rules, 21.5% of the income tax revenue and 21.5% of the industrial commodity tax revenue collected by Federal government are transferred to regional governments. It's worth to note that the choice of the tax rates is an independent policy decision from the Federal government and can be an important channel of influence on the regional governments' behavior.

Figure 1 highlights the governments' budget in B-MARIA-RS and Table 1 reveals the importance of specific tax revenues for the whole fiscal budget. Indirect commodity taxes are the main source of tax revenue for regional governments, while income taxes and payroll taxes are the main source of tax revenue for Federal government. The Federal grants represent almost 4% of the regional government revenue[2]. The indirect commodity tax revenues from regional governments are computed only from an excise tax denominated ICMS in B-MARIA-RS, which is the main strategic tax in the regional tax competition game among the Brazilian states[3]. Then, the other indirect tax revenues encompass the indirect tax receipts from municipalities of each region.

---

[1] In addition to the assumption of interindustry and interregional immobility of capital, the short-run closure would include fixed regional population and labor supply, fixed regional wage differentials, and fixed national real wages. Regional employment is driven by the assumptions on wage rates, which indirectly determine regional unemployment rates. On the demand side, investment expenditures are fixed exogenously – firms cannot reevaluate their investment decisions in the short-run. Further, technology variables are exogenous.

[2] The other revenues presents a high share in the budget database because of PROES, a Federal program that aided the public finance of state governments. Currently, the ICMS tax revenue and the Federal transfers represents 55% and 18% of the budget revenue of Rio Grande do Sul government.

[3] Technically, state indirect taxes cannot be reduced unilaterally by a single state. Such tax reductions need to be unanimously approved in a states' fiscal council (CONFAZ). State tax competition measures are usually implemented by means of tax deferrals with negative interest rates that mimic, in practice, tax rate reductions (Shah, 1991).

In order to evaluate the effects of regional tax competition, the ICMS tax rate is assumed as the strategic variable of policy decision of the regional governments for attraction of business investments. Specifically, the simulation is implemented assuming that regional governments play an one-shot non-cooperative game applying percentage changes in ICMS tax rate on manufacturing goods to promote reallocations of the productive factors. The goal of regional governments is to increase the welfare of the regional representative household. Capital and labor are allowed mobile. A fiscal solvency rule should be defined and is a key aspect of the tax competition game. Usually, the theoretical issues on tax competition assume that public goods consumption is adjusted in order to guarantee the budget balance. But here we assume that regional governments do not wish to charge the costs of reductions in the public goods consumption due the electoral implications in the political cycle, so they expect to achieve the budget balance by transfers from Federal government. In the sense to analyses if the Federal government plays an important role in the regional tax competition, we assumes that its income tax policy is conditioned by the regional tax competition policy but the changes in the income tax rate aims to maximize the welfare of the national representative household. In summary, the income tax rate are endogenously adjusted to guarantee the fiscal solvency of the regional governments' budget, but the decision of the Federal government is based on the welfare of the national representative household. Then, the Federal government also is an active player in the tax competition game.

Figure 1. Structure of the public finance module and vertical linkages

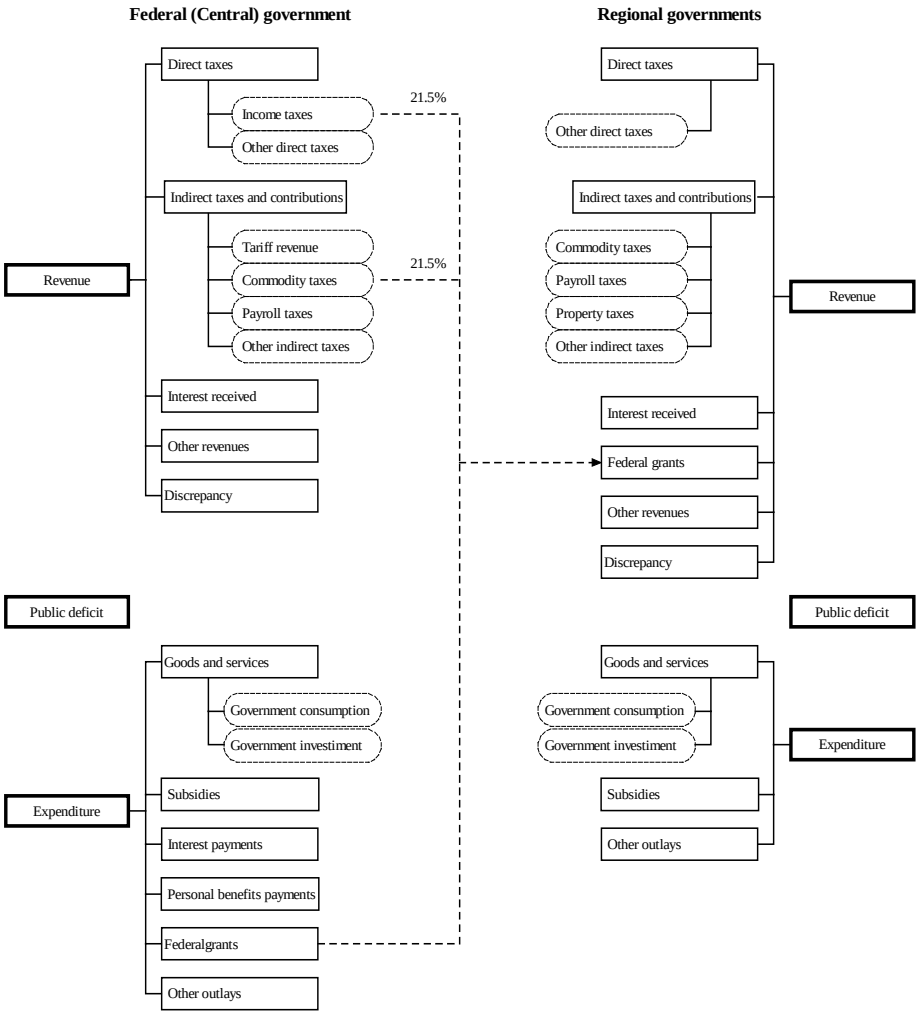


Table 1

Composition of the government revenues in B-MARIA-RS (%)

