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VERTICAL INCOME TAX EXTERNALITIES AND FISCAL INTERDEPENDENCE: EVIDENCE FROM THE U.S. [a,b]

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ABSTRACT: Concurrent taxation is a feature of many federal systems. As a result, the tax policy of one level of government affects the tax base of the other. A way to check the empirical relevance of this hypothesis is to test for the existence of interdependencies in the tax setting behaviour of various layers of government. Following this approach, this paper estimates the reaction of U.S. state personal income and general sales taxes to federal tax rates, taking into account the special features of the U.S. tax system. We find that when the federal government increases taxes, there is a significant positive response of state taxes.

RESUMEN: El solapamiento de bases impositivas es una característica de muchos sistemas federales. Como resultado, la política impositiva de un nivel de gobierno afecta la base impositiva del otro. Una forma de verificar la relevancia empírica de esta hipótesis es contrastar la existencia de interdependencias en la decisiones de política impositiva de varios niveles de gobierno. A partir de esta metodología, el trabajo estima la reacción en los impuestos sobre la renta personal y ventas de los estados de los EEUU frente a cambios en los tipos federales, tomando en consideración ciertas características peculiares del sistema fiscal norteamericano. Hallamos que cuando el gobierno federal sube los impuestos, hay una respuesta significativa de los impuestos estatales.

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1. Introduction

Traditionally the literature on fiscal federalism has devoted a great deal of interest to the analysis of fiscal externalities that arise among regional governments. Many studies have dealt with issues of tax competition and tax exporting, both theoretically (Gordon, 1983, Arnott and Grieson, 1984, and Mintz and Tulkens, 1986) and empirically (Stephenson and Hewett , 1983, and Case, 1993, on the first topic, and Bird and Slack, 1983, and Hogan and Shelton, 1984, on the second). Other studies have focused on the relevance of expenditure spillovers among neighbouring regional governments (Case *et al.*, 1993). However, as Keen (1998) pointed out in a recent survey, the relevance of externalities between levels of government also has to be recognised. In a federal setting, characterised by the existence of a federal government and many regional governments, it is quite possible that the policy decisions of one level of government will affect the policy outcomes at the other level. If both levels ignore such policy externalities, the resulting decentralised policy decisions may be socially sub-optimal. These vertical spillovers can arise both on the expenditure side of the budget (Dahlby and Wilson, 1997), and in tax-setting situations. This paper will deal with the latter topic.

Vertical externalities in the design of tax policy arise mainly as a result of concurrent taxation. In many federal countries, some tax bases are the joint property of the federal and regional levels of government. That is, both levels of government have the capacity to change fundamental tax parameters on the same base. It has to be stressed that tax-sharing arrangements – that is, when the regional government is entitled to a share of the revenues raised in its territorial jurisdiction – do not conform to what we mean by 'concurrent taxation'. Tax-sharing is a necessary but not sufficient condition for our definition of concurrent taxation; what is in fact necessary is that both levels of government share tax powers regarding that base. In this case, the tax rate (or other parameters of the tax that define the tax burden) set by one level of government affects the revenues raised by the other. Of course, for this vertical tax spillover to arise the tax base has to be responsive to tax rate changes; that is, the tax has to be distortionary. In this setting, if each level of government ignores the effects its tax policies have on the revenues of the other level of government, the tax rates will be too high.

The interest of public finance scholars in the tax spillovers arising from concurrent taxation is very recent. Traditionally, analysts have stressed certain administrative problems related to the joint property of tax bases. Musgrave (1983) and Break (1984) worried about the higher compliance and administrative costs that a taxing arrangement of this kind among levels of government generates, and Tanzi (1995) and Bordignon *et al*. (1996) emphasised the moral hazard problems appearing when different levels of governments collect joint taxes. Nevertheless, the first papers dealing with vertical externalities caused by uncoordinated distortionary taxation were those of Flowers (1988) and Johnson (1988). More recently, Wagoner (1995), Wrede (1996), Boadway and Keen (1996), Dalhby (1996), Boadway *et al*. (1997), and Sato (1997) have also addressed this issue.

