The Brazilian 'Tax War': The Case of Value-Added Tax Competition among the States

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ABSTRACT/RÉSUMÉ

The Brazilian "tax war": the case of value-added tax competition among the states

This paper tests for horizontal tax competition in the VAT for a sample of Brazilian states in the period 1985-2001. The states have considerable autonomy to set their VAT rates and bases, often using this tax as an industrial policy tool. The empirical findings, based on the estimation of a tax reaction function in an error-correction set-up, confirm the hypothesis of horizontal tax competition: the states react strongly to changes in their neighbours' VAT code, especially those that belong to the same geo-economic region. Also, there appears to be a Stackelberg leader among the states, with the remaining jurisdictions responding strongly to its policy moves. There is no co-occupancy of tax bases between different levels of government and hence limited scope for vertical externalities in tax setting. But the fact that the federal government shares with the states part of the revenue of its more elastic taxes, such as the income tax, appears to affect the opportunity cost of horizontal tax competition.

JEL Classification: H2, H7.
Key words: Tax reaction function, fiscal federalism, Brazil, ICMS, Nash, Stackelberg.

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La "guerre fiscale" au Brésil: la concurrence des états sur la taxe sur la valeur ajoutée

Ce document présente une analyse empirique de la concurrence horizontale sur la taxe sur la valeur ajoutée (TVA) parmi les états du Brésil durant la période 1985-2001. Les états brésiliens ont une autonomie considérable en matière de politique fiscale pour établir le taux d'imposition et l'assiette de leur TVA. Ils se servent souvent de cet impôt comme instrument de politique industrielle. Les résultats de l'analyse empirique basée sur l'estimation d'une fonction de réaction fiscale avec un mécanisme de correction d'erreur confirme l'hypothèse de concurrence horizontale parmi les états: ils réagissent fortement aux changements des taux d'imposition de la TVA de leurs voisins, surtout ceux qui appartiennent à la même région géo-économique. Par ailleurs, il y a un leader Stackelberg parmi les états, puisque les autres administrations réagissent fortement à sa politique fiscale. Les différents niveaux d'administration ne partagent pas les mêmes assiettes de sorte que les externalités verticales associées à la politique fiscale sont assez limitée au Brésil. Néanmoins, le fait que l'administration fédérale partage avec les états une part importante des recettes de ses impôts plus élastiques, tel que l'impôt sur le revenu, affecte le coût d'opportunité de la concurrence horizontale parmi les états en terme de politique fiscale.

JEL Classification: H2, H7.
Mots clés: Fonction de réaction fiscale, fédéralisme budgétaire, Brésil, ICMS, Nash, Stackelberg.

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The Brazilian "tax war": the case of value-added tax competition among the states

Luiz de Mello,[1]

1. Introduction

There is a large and growing literature on tax competition among same-level sub-national jurisdictions and between them and the central government. Competition arises across levels of government when they co-occupy a tax base, which creates vertical externalities in tax setting, and among same-level jurisdictions, typically to attract cross-border shoppers, investment and wealthy residents. The empirical literature has focused on testing for vertical and horizontal tax competition in the income tax and excises, suggesting that states or provinces respond to changes in central government tax policy, which often acts as a Stackelberg leader, or compete among themselves in a Nash game. Building on the empirical literature, this paper will test the hypothesis that the Brazilian states have competed over the value added tax (VAT), benefiting from full administrative and policymaking autonomy in setting their VAT rates and bases. Because the states do not have the autonomy to tax factor income as in other large federations, such as the United States and Canada, they have used the VAT extensively as an industrial policy instrument, granting tax exemptions and holidays to attract economic activity, particularly investment.[2]

Tax competition among the states – the "tax war", as it is referred to in Brazil – is claimed to have been predatory, resulting in an erosion of the VAT base over time. But this hypothesis has not yet been formally tested, possibly due to the institutional complexity of state-level VAT legislation, and evidence therefore remains essentially anecdotal.[3] VAT legislation is complex because of multiple rates within the same state, and fragmented, as the 27 states (including the Federal District) are free to set their own rates and bases. Taxes are collected on an origin basis, and interstate trade is taxed at different rates to compensate, albeit imperfectly, net importers for the ensuing revenue losses. Notwithstanding this level of institutional complexity, the evidence reported below suggests that: first, the states do react to changes in their peers' tax policy, being particularly responsive to policy changes in neighbouring states, especially those that belong to the same geo-economic region; and, second, there appears to be a Stackelberg leader among the states, with the remaining jurisdictions responding strongly to its policy moves.

The paper contributes to the empirical literature not only by focusing on horizontal, same-level sub-national tax competition in the VAT, rather than excises and factor income taxation, but also by taking explicit account of longer-term fiscal sustainability and horizontal interdependencies in tax-setting behaviour that are unrelated to tax co-occupancy. To deal with longer-term fiscal sustainability, an error-correction specification is used. This is important because, although the theory on tax competition does not

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2. See Varsano (1997) for an overview of ICMS – the state-level VAT – taxation and a discussion of the channels for predatory tax competition among the states.

3. It should be recognised that tax competition to attract business may not be distortionary, as in the case where the marginal cost of supplying a firm and its work force with public goods is less than the tax revenue it generates. In this case, a subsidy may facilitate the efficient allocation of capital. See Black and Hoyt (1989) for a simple theoretical model and Wilson (1999) for a survey.

explicitly distinguish short- and long-term effects, the option of foregoing current revenue in expectation of higher taxes in the future has a bearing on longer-term policy sustainability. Failure to take these longer-term constraints into account would bias parameter estimates. This is all the more important when testing the theory for Brazil, given that the states have gone through a period of fiscal adjustment, particularly since the second half of the 1990s, underpinned by institutional reform to introduce hard-budget constraints at all levels of government.[4]

To deal with possible horizontal interdependencies in tax setting that are not due to tax co-occupancy, an attempt is made to control for the mandated sharing of federal revenue with the states, which drives a wedge between the benefits and costs of provision. Although the federal and state governments do not co-occupy the VAT base, revenue sharing may create pressures for spending at the state level, thus affecting their tax reaction function. To deal with this possibility, a measure of vertical imbalance in federal-state relations, defined as the share of intergovernmental transfers in state-level revenue, is included as an additional determinant of state-level taxation because it affects the opportunity cost of strategic tax competition.