Components	Rio Grande do Sul	Rest of Brazil	Federal
Government revenue	100.0	100.0	100.0
Direct taxes	0.9	0.7	22.7
Income taxes	0.0	0.0	16.7
Other direct taxes	0.9	0.7	6.0
Indirect taxes and contributions	42.1	47.4	37.0
Tariff revenue	0.0	0.0	2.6
Commodity taxes	34.5	40.1	7.3
Payroll taxes	2.9	2.1	25.0
Property taxes	2.9	4.9	0.0
Land taxes	0.0	0.0	0.0
Other indirect taxes	1.8	0.3	2.1
Interests received	1.5	1.5	7.1
Federal transfers	4.2	4.3	0.0
Other revenues	51.3	46.0	33.2

The game's payoffs are calculated by a welfare measure that combines additively the Hicksian measure of *relative* equivalent variation with the percentage changes in the provision of regional public goods post-simulation the tax competition policy. The first one is defined as the *percentage change* of the benchmark income the representative household would need in order to get a post-simulation utility under benchmark prices (Bröcker, 1998). Formally, for linear utility functions, the welfare measure used to compute the payoffs of the tax competition game it can be written as[4]:

$$w^r = \theta_u \frac{u^r(1)-u^r(0)}{u^r(0)} + \theta_g \frac{g^r(1)-g^r(0)}{g^r(0)}, \qquad \theta_u + \theta_g = 1 \tag{1}$$

where $u^r(1)$ is the post-shock private consumption utility, $u^r(0)$ is the benchmark private consumption utility, $g^r(1)$ is the post-shock public good consumption, $g^r(0)$ is the benchmark public good consumption and θ_U and θ_G are the private and public goods shares of the representative household consumption. In fact, the second component of equation 1 could be dropped because the fiscal solvency rule imposes that provision of public good is exogenous and, then, will remain at the initial level.

Following Mendoza and Tesar (2003) with some adaptations, we can define the Nash equilibrium of this regional tax competition game as a pair of percentage changes in ICMS tax rates from regional governments (τ^{RS}, τ^{RB}) and one income tax rate from Federal government (τ^{CG}) whose payoffs $u^{RS}(\tau^{RS} \mid \tau^{RB}, \tau^{CG})$, $u^{RB}(\tau^{RB} \mid \tau^{RS}, \tau^{CG})$ $u^{RS+RB}(\tau^{CG} \mid \tau^{RS}, \tau^{RB})$ are evaluated under these conditions:

i) τ^{RS} maximizes $u^{RS}(\tau^{RS} \mid \tau^{RB}, \tau^{CG})$ given τ^{RB} and τ^{CG};

ii) τ^{RB} maximizes $u^{RB}(\tau^{RB} \mid \tau^{RS}, \tau^{CG})$ given τ^{RS} and τ^{CG};

iii) τ^{CG} maximizes $u^{RS+RB}(\tau^{CG} \mid \tau^{RS}, \tau^{RB})$ given τ^{RS} *and* τ^{RB};

iv) the payoffs are supported by the prices and allocations corresponding the competitive equilibrium for $(\tau^{RS}, \tau^{RB}, \tau^{CG})$ and τ^r $(r = RS, RB) \in [-0.10, +0.10]$;

v) the fiscal solvency rules are satisfied for the regional and federal governments.

Note that we have defined *ad hoc* that the range of ICMS tax rates changes is 10%, that is, the strategies set of the regional governments is composed by percentage changes in tax rates limited to the space *[-0.10, +0.10]*. This *ad hoc* rule was imposed for operational reasons, but also because the empirical variability of ICMS tax rate is not very high[5]. Such low variance can be explained because, on one hand, the increase in tax rates produce a higher cost of living for citizens and, on the other hand, governments dislike reductions in tax rates because this constraint their public policies. Usually, the theoretical literature on tax competition assumes that there is no limit for variations in tax rate by the governments engaged in a tax competition game. But, of course, such assumption is unrealistic because it ignores that the tax policy decision of a policymaker can affect its permanence in the office

[4] See Layard and Walters (1978) for details on the equivalent variation concept and Almeida (2003) for derivations of the relative equivalent variation when handling linear utility functions.

[5] The coefficient of variation of the effective ICMS tax rates in Brazil was 11.2% between 1988 and 2004.