There are three papers that have sought to quantify the magnitude of the tax interdependence among levels of government: Besley and Rosen (1998), Goodspeed (2000) and Hayashi and Boadway (2000). The analysis of Besley and Rosen (1998) deals with spillovers in gasoline and cigarettes tax setting, and uses U.S. data for the period 1975-89. They find that when the federal government increases its taxes there is a significant response of state taxes, confirming the vertical externality hypothesis. The article by Goodspeed (2000) focuses on income taxation and uses a panel of data from 10 OECD countries during the period 1975-84. He finds a negative relationship between federal and regional tax rates. The paper by Hayashi and Boadway (2000) analyses vertical and horizontal externalities in business taxation using a panel of data for Canada during the period 1963-96. They model the behaviour of the Canadian federal government, of the two biggest provincial governments (Ontario and Quebec) and of the aggregate of the other provinces. The main findings are a negative reaction of provincial taxes to the federal tax, and a positive reaction of the federal tax only to Ontario's tax policies.

As we will discuss in the theoretical section, these contrasting results – i.e., different sign and size of the reaction – are consistent with the ambiguity of the theoretical predictions, but may also be due to differences in the taxes analysed or to differences in the federal institutional context in which tax decisions are made. We think that further empirical analysis of this kind is needed to clarify these issues. In particular, we need to know more about vertical externalities in 'first class' taxes, such as the personal income tax, controlling for the institutional features of the federal system/s analysed. The main purpose of this paper is precisely to perform an empirical test of the existence of vertical externalities in the U.S. personal income and general sales taxes.

The structure of the paper is as follows. In the next section, we present a brief survey of the main theoretical results found in the literature on vertical tax externalities, in order to derive testable hypotheses. Next, we introduce the procedure used in the empirical analysis, based on theoretical predictions about the slope of the reaction function. We also analyse other competing explanations which (like vertical externality) could also lead to interdependencies in the tax policies of various layers of government. In the U.S. case, the most important factors that might be confused with interdependencies arising from concurrent distortionary taxation are tax deductibility and formal links between the tax codes at various levels of government. In the third section, we test the different hypotheses developed in the previous sections with data on U.S. personal income and general sales taxation for the period 1987-96. Finally, in the fourth section, we conclude.

2. Theoretical considerations

2.1 *Vertical tax externalities and fiscal interdependence*

In this part of the paper, our purpose is to present the theoretical background for the empirical analysis of vertical tax externalities. This type of externality arises from the co-occupancy of tax bases between different layers of government. Such co-occupancy can be either explicit, that is, between exactly the same tax bases, or implicit, that is, between tax bases that are in some way interrelated in an economic sense (e.g., between personal income and general sales taxation). Co-occupancy of tax bases (or 'concurrent taxation') means that the tax decisions of each layer of government are interrelated, as long as the taxes of each layer of government are distortionary.

In order to show the consequences of concurrent taxation, theoretical analysis assumes that each layer of government maximises an objective function subject to its budget constraint. This objective function can be either a social welfare function (Johnson, 1988, or Keen, 1998) or tax revenue (Flowers, 1988, or Keen, 1998). In the first case the government is considered as benevolent; in the second, it is considered as a Leviathan. However, more importantly, in both cases, if each layer of government ignores the effects of its actions on the other when choosing its tax parameters (i.e., they both behave Nash), this will produce an excessively high level of taxation with respect to the level that would be set by a unitary government

(Dahlby, 1996)[1].