The paper is organised as follows. Section 2 provides general background information on the ICMS, the Brazilian state-level VAT, including on how its revenue performance has evolved over time. Section 3 briefly reviews the literature on tax competition. Section 4 discusses the conventional estimation strategy, the data used in the empirical analysis and the sources of information, as well as preliminary results. Section 5 reports the results of the error-correction regressions, including the robustness analysis, with particular attention to testing the hypotheses of Nash and Stackelberg competition among the states. Section 6 concludes.

2.   The ICMS: Background information

The ICMS is a tax collected by the states on goods and selected services.[5] The invoice-credit mechanism is used. Services that are exempt from ICMS taxation, such as inter-municipal transport, are taxed by the municipalities. The municipal tax on services is the ISS, which is not creditable against state or federal tax liabilities. The ISS paid on inputs is not creditable either. ICMS revenue accounted for approximately 7.5% of GDP in 2000-01 (Figure 1), or nearly two-thirds of overall state revenue (including mandated revenue sharing with the federal government).

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4.   It has been argued that the institutional reform leading to the enactment of the Fiscal Responsibility Law in 2000 has been instrumental for fiscal consolidation at the sub-national level of government. See de Mello (2006) for more information and empirical evidence based on the estimation of a fiscal reaction function for the different levels of government.

5.   See de Mello (1999) and Afonso and de Mello (2002) for an overview of intergovernmental fiscal relations in Brazil.

Figure 1. ICMS collection, 1985-2001

In % of GDP

Of which: ☐ Electricity ■ Oil and fuels ■ Telecoms
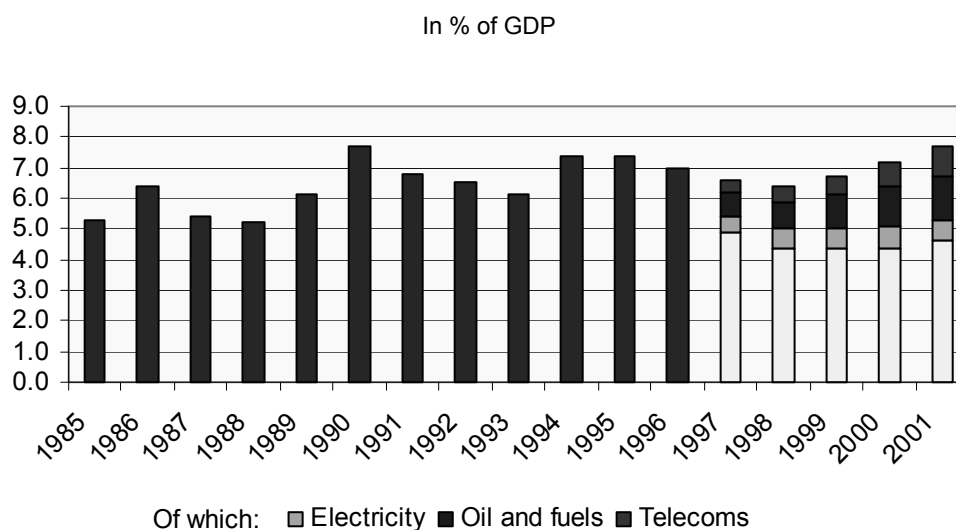
Source: IPEA.

There is a wide dispersion of rates levied on intra-state transactions, and a systematic compilation of ICMS legislation is not available. Intra-state rates are required to be set in principle within a range determined by the Senate, with a minimum rate of 12%. Basic necessities are typically exempt, zero-rated (which generates a credit) or taxed at 7%. Because several states use the ICMS as an industrial policy instrument, many sectors are taxed in the 12%-18% range, such as the motor industry, while utilities and oil/fuels are taxed at 25%. The ICMS collected in these sectors accounted for about 40% of total ICMS revenue in 2001, up from nearly 27% in 1997. Luxury goods, as well as typical excisables, such as tobacco and beverages, tend to be taxed at a higher rate of 30-35%. The states with fiscal consolidation needs often levy this higher rate on price-inelastic goods and utilities as a means of raising revenue. This is despite the fact that, as discussed below, horizontal tax competition is likely to be fiercer in the case of goods and services for which demand is more inelastic. As in the case of the federal indirect taxes, many states collect the ICMS at the production, rather than the retail, stage on the basis of the estimated tax liability for an average production chain in different sectors.[6] Liabilities are calculated on a tax-inclusive basis.[7]

The ICMS is collected on an origin basis, so that revenue accrues to the state where the good/service is produced. Poorer states, typically net importers of ICMS-liable goods and services, have therefore called for shifting collection to the destination, which would result in a redistribution of the ICMS tax take in their favour. A compromise has been reached by applying different rates on inter-state trade. Accordingly, trade between a rich state (*i.e.*, those states located in the South, South-East and Centre-West) and a poor state (*i.e.*, those located in the North and Northeast, as well as the state of Espírito Santo) is taxed at 7%; otherwise, interstate trade is taxed at 12%, the lowest rate applicable in principle to intra-state trade in any state. Registered traders in an importing state are allowed to credit their taxes paid on inter-state imports against their ICMS liabilities in the importing state. As a result, the lower rate levied on trade with the less prosperous states allows these states to collect more revenue by levying their own intra-state rates on shipments from more prosperous states, and refunding registered traders for the ICMS paid on these

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6.   This practice is referred to in Brazil as "substituição tributária" or "cobrança monofásica."