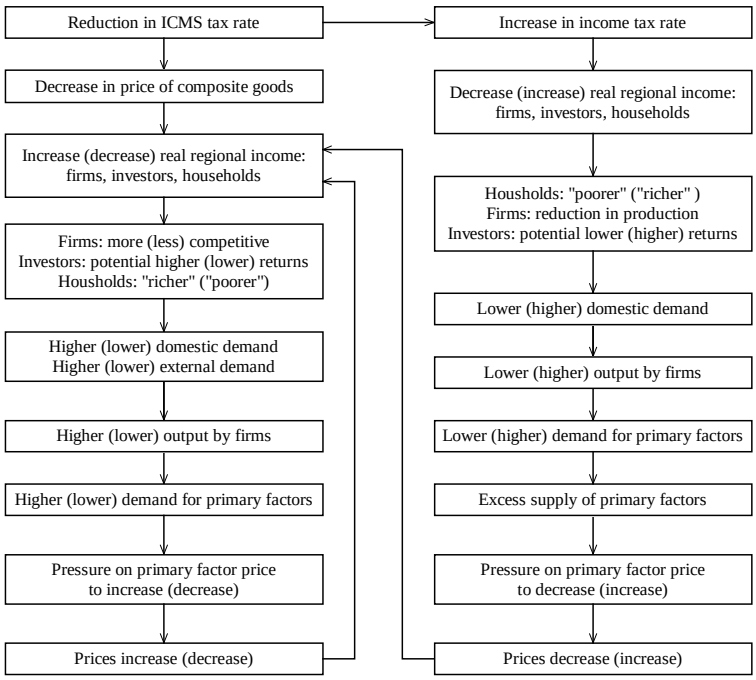
over the political cycle. It seems very plausible that there is a threshold range for changes in tax policy by the governments.

4 Main causal relationships in simulation

The welfare effect of the regional tax competition policy presented in previous section will depend on two major forces that move in opposite directions. Both taxes changes in the tax competition game have a direct linkage with the welfare index. The changes in ICMS tax rate affect the basic prices of goods while the changes in income tax rate affect the disposable income, and both effects are relevant for the Hicksian welfare measure. On one hand, if regional governments reduce the ICMS tax rate, the representative household can be better off because the decreases in prices of private goods. But, on the other hand, the Federal government should increases the income tax rate to ensure the fiscal solvency rule and this causes reduction in disposable income and therefore in the household welfare. At the Nash equilibrium, the net effect on welfare of the representative household is conditioned by these two forces.

Figure 2 highlights the impacts broken out by the policy decisions involved in this tax competition game. Assuming that regional governments reduce the ICMS tax rate, the price of composite commodities decreases and causes positive effects on real regional income. Firms become more competitive as the cost of production also declines – investors foresee potential higher returns – and households increase their real income, envisaging higher consumption possibilities. Higher incomes generate higher domestic demand, while increases in the competitiveness of national products stimulate external demand. This promotes increasing in firm's output that will require more input and primary factors. Increasing demand puts pressure on the factors markets for price increases, with a concomitant expectation that the prices of domestic goods would increase. Since both regional economies experiment these effects and capital and labor are mobile, there is a high pressure for increases in the price of factors. But these movements are countervailing by the increase in income tax rate that is needful to guarantee the fiscal solvency rule. As a result, the household disposable income decreases and reduces the domestic demand. Firms reduce the production, the demand for primary factor and the investments. Decreasing demand puts pressures on the factors market for price decreases which reduce the cost of production. As the costs of production go down, investors perceive potential higher returns and can recover the production level. With lower costs of production, prices of goods will be lower and real income of household rises.

Figure 2. Causal relationships in the simulation



Aside with mobility of factors, four major forces – two price effects and two income effects – operate in the tax competition closure and the net result will depend on the structure of the integrated interregional system. On basis of regional performance, two substitution channels through price effects are involved in the adjustment process. First, there is a direct substitution effect because both regions reduce the ICMS tax rate and, then, both regional prices of goods decrease. As the competitiveness of the regional economies rises, Rio Grande do Sul will increase its penetration in Rest of Brazil as it will now be cheaper for the agents in Rio Grande do Sul to buy from Rest of Brazil. Second, an indirect substitution effect operates in the sense that regions buy inputs at the interregional trade market. As the input prices in both regions are now lower, the interregional trade volume rises. These price effects contribute to expand the output of regions.

However, the other two income effects have not a clear net impact. With the increase in real household income due the reductions in price goods, the demand for domestic products would increase and put pressures on prices, countervailing the positive impacts from the direct and indirect substitution. But conversely, the increase in the income tax rate by Federal government, in order to maintain the fiscal solvency of the regional governments, works as a negative income effect. Then, the reduction in disposable income forces the decrease in demand for domestic products and can compensate or even overcome the first income effect. The net welfare effect will depend on the final result of these income effects and on the direct and indirect substitution effects.

5 Results

A four-step Euler procedure is adopted in the solution the model and the results are reported as percentage changes from the benchmark database. Table 2 presents the payoffs matrix for the regional tax competition game simulated using B-MARIA-RS model. The third column for each strategy indicates the national payoff, which is the goal of Federal government. The payoffs are positive only when Federal government plays decreases in income tax rate. Since payoffs are negative when regional governments play reductions in ICMS tax rate, this suggests that the welfare benefits generated by decreases in prices of goods are lower then the welfare costs from the increases in income tax rate which is needful to guarantee the fiscal solvency of regional governments. As Federal government aims to maximize the national household welfare, its optimum strategy is to play reductions in income tax rate, compelling regional governments to increases ICMS tax rate. Then, the Nash equilibrium is race-to-the-top and welfare improving. The welfare benefits for regional and national households generated by the decrease in income tax rate is big enough to compensate the welfare losses associated with the increases in ICMS tax rate.

Table 2

Payoffs matrix of the regional tax competition game

Strategies		RB					
		-0.10			0.10		
RS	-0.10	-0.613	-1.229	-1.179	0.149	1.028	0.956
	0.10	-0.172	-1.029	-0.958	**0.612**	**1.237**	**1.186**

Source: Calculated by the authors.
Notes: The strategies are percentage changes in indirect tax rate of manufacturing goods by the regional governments and changes in income tax rate by the Federal government. The payoffs were calculated as defined in equation (1) and the Nash equilibrium is indicated by gray cells.