In all likelihood, this inefficient behaviour will cause each layer of government to react to variations in the tax rate of the other layer of government in order, first, to recover the revenue loss due to the erosion of its tax base, and second, to adjust its tax rates to the new value of the marginal cost of obtaining public funds. Therefore, the reaction will depend both on the marginal valuation of public revenues and on the marginal cost of raising public funds. As Keen (1998) showed, the net effect of this reaction is ambiguous. No clear-cut sign arises from a theoretical analysis, but the result depends on the way the elasticity of the tax base with respect to its tax rate varies with the tax rate. Thus, for example, Keen (1998) found that when the elasticity of the tax base is constant, the reaction is positive, and when the tax base is linear in the tax rate the reaction is negative.

Nonetheless, the assumption that both layers of government take as given the consequences of their actions on the other layer of government (Nash behaviour) is not obvious. That is, not all layers of government may set up their level of taxation independently of what is socially optimal, nor, in consequence, will they all react in the same way. On the one hand, the Federal government might be expected to act as a Stackelberg leader, so taking into account the effects its actions have on the regional governments (Boadway and Keen, 1996, Hoyt and Jensen, 1996). If this were the case, and depending on whether the Federal government has or does not have access to unrestricted intergovernmental transfers, it could undo any inefficient action of the regions, and so obtain the socially optimal level of taxation. Therefore, we would expect the reaction of the Federal government to be lower as long as it behaved as a Stackelberg leader.

On the other hand, why would regional governments not see through the federal government's budget constraint, and in consequence also take into account the effects of its actions on federal taxes? We think that this behaviour is unrealistic as long as the number of regions is large enough and the share of the tax base of each region is not disproportionately high.

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[1]Nonetheless, note that this result could be mitigated in the presence of horizontal tax competition. Unlike the situation of over-taxation caused by the vertical tax externality, horizontal tax competition will lead regional governments to set tax rates inefficiently low. In that case, concurrent taxation between different layers of government might result in a Pareto improvement, since the tendency to produce higher taxes might help to bring the level of taxation closer to the social optimum (defined now as a situation with no concurrent taxation or horizontal tax competition). For a detailed analysis of how both types of externalities interact at the same time, see Wrede (1996).

Concluding, there are two empirical predictions that derive from the traditional theoretical analysis of vertical tax externalities[2]. The first refers to the equilibrium levels of taxation. We would expect federal structures that allow for overlapping of tax bases to create an inherent tendency towards excessively high tax rates. The second is to do with the interdependencies between federal and regional tax rates created by the vertical tax externality, and so focuses on the slope of the reaction function and not on equilibrium tax levels. This is the strategy we follow in the empirical part of the paper. In this case, for an empirical test of the vertical tax externality, the relevant issue is to check whether this reaction is significantly different from zero. While the sign of the reaction is ambiguous, as the federal tax is equally likely to crowd out or crowd in state taxes, the magnitude of the reaction will reflect the tax setting behaviour of each layer of government, and will be lower in the case of Stackelberg behaviour.

2.2. *Competing hypotheses of fiscal interdependence*

A clear empirical prediction of the theoretical analysis of vertical tax externalities is the existence of fiscal interdependence between the tax policies of different layers of government. However, though vertical tax externalities lead to interdependent tax-setting behaviour, not all the observed interdependencies in taxation must be due to those externalities. That is, when testing the vertical tax externality hypothesis, the researcher has to check the robustness of the results against other competing explanations of observed fiscal interdependence among layers of government. Notably, most of these alternative explanations are due to the particular federal institutional context in which taxes are set.