7.   For example, for a rate of 17%, the tax liability for a transaction worth $100 would be calculated on $117, which includes the tax, resulting in a tax liability of $19.89, rather than $17, which would be the tax-exclusive liability.

transactions at a lower rate. Although these differentiated rates for inter-state trade result in some horizontal revenue sharing between net importers and exporters while keeping collection at origin, they have encouraged "invoice sightseeing" and, to a lesser extent, cross-border shopping, increasing compliance costs and hindering tax harmonization.

Efforts to curb predatory tax competition have been by and large unsuccessful. According to current legislation (Complementary Law no. 25 of 1975), tax benefits can only be granted by unanimous decision within CONFAZ, a forum for discussion of tax policy matters among the state finance secretaries. However, in the absence of institutional instances for monitoring compliance with CONFAZ resolutions, as well as enforcing them, there is limited scope for credible horizontal cooperation in this area. Also, despite several attempts, and a general agreement over the detrimental impact of predatory tax competition on public finances and on the allocation of investment, it has been difficult for the federal government to secure congressional approval for legislation to harmonise ICMS rates and bases among the states. The option of shifting collection to the destination, for example, would simplify the taxation of inter-state trade, but faces particular opposition from net exporters, which would face the largest potential revenue losses in the absence of compensatory measures.

3.   The literature

The literature on indirect tax competition among same-level sub-national jurisdictions has focused on excises and the role of cross-border shopping in eroding the tax base and forcing a convergence of statutory rates between neighbouring jurisdictions, typically to a lower level of taxation. The main theoretical argument is that the tax rate in a given jurisdiction responds to changes in the rates of neighbouring jurisdictions when the demand for the relevant good/service is relatively price-inelastic and cross-border shopping is possible (Kanbur and Keen, 1993; Keen, 1998). If demand is inelastic, a tax cut in a given state encourages neighbouring states to do the same. Because horizontal competition depends on the elasticity of demand, it is likely to be fiercer in the case of excises than, say, income or general sales taxes. Horizontal interactions can also arise due to yardstick competition because voters compare the tax rates in their own jurisdictions with those of their peers to keep politicians accountable (Besley and Case, 1995).

Empirical tests of horizontal tax competition – recently surveyed by Brueckner (2003) – have focused on gasoline and tobacco excises for samples of U.S. states, confirming the hypothesis that the states play a Nash game when setting the tax rate. Overall, the empirical literature suggests that horizontal tax competition exerts downward pressure on sub-national tax rates, at least as far as price-inelastic bases are concerned. Rork (2003) tests for horizontal competition for a variety of U.S. state taxes and reports the expected positive correlation between own gasoline and tobacco excise rates and that of neighbouring jurisdictions, as well as a negative correlation for the sales tax, and the corporate and personal income taxes. Nelson (2002) finds stronger effects for gasoline than tobacco excises in a sample of U.S. states.

The possibility of vertical indirect tax competition, when different levels of government co-occupy the same tax base, has also been examined and tested empirically (Besley and Rosen, 1998; Keen, 1998; Goodspeed, 2000; Esteller-More and Sole-Olle, 2001; Hayashi and Boadway, 2001). In this case, taxes in a given sub-national jurisdiction respond to changes in federal taxation in addition to tax policy in same-level, neighbouring jurisdictions. The combined effect of vertical and horizontal tax competition on tax rates is complex. But, in principle, if bases are shared by different levels of government, horizontal tax competition results in lower sub-national tax rates, whereas vertical tax competition leads to higher sub-national taxes at the expense of the central government (Keen, 1998; Keen and Koutsogiannis, 2004; Devereux *et al.*, 2004). The size of the sub-national jurisdictions relative to the central government also matters (Brulhart and Jametti, 2004).

Empirical evidence is by and large supportive of the theoretical hypotheses. Based on a sample of U.S. states, Devereux *et al.* (2004) dismiss the hypothesis of vertical tax competition as far as excises are concerned, while accepting the hypothesis of horizontal tax competition, at least as far as tobacco excises are concerned. The earlier evidence provided by Besley and Rosen (1998) for a sample of U.S. states also confirms the vertical competition hypothesis for cigarette and tobacco excises. Turning to factor income taxation, Goodspeed (2000) finds a negative relationship between central government and middle-tier income tax rates in a panel of OECD countries. Hayashi and Boadway (2001) estimate a reaction function for the corporate income tax using Canadian provincial data, whereas Esteller-More and Sole-Olle (2001) focus on the personal income tax and use U.S. state data to estimate the tax reaction function. Brulhart and Jametti (2004) provide evidence for a sample of Swiss municipalities in support of vertical tax competition. The empirical findings reported by Buettner (2001) for local governments in Germany confirm the presence of horizontal tax competition in business taxation and suggest that public finances, through revenue and spending mandates, affect strategic tax behaviour.

4.   Estimation strategy

4.1.   *The estimating equation*

The hypothesis of horizontal tax competition, or the presence of strategic tax interdependencies among same-level jurisdictions, is conventionally tested by estimating the following equation:

$$\tau_{it} = \alpha_0 + \alpha_1 \sum\nolimits_{j \neq i} \zeta_{ij}\tau_{jt} + \alpha_2 \tau_{L,t-1} + \alpha_3 X_{it} + e_{it}, \tag{1}$$

where τ_{it} is the tax rate levied by jurisdiction i at time t; $\sum\nolimits_{j \neq i} \zeta_{ij}\tau_{jt}$ is the tax rate prevailing in competing jurisdictions in a Nash game, based on a given aggregation matrix ζ_{ij}; τ_L is the tax rate levied by the leader in a Stackelberg game; X_{it} is a vector of control variables; and e_{it} is an error term.