However, the macroeconomic effects reported in Table 3 show that Nash equilibrium produce negative effects on the economic system. The national GDP and employment decreases and the results are very asymmetric between regions. While the employment and household consumption rises in Rest of Brazil, the opposite occurs in Rio Grande do Sul. In part, these effects are explained because Rest of Brazil is bigger than Rio Grande do Sul e mainly due the mobility of the productive factors. There is a clear labor migration effect from Rio Grande do Sul to Rest of Brazil e this can explain the reduction of household consumption in Rio Grande do Sul. Moreover, the increase in relative equivalent variation is higher in Rest of Brazil. As Federal government is concerned on national household welfare, the welfare results for households living in Rest of Brazil are dominant for the Federal government reaction in the tax competition game.

The increase in ICMS tax rates in both regions causes a general increase in basic prices of goods, raising the costs of production and decreasing the real disposable income. Firms become less

competitive and investors foresee reductions in returns, reducing the level of investment and freeing labor in the economic system. The substitution effects caused by prices increases spillover for all regions through the interregional trade and contribute for losses in competitiveness. As result, interregional trade volume goes down. Due higher prices of domestic goods, the demand for international imported goods rises and the international export volume decreases. The real household consumption decreases in Rio Grande do Sul and increases in Rest of Brazil. This result is explained by mobility of the productive factor, mainly labor. Under the adversities imposed by the tax competition equilibrium, the results suggest that differences in economic structure of the regions imply in lower losses for factors returns in Rest of Brazil. Then, the reduction in level of investment in Rest of Brazil is lower than in Rio Grande do Sul and labor moves to Rest of Brazil. Aside to reductions in income tax rate, the increase in employment contribute to expand the whole disposable income in Rest of Brazil, rising real household consumption.

Table 3

Macro-regional effects at the Nash equilibrium (%)

Variables	Rio Grande do Sul	Rest of Brazil	Brazil
GDP components			
Real household consumption	-0.123	0.303	0.273
Real aggregate investment	-1.918	-0.017	-0.140
Real aggregate regional government demand	-	-	-
Real aggregate federal government demand	-	-	-
Interregional export volume	-0.151	-0.791	-
International export volume	-1.930	-2.411	-2.364
Interregional import volume	-0.791	-0.151	-
International import volume	0.347	0.964	0.930
Prices			
Consumer price index	1.405	1.495	1.488
Investment price index	0.553	1.397	1.343
Regional government price index	0.856	0.918	0.914
Federal government price index	0.856	0.918	0.914
Interregional export price index	0.920	1.030	-
International export price index	0.982	1.027	1.023
Interregional import price index	1.030	0.920	-
International import price index	-	-	-
GDP deflator (expenditure side)	1.223	1.531	1.508
Primary factors			
Aggregate payments to capital	0.064	1.255	1.168
Aggregate payments to labor	0.498	0.807	0.784
Aggregate capital stock	-0.483	-0.143	-0.168
Welfare indicators			
REV	0.612	1.237	1.186
Real GDP	-0.334	-0.093	-0.111
Employment	-0.287	0.019	-0.003

Source: calculated by the authors.

Table 4 reports the tax competition effects on the public finances at the Nash equilibrium. As expected, the federal transfers to regional governments present a strong reduction and the budget balance is achieved by growth in commodity tax revenue generated by higher ICMS tax rates. In terms of real variations, the revenues of Rio Grande do Sul government present a low decrease and the revenues of Rest of Brazil government present a low increase. But the federal government has a significant decrease in its revenues because of the negative tax base effects generated by the regional tax competition. Its revenues go down due the reduction in income tax rate and due the reduction in domestic tax base generated by the negative effects of the increases in ICMS tax rates.

On the expenditure side, Federal government reduces the public investment outlays following the reduction in national private investment. Then fiscal resources from central government are freed to increase subsidies in economy. The personal benefits payments rise because of the increase in unemployment. Again, we observe asymmetric results for the regional governments. All real expenditures of Rest of Brazil increase, while the Rio Grande do Sul government reduces its public investment outlays following the decrease in private investments in its regional economy. In B-MARIA-RS, the subsidy outlays of regional governments are conditioned to indirect commodity taxes, so they rise with the commodity tax revenue.

Table 4

Public finances effects at the Nash equilibrium by level of government (%)

Variables	Governments		
	Rio Grande do Sul	Rest of Brazil	Federal
Government's revenue	**-0.232**	**0.118**	**-1.734**
Tax revenue	-0.041	0.221	-2.664
Direct taxes	0.028	0.519	-12.166
Income taxes	-	-	-16.736
Other direct taxes	0.028	0.519	0.481
Indirect taxes	6.595	5.635	-0.244
Tariff revenue	-	-	0.071
Commodity taxes	8.065	6.609	-3.059
Payroll taxes	-0.377	-0.132	0.481
Property taxes	0.028	0.519	-
Land taxes	-	-	-
Other indirect taxes	0.028	0.519	0.481
Interests received	0.028	0.519	0.481
Federal transfers	-67.659	-62.165	-
Other revenues	0.028	0.519	0.481
Discrepancy	-	-	-
Public deficit	**-**	**-**	**-**
Government's expenditure	**-0.232**	**0.118**	**-1.734**
Expenditures with goods and services	-0.259	0.058	-0.036
Government consumption	-	-	-
Government investment	-2.231	0.462	-0.481
Personal benefit payments	0.341	0.590	0.563
Subsidies	5.910	4.668	4.769
Interest payments	0.028	0.519	0.481
Federal transfers to regions	-	-	-65.553
Other outlays	-0.232	0.118	-1.734

Source: calculated by the authors.