More specifically, we are able to identify two situations that are especially relevant in the U.S. case, where the interdependencies observed may be confused with vertical externalities. The first refers to the deductibility of the state tax liability from the federal personal income tax base (*Tax deductibility*). Additionally, in some States there exists the possibility to deduct the federal tax liability from the state personal income tax base (*Reciprocal Tax Deductibility*). In order to understand how the incentives to set tax rates vary depending on each of these institutions, we express the total tax liability for the case of no-tax deductibility (or basic case) as: $B(t_S + t_F)$, where B is the common tax base, t_S is the state average effective tax rate, and

[2] Obviously, any departure from traditional theoretical analysis – e.g., assuming partisan preferences on the part of the governments or strategic voting by the taxpayers (Alesina and Rosenthal, 1995, or Persson and Tabellini, 1992) – would require a different explanation of the tax interdependencies arising from the vertical tax externality. However, to our knowledge, there is no specific theoretical model that analyses vertical tax externalities departing from the traditional framework.

t_F is the federal average effective tax rate. In contrast to the basic case, tax liabilities according to both possibilities of tax deductibility are expressed as[3]:

$$\textit{Tax deductibility: } Bt_F + Bt_S(1-t_F)$$

$$\textit{Reciprocal Tax deductibility: } \frac{Bt_F(1-t_S)+Bt_S(1-t_F)}{1-t_S t_F}$$

In the case of *Tax Deductibility* and *Reciprocal Tax Deductibility*, the tax liability is lower than in the case of no-tax deductibility, though in the case of *Reciprocal Tax Deductibility*, the reduction is obviously stronger, since the deductibility affects both the federal and the state tax liability. In the denominator of the liability of the latter case, there appear second round effects due to the fact that the reciprocal deductibility causes simultaneous interactions when calculating each tax liability (in fact, a system of two equations must be used to solve each tax liability) [4].

Therefore, the state tax deductibility in the federal income tax clearly provokes a reduction in the marginal cost of public funds of the state government, and so, ceteris paribus, tends to produce higher state tax rates. Therefore, this effect would point in the same direction than the vertical tax externality, that is, to higher state tax rates with respect to the socially optimal level[5]. With respect to the reaction of the state government, given the lower marginal cost of public funds, we would also expect a stronger reaction of state taxes to federal tax changes than in the situation without tax deductibility[6]. As we will see, the empirical analysis for the

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[3] These analytical expressions do not provide an exact reflection of the real situation, because in practice the deductibility of the tax liability from the tax base is done according to the marginal tax rate, not the federal average effective tax rate. For instance, in the case of the *Tax deductibility*, the regional tax liability should have been expressed as $Bt_F+Bt_S(1-t_{m,F})$, where $t_{m,F}$ is the federal marginal tax rate. However, this analytical simplification will not affect our explanations of how tax deductibility interacts with the vertical tax externality when analysing the tax setting behaviour of the state government.

[4] See Feenberg and Rosen (1986) and Fisher (1996) for a detailed explanation of the differential effects of tax deductibility, and Fisher (1996), pp. 425-426, for a numerical example.

[5] The empirical literature on the effect of the US federal tax deductibility of state taxes implicitly assumes that the only effect at work is the one derived from *Tax deductibility*. Although several studies (e.g., Feldstein and Metcalf, 1987, Holtz-Eakin and Rosen, 1987) found a significant statistical effect of deductibility on the use of some state taxes, they do not consider the possibility that part of this effect could be due to the interdependence caused by the vertical tax externality.

[6] See Esteller-Moré and Solé-Ollé (1999) for a comparative static analysis of the effects of the tax deductibility on the slope of the reaction function of the state government. The analysis is based on

US will not allow us to ascertain to what extent the estimated reaction of the States is caused by the possibility of tax deductibility or by the vertical tax externality. Instead, we will only be able to check whether those States that allow for the reciprocal tax deductibility react significantly differently from the rest.

The theoretical analysis of the reciprocal tax deductibility becomes much more difficult, and there is no clear prescription of the expected reaction on the part of the States affected (see Esteller-Moré and Solé-Ollé, 1999). In this case, faced with changes in the federal tax parameters, on the one hand, those States that allow for reciprocal tax deductibility suffer a revenue loss due both to the explicit erosion of their tax base, and to a higher deductibility in their tax base. However, their marginal cost of obtaining public funds is now higher than in the *Tax deductibility case* (due to the deductibility of the federal tax liability in their tax base). In conclusion, the relative magnitude of their reaction will be influenced both by the higher marginal cost of public funds and by their higher marginal valuation of public goods for each level of the federal tax rate. If the former effect dominates the latter, we would expect a lower state reaction of those States that do allow for reciprocal tax deductibility.