Equation (1) is often estimated for a panel of countries or same-level sub-national jurisdictions in a single country. The parameters of interest are the slopes of the reaction function: α_1 and α_2. If $\alpha_1 \neq 0$, for a given weighting matrix, competing jurisdictions play a Nash game, and $\alpha_2 \neq 0$ suggests the presence of a Stackelberg leader (Altshuler and Goodspeed, 2003). Equation (1) is conventionally estimated with first-differenced data, because the residuals are likely to be serially correlated, and by instrumenting the competing jurisdictions' average tax rate (and sometimes the Stackelberg leader's) because it is hypothesised to be endogenous in theory. Serial correlation in the residuals can also be dealt with by adding the lagged dependent variable among the regressors, when estimating the reaction function in levels.

4.2.   *Data and variables*

The descriptive statistics of the public finance variables used in the empirical analysis are reported in Table 1. The source of data is the Brazilian Treasury. The data set contains information for the 27 Brazilian states, including the Federal District, over the years 1985-2001. All other data (below) are available from IPEA.

An issue to be addressed is the definition of the ICMS rate. In the absence of systematic information on the several intra-state rates levied by the states and because of the multiplicity of rates in place, the option of defining tax rates as average effective rates, defined as ICMS revenue divided by value added in each state, becomes appealing from the point of view of analytical parsimony and statistical tractability. Of course, this definition does not allow for distinguishing changes in revenue that are due to changes in the statutory rate or the tax base. The use of the average effective, rather than the statutory, rate is standard in the empirical literature, except for the case of excises (Hayashi and Boadway, 2001; Esteller-More and Sole-Olle, 2002; Altshuler and Goodspeed, 2003, among others).

Table 1. **Descriptive statistics**[a]

	Mean	Standard deviation	Maximum	Minimum	No. observations
ICMS rate (revenue divided by value added)	6.7	2.3	15.1	1.1	449
ICMS rate (average of all other states)	6.6	1.3	8.8	4.1	459
Vertical imbalance (federal current transfers divided by current revenue)	34.5	21.1	87.3	2.3	454
Vertical imbalance (average of all other states)	34.1	4.2	40.5	25.5	459
State government size (government spending divided by state GDP)	15.2	8.5	51.6	4.7	454
State government size (average of all other states)	15.0	2.4	18.4	10.1	459
State revenue (government revenue divided by state GDP)	19.6	12.0	70.8	6.3	454
State revenue (average of all other states)	19.4	2.3	23.2	13.7	459

Source : Brazilian Treasury.
a) The sample is 1985-2001.

A number of control variables are standard in the literature. The unemployment rate is conventionally used to control for business-cycle effects on public finances, which may affect tax setting in any given jurisdiction. But due to labour informality, which is relatively high in Brazil, the unemployment rate would underestimate the effect of the business cycle on labour utilisation and public finances. Instead, the formality rate, defined as the share of the labour force that is employed with social security coverage, is used, given that it is correlated with income and the business cycle and, in addition, might proxy for underutilised tax bases, which could be tapped to compensate for the loss in ICMS revenue due to horizontal competition. It has also become customary in the literature to include controls for the effects of demography and the political environment on public finances. The old-age dependency ratio was experimented with but dropped, because it turned out to be insignificant in all equations. The inclusion of political variables may be less compelling in the Brazilian case because most of the changes to state VAT legislation that are relevant from the purpose of industrial recruitment can be carried out by the executive branch of government and does not require approval by state legislatures.

Additional controls are considered. Because tax setting is constrained by the government's intertemporal budget constraint, the set of control variables includes current government spending as a measure of the extent to which state governments are prepared to forego current revenue through tax competition in exchange for future gains in economic activity. Data constraints prevent the inclusion of state indebtedness among the regressors, which would allow for controlling for the effect of debt sustainability on the ability of state governments to forego revenue when engaging in tax competition. It is also important to control for the extent of federal-state vertical imbalances in rival jurisdictions as an additional proxy for the opportunity cost of tax competition.

There is considerable revenue sharing in the case of the income tax between the federal government and the states.[8] But this does not constitute co-occupancy; in fact, Brazilian tax legislation, unlike that of many other federations, formally prevents different levels of government from sharing a tax base. For example, the base of the IPI, which is a schedular tax by inclusion levied by the federal government on industrialised goods, is not concurrent with that of the ICMS. In addition, the revenue-sharing arrangements between the federal government and the states do not provide for strong equalisation,[9] and state tax liabilities are not deductible against federal taxes and vice-versa, which is known to create additional vertical spillover effects in tax-setting behaviour. Revenue sharing can nevertheless create interdependencies in tax setting among the states, which are unrelated to base co-occupancy, because it allows the states to export the cost of provision to other jurisdictions instead of internalizing them through higher tax rates to be borne by the state residents. As a result, a measure of vertical imbalances in intergovernmental relations, defined as the percentage in competing state revenue of mandated revenue-sharing transfers from the central government, is included among the regressors.

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8.   The 1988 Constitution mandates that 22.5% of the revenue from the income tax and the federal VAT (IPI) be shared with the states and that a further 21.5% of the revenues from these federal taxes be transferred to the municipalities. Taking into account all mandated transfers to states and municipalities, 47% of income tax revenue and 57% of the revenue from the IPI are transferred to the sub-national governments. See Afonso and de Mello (2002) for more information.

9.   This is despite an agreement among the states that 85% of the shared revenue be transferred to the poorer states of the North, North-East and Centre-West, because shared revenue is distributed among these states on the basis of resident population. This arrangement replaced the revenue-sharing formula used until 1989 in which revenue was shared in direct proportion to the resident population and the inverse of income per capita. See Afonso and de Mello (2002) for more information.