6 Final remarks

This paper was building in order to evaluate if Federal government plays a role in a regional tax competition game. On the basis of a CGE approach and on vertical linkages of Brazilian federalism, we carried out one experimental tax competition game between two regional governments, where Federal government also is an active player. As constitutional rules impose that one part of income tax revenue collected by Brazilian Federal government should be transferred for regional governments, we assumed that income tax policy of Federal government is endogenously adjusted in response of a regional tax competition. The simulation results reveal the power of influence of Federal government decisions on regional governments' behavior and on the welfare effects of regional tax competition.

In fact, the results showed that income tax policy of Federal government can be very important for the output of regional tax competition due the transfer mechanisms. While theoretical issues have showed that Nash equilibrium of horizontal tax competition, building on hypothesis of governments are benevolent, is race-to-the-bottom and welfare worsening, our findings showed that the intervention of Federal government can produces different results if regional governments do not wish to absorb the costs of tax competition, that is, they do not wish reduce the provision of public goods. In our experimental exercise, the Nash equilibrium is race-to-the-top and welfare improving. This result suggests that transfers mechanism can be an effective way to change the potential welfare losses of decreases in provision of public goods in a environment of regional tax competition.

However, the welfare improving result founded in such a tax competition game can be viewed as a fiscal illusion. The welfare gains are supported by reduction in income tax rate associated with the optimum strategy of Federal government, but the increase in ICMS tax rate by regional governments produce negative deviation effects. Additionally, the hypothesis that governments are fully benevolent is crucial for the results. But, on the fiscal results, the effects on revenues of Rio Grande do Sul government and mainly on revenues of Federal government are negatives and imply constraints for policy makers carry out their public policies. If governments are not fully benevolent, the negative effect on fiscal performance revenue could be not useful for non benevolent governments.

It's worth to note that the equilibrium do not configures a bailout policy by the Federal government because its optimum strategy is to force the regional governments to increase the ICMS tax rate to achieve the fiscal balance by themselves. As the regional governments can not achieve fiscal balance with more transfers and have to increase the ICMS tax rate, such a result goes in opposite direction of their initial expectation. In this case, the simulation results suggest that the incentives for regional governments engage in tax competition games could be reduced if Federal government does not help them to achieve the fiscal balance.

Finally, our findings highlight that vertical linkages do matter for the welfare effects of regional tax competition. This put in evidence potential modeling issues to analyses the effects of fiscal war in Brazil.

References

Almeida ES (2003) *Um modelo de equilíbrio geral aplicado espacial para planejamento e análise de políticas de transporte*. Ph.D Dissertation, Department of Economics, University of Sao Paulo

Bröcker J (1998) Operational spatial computable general equilibrium modeling. *The Annals of Regional Science* 32: 367-387

Haddad EA (1999) *Regional inequality and structural changes: lessons from the Brazilian experience*. Ashgate, Aldershot

Haddad EA, Hewings GJD (1999) The short-run regional effects of new investments and technological upgrade in the Brazilian automobile industry: an interregional computable general equilibrium analysis. *Oxford Development Studies* 27(3): 25 p.

Layard PRG, Walters AA (1978) *Microeconomic theory*. McGraw-Hill, New York

Mendoza EG, Tesar LL (2003) A quantitative analysis of tax competition v. tax coordination under perfect capital mobility. NBER Working Paper No. 9746

Mintz J, Tulkens H (1986) Commodity tax competition between member states of a federation: equilibrium and efficiency. *Journal of Public Economics* 29(2): 133-172

PorsseAA, Haddad EA, Ribeiro, EP (2004) Estimando uma matriz d insumo-produto inter-regional Rio Grande do Sul-Restante do Brasil. Encontro Brasileiro de Estudos Regionais, Belo Horizonte

Shah A. (1991) The new fiscal federalism in Brazil. World Bank Working Paper No. 124

Wellisch D (2000) Theory of public finance in a federal state. Cambridge University Press, United Kingdom

Wildasin DE (1988) Nash equilibrium in models of fiscal competition. *Journal of Public Economics* 35(2): 229-240

Zodrow GR, Mieszkowski P (1986) Pigou, Tiebout, property taxation, and underprovision of local public goods. *Journal of Urban Economics* 19(3): 356-370

Appendix

The notational convention uses uppercase letters to represent the levels of the variables and lowercase for their percentage-change representation. Superscripts *(u)*, *u = 0, 1j, 2j, 3, 4, 5, 6*, refer, respectively, to output *(0)* and to the six different regional-specific users of the products identified in the model: producers in sector *j (1j)*, investors in sector *j (2j)*, households *(3)*, purchasers of exports *(4)*, regional governments *(5)* and the Federal government *(6)*; the second superscript identifies the domestic region where the user is located. Inputs are identified by two subscripts: the first takes the values *1, ..., g*, for commodities, *g + 1*, for primary factors, and *g + 2*, for "other costs" (basically, taxes and subsidies on production); the second subscript identifies the source of the input, being it from domestic region *b (1b)* or imported *(2)*, or coming from labor *(1)*, capital *(2)* or land *(3)*. The symbol (•) is employed to indicate a sum over an index.