The second institutional feature that can compete with the hypotheses that fiscal interdependence is owed to the vertical tax externality in the U.S. case is the possibility that the taxes of the different layers of government maintain a degree of interrelation in their legal definition. For example, this is the case when the state tax liability is calculated applying a tax rate on the tax base defined according to the federal tax code. In this case, if the tax base is widened, those States will see an increase in their disposable amount of tax revenue unless they explicitly act to offset the federal action. There is some empirical evidence in the literature that shows that automatic increases in state tax revenues (e.g., coming from elastic tax bases or derived from the effects of federal reforms) tend not to be fully compensated through discretionary policies on the part of the States (Feenberg and Rosen, 1987, Ladd, 1993), and so this state tax-setting behaviour suffers from fiscal illusion. Note that according to the traditional analysis of the vertical tax externality, in which the governments behave rationally maximising an objective function, a passive reaction of this type would never arise, since they would optimally re-adapt their tax policy to the new situation.

Therefore, the interdependency arising from passive adaptation to federal reforms should also

restrictive assumptions with respect to the elasticity of the tax base and the utility function, which make it impossible to infer general conclusions.

be differentiated from the strict interdependence coming from the vertical tax externality. Otherwise, if the States do not completely offset such wind-fall gains (or losses), i.e. suffer from fiscal illusion, their reaction in the empirical analysis would appear to be higher, though it would only reflect a passive adaptation, not a reaction coming from the rational behaviour the analysis of the vertical tax externality supposes.

3. Empirical implementation

3.1 *Empirical framework*

Our main empirical purpose is to estimate the magnitude of the reaction of state income tax rates to exogenous changes in federal income tax rates; that is, to estimate the slope of the reaction function of the state government. We choose as our dependent variable the state tax rate – and not the federal tax rate – because in practice it is not true that there is only one state government. With the existence of many state governments, and under the obligation to define the same tax laws for the entire federation, the federal government does not react to the tax rate changes of each of the state governments, but probably to a weighted sum of all of them. Of course, this consideration does not automatically rule out the possible endogeneity of the federal tax rate; the econometric procedure will have to account for this possibility.

As the analysis is carried out for the U.S. we use some specific institutional features of that country in order to devise a complementary hypothesis for testing. Unfortunately, as state tax deductibility in the federal income tax is a feature common to all the States and years, it does not provide institutional variation that we can exploit in the analysis. However, we expect a different reaction in States that allow the deductibility of the federal income tax (*Reciprocal Tax deductibility*). However, as we have already discussed in the previous section, there is no clear prescription of whether the reaction will be stronger or not than in the case of *Tax deductibility*. The general specification to test these hypotheses is:

$$t_{S,it} = \alpha_1 \times t_{F,it} + \alpha_2 \times (t_{F,it} \times DRec_i) + \alpha_3 \times \textstyle\sum_{j\neq i} \omega_{ij} \times t_{S,jt} + \sum_k \alpha_k \times Z_{k,it} + \alpha_{0,i} + \varepsilon_{it} \qquad (1)$$

Where $t_{S,it}$ and $t_{F,it}$ are the state and federal tax rates, and where subscripts i and t indicate State and year. $DRec_i$ is a dummy variable equal to one if *Reciprocal deductibility* applies. The parameter α_1 is an estimate of the average tax rate reaction of the States without *Reciprocal tax deductibility*, while $(\alpha_1+\alpha_2)$ is the estimated reaction of the States that allow for the deductibility of the federal income tax.