4.3.   Preliminary findings

The tax reaction function defined in Equation (1) was estimated by fixed effects in levels and by random effects with first-differenced data. The estimators were selected on the basis of the Hausman test (Table 2). The lagged dependent variable was included among the regressors when the reaction function was estimated in levels, because the residuals were found to be serially correlated on the basis of the Wooldridge test. In this case, the lagged dependent variable was instrumented by its own lagged values. A standard overidentification test is reported to assess the adequacy of this instrumentation strategy. As a preliminary test of the theory on which the empirical analysis is based, the Durbin–Wu–Hausman test was applied to the average tax rate in competing states, which was found to be exogenous.[10] This finding invalidates the theoretical hypothesis of strategic interactions in tax setting among same-level jurisdictions. By theory, if the states are playing a tax game, the tax rate of competing jurisdictions should be endogenous to tax setting in the reference state.

The results reported in Table 2 suggest that the slope of the tax reaction function – the coefficient of the average tax rate in competing states – is positive and statistically significant regardless of whether Equation (1) is estimated in levels or in first differences. The estimated coefficient is nevertheless larger in magnitude when the reaction function is estimated in first differences. This suggests that the scope for horizontal tax competition among the states may be underestimated in the long term (when the regression is estimated in levels) and overestimated in the short term (when the regression is estimated with first-differenced data). By the same token, the role of informality may be overestimated in the long term and underestimated in the short term. With regard to the other controls, neighbour's vertical imbalances are not statistically significant at classical levels, regardless of whether the equation is estimated in levels or in first differences, whereas government spending is signed as expected and the estimated coefficients are of the same magnitude in both regressions. It will be argued below that neither estimation strategy is adequate for assessing the scope of horizontal tax competition among the Brazilian states.

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10.   All other regressors (formality, government size and vertical imbalances) were found to be exogenous on the basis of the Durbin–Wu–Hausman test (results not reported but available upon request).

Table 2. **Horizontal tax competition: Partial-equilibrium estimations**

Dep. Var.: Own ICMS rate[a]

	Variables defined in:	
	Levels	First differences
Own ICMS rate (lagged)	0.45 ***	…
	(0.064)	
Neighbours' ICMS rate	0.70 ***	0.86 ***
	(0.076)	(0.055)
Neighbours' vertical imbalance	0.07	0.14
	(0.152)	(0.104)
Formality	-0.38 ***	0.03
	(0.074)	(0.078)
Government spending	0.14 **	0.14 ***
	(0.055)	(0.046)
Definition of neighbours	All other states	
Estimator	FE-IV	RE
No. of observations	314	366
No. of cross-sectional units	27	27
R-squared (overall)	0.65	0.56
Prob > chi-sq. (*p* value)	0.00	0.00
Hausman: Prob > chi-sq (*p* value)	0.00	0.95
Wooldridge: Prob > F (p value)	0.00	0.36
Durbin-Wu-Hausman: Prob > chi-sq (*p* value)	0.22	0.72
Over-identification test (*p* value)	0.98	…

a) FE and RE refer respectively to the fixed- and random-effects estimators. IV refers to instrumental variables. Standard errors are reported in parentheses. All models include an intercept (not reported). Statistical significance at the 1, 5, and 10 percent levels is denoted by respectively (***), (**), and (*). The lagged dependent variable is instrumented by its own lags (2 lags) when the model is estimated by FE.

5.   The error-correction regressions: Baseline results

5.1.   *Do the states play a Nash game?*

The findings reported above suggest that it is important to allow for more complex dynamics in the regressors to adequately distinguish the short- and long-term effects of tax competition, as well as those of other determinants of tax setting at the state level. This can be done in an error-correction set-up by defining the tax reaction function in levels, to capture long-term effects, and with first-differenced data to model the short-term dynamics in tax setting in each state:

$$\Delta \tau_{it} = \beta_0 + \beta_1 e_{i,t-1} + \beta_2 \sum_{j \neq i} \zeta_{ij} \Delta \tau_{jt} + \beta_3 \Delta \tau_{L,t-1} + \beta_4 \Delta X_{it} + u_{it}, \text{ with } \beta_1 < 0,$$ (2)

where Δ is the first-difference operator and u_{it} is an error term.

Equations (1) and (2) can be estimated jointly as:

$$\Delta\tau_{it} = (\beta_0 - \beta_1\alpha_0) + \beta_1\tau_{i,t-1} + \beta_2\sum_{j\neq i}\zeta_{ij}\Delta\tau_{jt} - \beta_1\alpha_1\sum_{j\neq i}\zeta_{ij}\tau_{jt-1} + \beta_3\Delta\tau_{L,t-1} - \beta_1\alpha_2\tau_{L,t-2} + \beta_4\Delta X_{it} - \beta_1\alpha_3 X_{i,t-1} + u_{it} \quad (3)$$

There are two main reasons for estimating the slope of the reaction function in an error-correction set-up using Equation (3). First, it allows for richer dynamics in horizontal tax competition than in the partial-equilibrium case where the lagged dependent variable is added to the set of regressors to deal with serial correlation in the residuals.[11] The implied long-term coefficients are often ignored in empirical analysis of horizontal tax competition, because tax theory does not distinguish explicitly between the short- and long-term dynamics of tax interdependencies among same- or different-level jurisdictions. However, the partial equilibrium set-up is very simple to estimate more complex dynamics in a tax reaction function, because it implies that all regressors follow the dynamics of the tax rate in the reference state, thus affecting the magnitude of the implied long-run coefficients of the other regressors included in the reaction function, especially those related to the sustainability of public finances. By allowing the different right hand-side variables to have different dynamics, more meaningful long-run coefficients may be extracted from the regressions.

Second, it is important to take the long-run sustainability of public finances into account when estimating tax reaction functions. For example, a given jurisdiction's willingness to forego revenue in the short-term to match a reduction in its neighbours' tax rate (or in the central government's, in the case of tax co-occupancy) may be inconsistent with the need to finance longer-term expenditure needs or to honour debt service commitments. In this case, it is not only important to add a right hand-side variable to capture these sustainability effects, such as government spending, but also to allow these effects to vary over time. This can be done in an error-correction specification for the tax reaction function.