Equations

(A1) Substitution between products from different regional domestic sources

$$x^{(u)r}_{(i(1b))} = x^{(u)r}_{(i(1\bullet))} - \sigma^{(u)r}_{(i)}\left(p^{(u)r}_{(i(1b))} - \sum_{l \in S^*} (V(i,1l,(u),r)/V(i,1\bullet,(u),r)(p^{(u)r}_{(i(1l))})\right)$$

$$i = 1,...,g;\ b = 1,...,q;\ (u) = 3 \ \textit{and}\ (kj)\ \textit{for}\ k = 1 \textit{and}\ 2 \textit{and}\ j = 1,...,h; r = 1,...,R$$

(A2) Substitution between domestic and imported products

$$x^{(u)r}_{(is)} = x^{(u)r}_{(i\bullet)} - \sigma^{(u)r}_{(i)}\left(p^{(u)r}_{(is)} - \sum_{l=1\bullet,2} (V(i,l,(u),r)/V(i,\bullet,(u),r)(p^{(u)r}_{(il)})\right)$$

$$i = 1,...,g;\ s = 1\bullet \textit{and}\ 2;\ (u) = 3 \ \textit{and}\ (kj)\ \textit{for}\ k = 1e\,2 \ \textit{and}\ \ j = 1,...,h; r = 1,...,R$$

(A3) Substitution between labor, capital and land

$$x^{(1j)r}_{(g+1,s)} - a^{(1j)r}_{(g+1,s)} = \alpha^{(1j)r}_{(g+1,s)} x^{(1j)r}_{(g+1\bullet)} - \sigma^{(1j)r}_{(g+1)}\{ p^{(1j)r}_{(g+1,s)} + a^{(1j)r}_{(g+1,s)} - \sum_{l=1,2,3} (V(g+1,l,(1j),r)/V(g+1,\bullet,(1j),r))(p^{(1j)r}_{(g+1,l)} + a^{(1j)r}_{(g+1,l)})\}$$

$$j = 1,...,h;\ \ s = 1,2 \textit{ and } 3; r = 1,...,R$$

(A4) Intermediate and investment demands for composites commodities and primary factors

$$x^{(u)r}_{(i\bullet)} = \mu^{(u)r}_{(i\bullet)} z^{(u)r} + a^{(u)r}_{(i)} \qquad u = (kj)\ \ for\ \ k = 1,2\ \ and\ \ j = 1,...,h$$

$$if\ \ u = (1j)\ \ then\ \ i = 1,...,g+2$$

$$if\ \ u = (2j)\ \ then\ \ i = 1,...,g;$$

$$r = 1,...,R$$

(A5) Household demands for composite commodities

$$V(i,\bullet,(3),r)(\,p^{(3)r}_{(i\bullet)} + x^{(3)r}_{(i\bullet)}\,) = \gamma^{r}_{(i)} P^{(3)r}_{(i\bullet)} Q^{r}(\,p^{(3)r}_{(i\bullet)} + x^{(3)r}_{(i\bullet)}\,) + \beta^{r}_{(i)}(C^{r} - \sum_{j\in G}\gamma^{r}_{(j)} P^{(3)r}_{(i\bullet)} Q^{r}(\,p^{(3)r}_{(i\bullet)} + x^{(3)r}_{(i\bullet)}\,))$$

$$i = 1,\ldots,g; r = 1,\ldots,R$$

(A6) Composition of output by industries

$$x^{(0j)r}_{(i1)} = z^{(1j)r} + \sigma^{(0j)r}(\,p^{(0)r}_{(i1)} - \sum_{t\in G}(Y(t,j,r)/Y(\bullet,j,r))p^{(0)r}_{(t1)}\,)$$

$$j = 1,\ldots,h;\;\; i = 1,\ldots,g; r = 1,\ldots,R$$

(A7) Indirect tax rates

$$t(\tau,i,s,(u)r) = f_{(\tau)} + f_{(\pi)} + f^{(u)}_{(\pi)} + f^{(u)r}_{(\pi)}, \quad i = 1,\ldots,g;\;\; s = 1b,2 \text{ for } b = 1,\ldots,q;\; \tau = 1,\ldots,t$$
$$(u) = (3),(4),(5),(6) \text{ and } (kj) \text{ for } k = 1,2;\; j = 1,\ldots,h$$
$$r = 1,\ldots,R$$

(A8) Purchasers' prices related to basic prices, margins (transportation costs) and taxes

$$V(i,s,(u),r)p^{(u)r}_{(is)} = (B(i,s,(u),r) + \sum_{\tau\in T} T(\tau,i,s,(u),r))(\,p^{(0)}_{(is)} + t(\tau,i,s,u,r)) + \sum_{m\in G} M(m,i,s,(u),r)p^{(0)r}_{(m1)},$$
$$i = 1,\ldots,g;\; (u) = (3),(4),(5),(6)$$
$$\text{and } (kj) \text{ for } k = 1,2 \text{ and } j = 1,\ldots,h; s = 1b,2 \text{ for } b = 1,\ldots,q$$
$$r = 1,\ldots,R$$

(A9) Foreign demands (exports) for domestic goods

$$(\,x^{(4)r}_{(is)} - fq^{(4)r}_{(is)}\,) = \eta^{r}_{(is)}(\,p^{(4)r}_{(is)} - e - fp^{(4)r}_{(is)}\,), \qquad i = 1,\ldots,g\;;\; s = 1b,2 \text{ for } b = 1,\ldots,q; r = 1,\ldots,R$$

(A10) Regional governments demands

$$x^{(5)r}_{(is)} = x^{(3)r}_{(\bullet\bullet)} + f^{(5)r}_{(is)} + f^{(5)r} + f^{(5)} \qquad i = 1,\ldots,g;\; s = 1b,2 \text{ for } b = 1,\ldots,q; r = 1,\ldots,R$$