The other variables included in equation (1) are the tax rates set by neighbouring States ($t_{S,jt}$) and a vector of other control variables *Z,* indexed by *k.* These controls are needed because vertical spillovers are just one of the factors that influence tax-setting. Tax decisions are carried out within a very complex institutional process that accounts for the preferences of voters, electoral interests of politicians, and economic, institutional and cultural constraints. Many of those influences are correlated with federal effective tax rates, making any direct inference about its effects on state tax rates impossible. As a result, and in order to isolate the effect of tax interdependence, it is necessary to control for all the other relevant variables that affect the state tax-setting process. We include several groups of control variables:

Horizontal tax interdependencies. State governments mimic the tax policies of their neighbours mainly for two reasons. The first is *horizontal tax competition* (Wildasin, 1988; see Wilson, 1999, for a survey). In this setting, state governments fear that disparate tax rates from those of neighbouring States could drive out mobile tax bases. The other possibility is *yardstick competition*, (Besley and Case, 1995,a). Under this hypothesis, voters compare the tax rates of their own State with those of similar States in order to keep politicians accountable. Regardless of the underlying theory, many papers have shown the empirical relevance of *horizontal interdependencies* (Case *et al.*, 1993, Besley and Case, 1995,a and Brueckner, 1998). This possibility is controlled for in our empirical analysis with the inclusion in equation (1) of a weighted average of the tax rates of competing States, where $t_{S,jt}$ is the tax rate set by State *j* and ω_{ij} is the weight of State *j* in the set of competing States of State *i*. Because the number of weights increases with the number of observations, it is not possible to estimate them with the rest of parameters of equation (1). This implies that we have to assume that the elements ω_{ij} are known. More specifically, we will suppose in the empirical analysis of the U.S. case that ω_{ij}=1 if the States *i* and *j* are contiguous and that ω_{ij}=0, otherwise[7].

Economic resources. Richer populations will demand more state public goods and, in consequence, will tolerate higher income taxes; we include personal income per capita (*Inc*),

[7] There is some degree of arbitrariety in the definition of the spatial weights, as they could be based on other criteria rather than contiguity, for example Euclidean distance (Anselin, 1988) or socioeconomic similarity (Case *et. al*., 1993). However, we also tested other definitions which either give similar results (first and second order contiguity together, based on the inverse of distance) or that prove totally ineffective (contiguity weighted by population, income or population similarity).

and personal income per capita squared (*Inc*^{2}) to control for this effect. However, the effect of an increase in income on the tax rate is uncertain, due to the fact that the same level of revenue is now sustainable at a lower tax rate. Also, the amount of grants received by the State government can have an effect on the income tax rate. Although richer governments – that is, governments receiving more grants from the federal government – will also spend more, they will return part of the amount received to its citizens; so we expect income taxes to be lower, the higher the amount of transfers received. To control for this effect, we include the per capita amount of grants received from the federal government (*Grant*).

Expenditure needs. Populations with higher shares of potential users of public services and/or higher cost of delivering those services will need higher levels of expenditure and, therefore, their income tax burden will be heavier. We include as explanatory variables the size of two groups of potentially intensive service users: the proportion of population over 65 and under 15 (*Pop(>65)* and *Pop(<15)*). We also introduce as cost variables the size of the population (*Pop*), its squared (*Pop*^{2}), and the density of population (*Den*)[8].

Political environment. Although many politically motivated models of public policy generation suggest that parties converge towards the same platforms regardless of ideology[9], many others suggest that if politicians are policy-motivated and do not only care about winning elections the policies implemented need not be the same. For instance, in the U.S. case, some scholars have suggested that Democrat governors tend to tax and spend more than their Republican counterparts (Besley and Case, 1995,b[10]). We include a dummy variable that accounts for the ideology of the regional executive (*DexecD*, which takes the value of one if the executive is relatively on the left wing of the political arena), and two other variables that account for the ideology of the upper and lower tate legislative chambers (*UpperD* and *LowerD*, which are the proportions of left wing representatives in each chamber).