The usual econometric considerations when estimating Equation (1) are applicable to the estimation of Equation (3). First, the Stackelberg leader's tax rates enter the equation in lagged, rather than contemporaneous, values to deal with the potential endogeneity problems arising from the fact that, under the hypothesis of strategic interactions among competing tax-setters, the tax rates prevailing in different jurisdictions are jointly determined. The endogeneity of these variables also needs to be formally tested. In theory, the Stackelberg leader's tax rate should be exogenous to tax setting by the follower. Second, parameter estimates may suffer from spatial error dependence because jurisdiction-specific variables may be omitted. A two-stage instrumental variable estimation using spatially-lagged control variables as instruments can be used to deal with the endogeneity of the tax rates in neighbouring jurisdictions as well as spatial error dependence (Esteller-More and Sole-Olle, 2001, 2002; Altshuler and Goodspeed, 2003). Another issue is the definition of the weighting matrix, which tends to be guided by gravity considerations, with the weights depending on distance between jurisdictions, or simply by averaging the tax rates prevailing in neighbouring countries or regional peers, excluding the reference jurisdiction to avoid endogeneity. These considerations, among others, will be elaborated in greater detail below.

The baseline error-correction regression focuses on a simple Nash specification where the parameter of interest is the sensitivity of the state's own tax rate to the level of taxation in competing states. In this specification, the Stackelber leader is dropped. The neighbours' ICMS rate is treated as endogenous in all model specifications (on the basis of the Durbin-Wu-Hausman test) and instrumented by its lagged values (2 lags) and the spatially-lagged controls (formality, government size and vertical imbalances). Three

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11.   When the lagged dependent variable is included among the regressors, the associated long-run coefficients can be calculated by dividing the estimated coefficients of each regressor (the short-term coefficients) by 1 minus the coefficient of the lagged dependent variable.

options are considered for the definition of the level of taxation in competing states: *i*) the unweighted average of the tax rate applied in all states (excluding the reference state to avoid endogeneity), *ii*) the unweighted average (excluding the reference state) of the tax rate in contiguous states (*i.e.,* those states that share a border with the reference state), regardless of the fact that these states may be located in different geo-economic regions (*i.e.,* the states are conventionally, not administratively, grouped in five regions (North, North-East, South, South-East and Centre-West), reflecting broad common socio-economic characteristics), and *iii*) the unweighted average (excluding the reference state) of the tax rate in contiguous states that belong to the same geo-economic region.

The results of the baseline estimation of Equation (3) are reported in Table 3. A general-to-specific estimating strategy was followed, so that the variables that were found to be statistically insignificant in the baseline regression (Model 1) were dropped. The coefficient of the average tax rate in competing states is positive and statistically significant in all models, regardless of how the weighting matrix is defined. The magnitude of the coefficient in Model 1 indicates that a 10% reduction in the tax rate levied on average by competing states reduces the reference state's own tax rate by 5% in the short term, while having no effect in the long term, because the lagged level of the average tax rate prevailing in competing states is not statistically significant. The results also suggest that the reaction function is only marginally flatter with regard to tax changes in contiguous states (Model 2), but steeper when they belong to the same geo-economic region (Model 3), possibly as a result of cross-border shopping and gravity considerations. The result of the overidentification test suggests that the instrumentation strategy is appropriate in the baseline model. The Hausman test supports the estimation of the baseline regressions by fixed effects. The tax rate in competing states is endogenous in all models.

Table 3. **Horizontal tax competition: Nash game**

Dep. Var.: Own ICMS rate (first difference)[a]

	1	2	3
	Long-run effects (variables in lagged levels)		
Own ICMS rate	-0.40 ***	-0.33 ***	-0.29 ***
	(0.046)	(0.052)	(0.061)
Neighbours' vertical imbalance	0.80 ***	0.11	0.19 ***
	(0.170)	(0.073)	(0.072)
Formality	-0.28 ***	-0.08	-0.06
	(0.102)	(0.085)	(0.077)
Government spending	0.17 ***	0.22 ***	0.20 ***
	(0.058)	(0.063)	(0.064)
	Short-run effects (variables in first differences)		
Neighbours' ICMS rate	0.50 ***	0.48 ***	0.61 ***
	(0.118)	(0.150)	(0.195)
Neighbours' vertical imbalance	0.52 ***	0.08	0.12 *
	(0.133)	(0.057)	(0.068)
Formality	-0.25 **	-0.10	-0.06
	(0.121)	(0.113)	(0.112)
Government spending	0.23 ***	0.30 ***	0.23 **
	(0.068)	(0.087)	(0.098)
Definition of neighbours	All other states	Border-sharing states	Border-sharing states in the same region
Estimator	FE-IV	FE-IV	FE-IV
No. of observations	318	318	318
No. of cross-sectional units	27	27	27
R-squared (overall)	0.40	0.31	0.28
Prob > chi-sq. (*p* value)	0.00	0.00	0.00
Hausman: Prob > chi-sq (*p* value)	0.00	0.00	0.00
Durbin-Wu-Hausman: Prob > chi-sq (*p* value)	0.01	0.00	0.00
Over-identification test (*p* value)	0.72	0.00	0.01

a) FE-IV refers to the fixed-effects estimator with instrumental variables. Standard errors are reported in parentheses. All models include an intercept (not reported). Statistical significance at the 1, 5, and 10 percent levels is denoted by respectively (***), (**), and (*). Neighbours' ICMS rate is instrumented by its lagged values (2 lags) and the spatially-lagged controls.