(A11) Regional governments demands

$$x^{(6)r}_{(is)} = x^{(3)\bullet}_{(\bullet\bullet)} + f^{(6)r}_{(is)} + f^{(6)r} + f^{(6)} \qquad i = 1,\ldots,g;\; s = 1b,2 \text{ for } b = 1,\ldots,q; r = 1,\ldots,R$$

(A12) Margins demands for domestic goods

$$x^{(is)(u)r}_{(m1)} = \theta^{(u)r}_{(is)} x^{(u)r}_{(is)} + a^{(is)(u)r}_{(m1)}$$
$$m,i = 1,\ldots,g;$$
$$(u) = (3),(4b) \text{ for } b = 1,\ldots,r,(5) \text{ and } (kj) \text{ for } k = 1,2;$$
$$j = 1,\ldots,h;\; s = 1b,2 \text{ for } b = 1,\ldots,r;$$
$$r = 1,\ldots,R$$

(A13) Demand equals supply for regional domestic commodities

$$\sum_{j\in H} Y(l,j,r)x_{(l1)}^{(0j)r} = \sum_{u\in U} B(l,1,(u),r)x_{(l1)}^{(u)r} + \sum_{i\in G}\sum_{s\in S}\sum_{u\in U} M(l,i,s,(u),r)x_{(l1)}^{(is)(u)r} \qquad l=1,...,g;\ r=1,...,R$$

(A14) Regional industry revenue equals industry costs

$$\sum_{l\in G} Y(l,j,r)(\,p_{(l1)}^{(0)r} + a_{(l1)}^{(0)r}\,) = \sum_{l\in G^*}\sum_{s\in S} V(l,s,(1j),r)(\,p_{(ls)}^{(1j)r}\,), \quad j=1,...,h;\ r=1,...,R$$

(A15) Basic price of imported commodities

$$p_{(i(2))}^{(0)} = p_{(i(2))}^{(w)} - e + t_{(i(2))}^{(0)}, \qquad i=1,...,g$$

(A16) Cost of constructing units of capital for regional industries

$$V(\bullet,\bullet,(2j),r)(\,p_{(k)}^{(1j)r} - a_{(k)}^{(1j)r}\,) = \sum_{i\in G}\sum_{s\in S} V(i,s,(2j),r)(\,p_{(is)}^{(2j)r} + a_{(is)}^{(2j)r}\,), \quad j=1,...,h;\ r=1,...,R$$

(A17) Investment behavior

$$z^{(2j)r} = x_{(g+1,2)}^{(1j)r} + 100\,f_{(k)}^{(2j)r}, \qquad j=1,...,h;\ r=1,...,R$$

(A18) Capital stock in period T+1 – comparative statics

$$x_{(g+1,2)}^{(1j)r}(1) = x_{(g+1,2)}^{(1j)r} \qquad j=1,...,h;\ r=1,...,R$$

(A19) Definition of rates of return to capital

$$r_{(j)}^{r} = Q_{(j)}^{r}(\,p_{(g+1,2)}^{(1j)r} - p_{(k)}^{(1j)r}\,), \qquad j=1,...,h;\ r=1,...,R$$

(A20) Relation between capital growth and rates of return

$$r_{(j)}^{r} - \omega = \varepsilon_{(j)}^{r}(\,x_{(g+1,2)}^{(1j)r} - x_{(g+1,2)}^{(\bullet)r}\,) + f_{(k)}^{r}, \qquad j=1,...,h;\ r=1,...,R$$

Other definitions in the CGE core include: revenue from indirect taxes, import volume of commodities, components of regional/national GDP, regional/national price indices, wage settings, definitions of factor prices, and employment aggregates.

Variables

Variable	Index ranges	Description
$x^{(u)r}_{(is)}$	(u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1,…,h; if (u) = (1j) then i = 1,…,g + 2; if (u) ≠ (1j) then i = 1,…,g; s = 1b, 2 for b = 1,…,q; and i = 1,…,g and s = 1, 2, 3 for i = g+1 r = 1,…,R	Demand by user (u) in region r for good or primary factor (is)
$p^{(u)r}_{(is)}$	(u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1,…,h; if (u) = (1j) then i = 1,…,g + 2; if (u) ≠ (1j) then i = 1,…,g; s = 1b, 2 for b = 1,…,q; and i = 1,…,g and s = 1, 2, 3 for i = g+1 r = 1,…,R	Price paid by user (u) in region r for good or primary factor (is)
$x^{(u)r}_{(i\bullet)}$	(u) = (3) and (kj) for k = 1, 2 and j = 1, …,h. if (u) = (1j) then i = 1, …,g + 1; if (u) ≠ (1j) then i = 1, …,g r = 1,…,R	Demand for composite good or primary factor i by user (u) in region r
$a^{(1j)r}_{(g+1,s)}$	j = 1, …,h and s = 1, 2, 3 r = 1,…,R	Primary factor saving technological change in region r
$a^{(u)r}_{(i)}$	i = 1,...,g, (u) = (3) and (kj) for k = 1, 2 and j = 1,..., h r = 1,…,R	Technical change related to the use of good i by user (u) in region r
C^r		Total expenditure by regional household in region r
Q^r		Number of households
$z^{(u)r}$	(u) = (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Activity levels: current production and investment by industry in region r
$fq^{(4)r}_{(is)}$	i = 1, …,g; s = 1b, 2 for b = 1, …,q r = 1,…,R	Shift (quantity) in foreign demand curves for regional exports
$fp^{(4)r}_{(is)}$	i = 1, …,g; s = 1b, 2 for b = 1, …,q r = 1,…,R	Shift (price) in foreign demand curves for regional exports
e		Exchange rate
$x^{(is)(u)r}_{(m1)}$	m, i = 1,…,g; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Demand for commodity (m1) to be used as a margin to facilitate the flow of (is) to (u) in region r
$a^{(is)(u)r}_{(m1)}$	m, i = 1,…,g; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Technical change related to the demand for commodity (m1) to be used as a margin to facilitate the flow of (is) to (u) in region r
$x^{(0j)r}_{(i1)}$	i = 1,…,g; j = 1,…,h r = 1,...,R	Output of domestic good i by industry j
$p^{(0)r}_{(is)}$	i = 1,…,g; s = 1b, 2 for b = 1,…,q r = 1,...,R	Basic price of good i in region r from source s