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[8] It could be argued that some measure of the cost of public inputs should also be included in equation (1). However, such a variable might well be endogenous – such as public sector expenditure (and taxes) increases, so might the cost of the factors employed by the public sector – and, in any case, it may be picked up by the other variables introduced in the model (population size, density and individual effects).

[9] See Alesina and Rosenthal (1995), chapter 2, for a survey.

[10] Although there is also empirical evidence that raising taxes has high political costs (in terms of votes lost) regardless of the ideology of the party in government. See Peltzman (1992) for evidence regarding the States in U.S.

The coefficient $\alpha_{0,i}$ represents a state time invariant individual effect. The estimation of a fixed effects model by OLS will give us consistent estimates of the parameters whenever the state effects are correlated with the explanatory variables included in the equation (Mundlak, 1978, Hausman and Taylor, 1987). State fixed effects represent specific circumstances of each State that stay relatively constant during the analysed period: characteristics of the local political market, specific differences in the cost of local public services or a permanent inflow of revenue from other tax resources. Otherwise, if these were correlated with the variables included in the empirical model, the parameters obtained would be inconsistent (Holtz-Eakin, 1986).

3.2 *The U.S. case: data and specification*

To test the tax interdependence hypothesis, we will use data corresponding to personal income taxation for the 41 U.S. States that have a broad-based income tax during the period 1987-96. The U.S. case is particularly interesting because there are not many countries where regional governments have tax power over this field and, therefore, conforms with the concept of 'concurrent taxation'. The period is of special interest because it includes a period of reductions in federal effective income tax rates (1987-90) as a result of the Tax Reform Act of 1986 and a period of tax increases in the following years (Gouveia and Strauss, 1996).

We use the effective average tax rate as the definition of our tax variables (we label t_S and t_F as the net effective average state and federal income tax rates). These tax rates are calculated as the ratio of income tax revenue to personal income; that is the so-called tax burden. Although this variable is not the best alternative for accounting for the impact of taxation on the allocation of resources in an economy, it is the best practical solution we have been able to find[11]. Other analyses of fiscal interdependencies use similar measures of tax levels (see Goodspeed, 2000, for personal income tax, and Hayashi and Boadway, 2000, for business income tax).

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[11] Of course, effective average marginal tax rates (Seater, 1985) would seem to be a more interesting variable to study, but the problem is that they are not found in the usual statistical sources. Some authors have also advocated using marginal tax rates computed directly from the statutory tax function (Barro and Sahasakul, 1986), or using the top marginal tax rate (Tannenwald, 1991, and Mullen and Williams, 1993). However, this last approach seems better suited to analysing problems of horizontal fiscal competition. Since the mobility of business and high income taxpayers is affected only by statutory tax differentials, the measure of fiscal competitiveness of the State government does not have to be affected by its income distribution or the composition of the tax base – as are effective tax rates.

We have chosen personal income instead of taxable income or a more narrow and legal definition of the tax base to avoid the effects that changes in the definition of the tax base over time and States have on the tax burden. This procedure is supported by the way income tax reductions are usually carried out; although in many cases the changes in effective tax rates have followed statutory tax changes or changes in deductions and credits, in many others income tax reforms have also changed the definition of tax bases. Therefore, doing the calculation in this way means that we do not accept the definition of tax base given by the U.S. federal government or by State governments as accurate, reliable and stable.

To focus only on personal income taxation may seem a little stringent in the U.S. case, since the States have also access to general sales taxation. For this reason, we estimate two versions of the basic equation (1), one that uses state effective income tax rate as the dependent variable ($t(i)_S$), and the other that uses the state effective income plus general sales tax rate ($t(i+s)_S$) for the same purpose. Note that the combined tax rate has also been calculated with respect to personal income; we feel this may be a reliable approximation to the underlying tax base. The interpretation of the results of this second version will require a comparison of the coefficients with the first one; for instance, if $\partial t(i+s)_S/\partial t_F$ is higher than $\partial t(i)_S/\partial t_F$ this would mean that the reaction to federal tax rate changes is distributed between state income and sales taxation, and that those taxes can be considered complements (as we expect, due to the economic equivalence of both tax bases).