As regards fiscal sustainability, government spending was found to have a stronger impact on the reference state's ICMS rate in the long term than tax policy in competing states. As a result, fiscal sustainability is a more powerful determinant of tax setting in any given jurisdiction over longer periods of time than tax policy in rival states. Horizontal tax competition is also dominated by fiscal sustainability considerations in the short term, given that a one standard-deviation increase in the average ICMS rate in competing states is associated with a lower increase in the ICMS rate in the reference state than that of

government spending. Finally, fiscal sustainability has a stronger effect on tax setting in the long than in the short term (the implied long-term coefficient of about 0.40 (0.17/0.40) is higher than the short-term coefficient of 0.23).

The additional regressors are also signed as expected. Formality is negatively related to own tax both the short and long terms, but is only statistically significant in the regression with the broadest definition of competing states. Vertical imbalances in rival states are positively signed in all models but, surprisingly, do not seem to affect the state's own tax rate in the equations where the weighting matrix is based on contiguity (Model 2). By Model 1, a 10% increase in vertical imbalances in rival states increases the reference state's ICMS rate by about 5% in the short run and doubles it (0.8 divided by 0.4) over the long run. This finding suggests that state-level tax competition is affected by vertical revenue sharing, because it creates the scope for exporting the cost of provision to other jurisdictions instead of internalizing these costs through higher tax rates to be borne by the state residents. As a result, higher vertical imbalances in competing states makes it easier for peers to forego revenue through tax competition and, therefore, creates inter-jurisdictional interdependencies in tax setting. In a related literature, evidence for the United States suggests that automatic revenue windfalls due to the sharing of revenue from elastic taxes, or revenue-raising measures at the federal level, are not fully offset at the state level – the flypaper effect (Hines and Thaler, 1995).[12] This effect of intergovernmental revenue sharing on state-level spending also elicits strategic responses by competing states.

The baseline results are reasonably robust. The results reported in Table 4 suggest that the estimated slope of the reaction function is somewhat higher when a time trend is included in the regression to pick up the effect of common shocks on its slope. The inclusion of wholesale price inflation among the control variables results in a somewhat higher estimated slope. Inflation is associated with lower effective tax rates both in the short and long terms. Wholesale price inflation is measured by the IGP-DI, a price index to which most utility prices are indexed and that tracks changes in the price of tradable goods more closely than the IPCA, the consumer price index used by the central bank to target inflation. Selection of this wholesale price index is due to the fact that in periods of real exchange rate depreciation, which was significant in Brazil in 1999, following the abandonment of the exchange rate peg, wholesale prices rise faster than consumer prices, creating a revenue windfall for the states. The scope for these windfall revenues is compounded by the fact that the services whose prices are indexed to the wholesale price index, such as utilities, are also taxed heavily by the states, as discussed above.

Taking account of the share of employment in trade/telecoms, which is positively associated with the tax rate, as expected, does not alter the magnitude of the estimated slope of the reaction function. This variable was included in the estimating equations to control for the expansion of the telecom sector since privatisation. The share of revenue accruing from the telecom sector in total ICMS revenue almost doubled to 12.5% between 1997 and 2001, a much faster increase than that of value added produced by the sector in GDP, which rose from 2% in 1997 to 2.7% in 2001. As mentioned above, collections of ICMS on the telecom, oil/fuel and electricity sectors accounted for about 40% of ICMS revenue in 2001, up from nearly 27% in 1997. Information on the sectoral composition of ICMS revenue is only available for this rather short time span (1997-2001), which does not allow for the inclusion of an additional control variable to test the robustness of the baseline results.

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12.   This hypothesis has so far not been empirically tested in the case of Brazil. Nevertheless, as discussed in Afonso and de Mello (2002) and de Mello (2006), because of the earmarking of sharable revenues, the federal government has increased emphasis on mobilizing revenue that is not shared with the states and municipalities, such as that from enterprise payroll and earnings taxes. This encourages the development of informal labour markets and affects competitiveness adversely, to avoid the sharing of additional revenue arising from its own fiscal effort, which the states are free to spend.

Table 4. **Horizontal tax competition: Robustness analysis**

Dep. Var.: Own ICMS rate (first difference)[a]

	Baseline	1	2	3
	Long-run effects (variables in lagged levels)			
Own ICMS rate	-0.40 ***	-0.38 ***	-0.40 ***	-0.39 ***
	(0.046)	(0.044)	(0.045)	(0.045)
Neighbours' vertical imbalance	0.80 ***	0.69 ***	0.80 ***	0.83 ***
	(0.170)	(0.168)	(0.174)	(0.170)
Formality	-0.28 ***	-0.32 ***	-0.29 ***	-0.29 ***
	(0.102)	(0.112)	(0.102)	(0.102)
Government spending	0.17 ***	0.12 *	0.10	0.13 **
	(0.058)	(0.060)	(0.061)	(0.059)
	Short-run effects (variables in first differences)			
Neighbours' ICMS rate	0.50 ***	0.67 ***	0.69 ***	0.53 ***
	(0.118)	(0.088)	(0.093)	(0.110)
Neighbours' vertical imbalance	0.52 ***	0.42 ***	0.48 ***	0.52 ***
	(0.133)	(0.127)	(0.134)	(0.131)
Formality	-0.25 **	-0.19	-0.19 *	-0.24 **
	(0.121)	(0.116)	(0.116)	(0.120)
Government spending	0.23 ***	0.15 **	0.13 **	0.20 ***
	(0.068)	(0.062)	(0.064)	(0.065)
	Other variables (long- and short-run effects)			
Time dummy		0.01 *		
		(0.005)		
Inflation (first-diff.) (x 1000)			-0.01 *	
			(0.006)	
Inflation (lagged level) (x 1000)			-0.01 **	
			(0.004)	
Employment in trade/telecoms (first-diff.)				0.09 *
				(0.049)
Employment in trade/telecoms (lagged level)				0.11 *
				(0.064)
Estimator	FE-IV	FE-IV	FE-IV	FE-IV
No. of observations	318	318	318	318
No. of cross-sectional units	27	27	27	27
R-squared (overall)	0.40	0.45	0.46	0.45
Prob > chi-sq. (*p* value)	0.00	0.00	0.00	0.00
Hausman: Prob > chi-sq (*p* value)	0.00	0.00	0.00	0.00
Durbin-Wu-Hausman: Prob > chi-sq (*p* value)	0.01	0.56	0.31	0.02
Over-identification test (*p* value)	0.72	0.14	0.63	0.83

a) FE-IV refers to the fixed-effects estimator with instrumental variables. Standard errors are reported in parentheses. All models include an intercept (not reported). Statistical significance at the 1, 5, and 10 percent levels is denoted by respectively (***), (**), and (*). Neighbours' ICMS rate is instrumented by its lagged values (2 lags) and the spatially-lagged controls.