Variable	Index ranges	Description
$p^{(w)}_{(i(2))}$	i = 1,…,g	USD c.i.f. price of imported commodity i
$t^{(0)}_{(i(2))}$	i = 1,…,g	Power of the tariff on imports of i
$t(\tau,i,s,(u)r)$	i = 1,…,g; τ = 1,…,t; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1,…,h r = 1,...,R	Power of the tax τ on sales of commodity (is) to user (u) in region r
$f^{(2j)r}_{(k)}$	j = 1,…,h r = 1,...,R	Regional-industry-specific capital shift terms
$f^{r}_{(k)}$	r = 1,...,R	Capital shift term in region r
$x^{(1j)r}_{(g+1,2)}(1)$	j = 1,…, h r = 1,...,R	Capital stock in industry j in region r at the end of the year, i.e., capital stock available for use in the next year
$p^{(1j)r}_{(k)}$	j = 1,…, h r = 1,...,R	Cost of constructing a unit of capital for industry j in region r
$f_{(\tau)}$	τ = 1,…,t	Shift term allowing uniform percentage changes in the power of tax τ
$f_{(\tau i)}$	τ = 1,…,t; i = 1, …,g	Shift term allowing uniform percentage changes in the power of tax τ on commodity i
$f^{(u)}_{(\tau i)}$	τ = 1,…,t; (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …, h	Shift term allowing uniform percentage changes in the power of tax τ of commodity i on user (u)
$f^{(u)r}_{(\tau i)}$	τ = 1,…,t; (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …, h r = 1,…,R	Shift term allowing uniform percentage changes in the power of tax τ of commodity i on user (u) in region r
$f^{(5)r}_{(is)}$	i = 1, …,g; s = 1b, 2 for b = 1,…,q r = 1,…,R	Commodity and source-specific shift term for regional government expenditures in region r
$f^{(5)r}$	r = 1,…,R	Shift term for regional government expenditures in region r
$f^{(5)}$		Shift term for regional government expenditures
$f^{(6)r}_{(is)}$	i = 1, …,g; s = 1b, 2 for b = 1,…,q r = 1,…,R	Commodity and source-specific shift term for Federal government expenditures in region r
$f^{(6)r}$	r = 1,…,R	Shift term for Federal government expenditures in region r
$f^{(6)}$		Shift term for Federal government expenditures
ω		Overall rate of return on capital (short-run)
$r^{r}_{(j)}$	j = 1,...,h r = 1,…,R	Regional-industry-specific rate of return

Parameters, Coefficients and Sets

Symbol	Description
$\sigma_{(i)}^{(u)r}$	Parameter: elasticity of substitution between alternative sources of commodity or factor i for user (u) in region r
$\sigma^{(0j)r}$	Parameter: elasticity of transformation between outputs of different commodities in industry j in region r
$\alpha_{(g+1,s)}^{(1j)r}$	Parameter: returns to scale to individual primary factors in industry j in region r
$\beta_{(i)}^{r}$	Parameter: marginal budget shares in linear expenditure system for commodity i in region r
$\gamma_{(i)}^{r}$	Parameter: subsistence parameter in linear expenditure system for commodity i in region r
$\varepsilon_{(j)}^{r}$	Parameter: sensitivity of capital growth to rates of return of industry j in region r
$\eta_{(is)}^{r}$	Parameter: foreign elasticity of demand for commodity i from region r
$\theta_{(is)}^{(u)r}$	Parameter: scale economies to transportation of commodity (i) produced in region r shipped to user (u) in region r
$\mu_{(i\bullet)}^{(u)r}$	Parameter: returns to scale to primary factors (i = g+1 and u = 1j); otherwise, $\mu_{(i\bullet)}^{(u)r}=1$
$B(i,s,(u),r)$	Input-output flow: basic value of (is) used by (u) in region r
$M(m,i,s,(u),r)$	Input-output flow: basic value of domestic good m used as a margin to facilitate the flow of (is) to (u) in region r
$T(\tau,i,s,(u),r)$	Input-output flow: collection of tax τ on the sale of (is) to (u) in region r
$V(i,s,(u),r)$	Input-output flow: purchasers' value of good or factor i from source s used by user (u) in region r
$Y(i,j,r)$	Input-output flow: basic value of output of domestic good i by industry j from region r
$Q_{(j)}^{r}$	Coefficient: ratio, gross to net rate of return
G	Set: {1,2, …, g}, g is the number of composite goods
G*	Set: {1,2, …, g+1}, g+1 is the number of composite goods and primary factors
H	Set: {1,2, …, h}, h is the number of industries
U	Set: {(3), (4), (5), (6), (k j) for k = 1, 2 and j = 1, …, h}
U*	Set: {(3), (k j) for k = 1, 2 and j = 1, …, h}
S	Set: {1, 2, …, r+1}, r+1 is the number of regions (including foreign)
S*	Set: {1, 2, …,r}, r is the number of domestic regions
T	Set: {1, …, t}, t is the number of indirect taxes