5.2. *Is there a Stackelberg leader in the ICMS tax war?*

The objective of this section is to estimate the slope of the policy reaction function with respect to the Stackelberg leader in Equation (3), following Altshuler and Goodspeed (2003). Several potential leaders have been experimented with, including the states of Bahia, Paraná, Minas Gerais and Rio Grande do Sul. Anecdotal evidence suggests that these states have used their ICMS legislation as an industrial recruitment tool and have offered tax incentives to attract investment over the years, including for the motor industry.

The results, reported in Table 5, suggest that the state of Bahia, which is among the country's poorer states located in the North-Eastern region, has acted as a leader in the tax war. The parameter estimates for Bahia are statistically significant both in levels and first-differences, suggesting the presence of short- and long-term effects on other states' tax policy. The hypothesis that the state of São Paulo, by far the most populous state concentrating about one-third of the country's value added, acts as a Stackelberg leader was also tested but rejected by the data. This possibility was motivated by the literature on horizontal tax competition in Canada, where the tax rate in the dominant province in terms of population and economic size has a strong bearing on tax policy in the other provinces, at least as far as the corporate income tax is concerned (Hayashi and Boadway, 2001).

Table 5. **Horizontal tax competition: Stackelberg game**

Dep. Var.: Own ICMS rate (first difference)[a]

	Baseline	1	2
	Long-run effects (variables in lagged levels)		
Own ICMS rate	-0.40 ***	-0.40 ***	-0.40 ***
	(0.046)	(0.047)	(0.043)
Neighbours' vertical imbalance	0.80 ***	0.79 ***	0.48 *
	(0.170)	(0.176)	(0.247)
Formality	-0.28 ***	-0.29 ***	-0.25 **
	(0.102)	(0.106)	(0.116)
Government spending	0.17 ***	0.17 ***	0.08
	(0.058)	(0.060)	(0.067)
	Short-run effects (variables in first differences)		
Neighbours' ICMS rate	0.50 ***	0.49 ***	0.92 ***
	(0.118)	(0.125)	(0.167)
Neighbours' vertical imbalance	0.52 ***	0.50 ***	0.42 **
	(0.133)	(0.138)	(0.164)
Formality	-0.25 **	-0.25 **	-0.11
	(0.121)	(0.126)	(0.124)
Government spending	0.23 ***	0.24 ***	0.11
	(0.068)	(0.071)	(0.072)
	Stackelberg leader effects		
Leader's ICMS rate (lagged, diff.)			0.36 **
			(0.178)
Lagged leader's ICMS rate (twice lagged level)			0.44 **
			(0.206)
Leader	…	…	BA
Sample	Full	Excl. BA	Full
Estimator	FE-IV	FE-IV	FE-IV
No. of observations	318	306	318
No. of cross-sectional units	27	26	27
R-squared (overall)	0.40	0.38	0.47
Prob > chi-sq. (*p* value)	0.00	0.00	0.00
Hausman: Prob > chi-sq (*p* value)	0.00	0.00	0.00
Durbin-Wu-Hausman: Prob > chi-sq (*p* value)	0.01	0.01	0.64
Over-identification test (*p* value)	0.72	0.71	0.40

a) FE-IV refers to the fixed-effects estimator with instrumental variables. Standard errors are reported in parentheses. All models include an intercept (not reported). Statistical significance at the 1, 5, and 10 percent levels is denoted by respectively (***), (**), and (*). Neighbours' ICMS rate is instrumented by its lagged values (2 lags) and the spatially-lagged controls.

6.   *Conclusions*

This paper tested the hypothesis of horizontal competition in the VAT for a sample of Brazilian states in the period 1985-2001. Although the states have considerable autonomy to set their VAT rates and bases, often using this tax as an industrial policy tool, the hypothesis of tax competition at the state level, often deemed predatory, has so far not been tested empirically. The fact that the federal government shares some of the revenue from its more elastic tax bases with the states, although both levels of government do not co-occupy the same bases, calls for controlling for interdependencies between federal and state-level tax setting behaviour that are nevertheless unrelated to tax co-occupancy. The states have also gone through a period of fiscal adjustment, especially since the second half of the 1990s, which has had a bearing on their finances, contributing to restoring fiscal sustainability at the sub-national level of government. This was taken into account by estimating the tax reaction function in an error-correction set-up, which allows richer dynamics in state-level public finances than that in the partial-equilibrium approach often used in the empirical literature.

The empirical findings confirm the presence of horizontal interdependencies in tax setting. The states were found to react strongly to changes in their neighbours' tax policy, especially those that belong to the same geo-economic region. Also, there appears to be a Stackelberg leader, with the remaining states responding strongly to its policy moves. The fact that the federal government shares part of the revenue from its more elastic taxes, such as the income tax, appears to affect state-level tax competition. The states may be willing to forego their own tax revenue through competition because they can rely on revenue mobilised elsewhere to maintain or increase their level of spending. By affecting the opportunity cost of tax competition, vertical imbalances in intergovernmental fiscal relations create horizontal interdependencies in tax setting that are nevertheless unrelated to tax co-occupancy.

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