As we noted in section 2, there are other features of U.S. income taxation, apart from *Tax deductibility*, that may generate interdependencies between federal and state effective income tax rates. Although in many States the state income tax structure does not conform at all to the federal definition, in many others the tax base used is the federal Adjusted Gross Income (*AGI*), or even the federal Taxable Income (*TI*, that is, *AGI* less standard or itemised deductions). Moreover, in some States the income tax is calculated as a surcharge over the federal tax liability (*TL*)[12]. This means that the effect of federal tax reform will differ

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Nevertheless, as we are mainly interested in vertical spillovers, we cannot employ simple characterisations of the statutory tax function.

[12] In the US, there are seven States that do not make use of their power to tax individual income: Alaska, Florida, Nevada, South Dakota, Texas, Washington, and Wyoming (ACIR, 1995). New Hampshire and Tennessee make only a limited use of it, since only certain interest and dividends are taxed. On the other hand, there are five States in which the tax system does not conform at all with the federal one (New Jersey, Pennsylvania, Alabama, Arkansas, and Mississippi); eight States use a

according to group of States, depending as well on the specific tax parameters that have been changed. On the one hand, for the group of States with income tax structures that do not conform to the federal definition, there is no direct impact on revenues collected. On the other hand, for the States that use a tax surcharge, all the changes in the federal effective tax rates (coming from changes in the definition of the tax base, changes in deductions and tax credits, and changes in statutory tax rates) will affect their revenues. The States that use the federal *AGI* as tax base will be affected only by changes in the definition of Gross income and in the cost of earning income, while for the States that use the *TI*, their collected revenues will be influenced by changes in federal deductions.

In this setting, a reform of the federal income tax could generate windfall gains or losses for the States, which could result in either automatic increases or reductions in effective tax rates. Many scholars have written about the effects of TRA86 on state government, focusing on the impact of the reform on state revenues derived from formal links between federal and state income taxes (e.g., Gold, 1991, Ladd, 1993, and Tannenwald, 1991). The results provided by these authors stress the relevance of this kind of automatic interdependency and thus to the existence of certain degree of fiscal illusion in state tax-setting behaviour. In order to check the robustness of our results against this possibility we also estimate another version of equation (1), allowing for different reactions depending on the kind of formal link between the state and the federal income tax. The equation used to test this hypothesis is the following:

$$t_{S,it} = \alpha_{11} (t_{F,it} \times DNC_{it}) + \alpha_{12} (t_{F,it} \times DAGI_{it}) + \alpha_{13} (t_{F,it} \times DTI_{it}) + \alpha_{14} (t_{F,it} \times DTL_{it}) + \alpha_2 \times (t_{F,it} \times DRec_i) + \alpha_3 \times \sum_{j \neq i} \omega_{ij} \times t_{S,jt} + \sum_k \alpha_k \times Z_{k,it} + \alpha_{0,i} + \varepsilon_{it} \quad (2)$$

Where *DNC* is a dummy equal to one if the state tax does not conform at all to the federal tax definition, *DAGI* is a dummy equal to one if the state base is the *AGI*, *DTI* is a dummy equal to one if the state base is the *TI*, *DTL* is a dummy equal to one if the State uses a tax surcharge on *TL*. Note that, on the one hand, if there is some degree of fiscal illusion we expect the parameters estimated for the federal tax rate to grow with the degree of relationship between federal and state tax codes; that is, we expect $|\alpha_{11}| < |\alpha_{12}| < |\alpha_{13}| < |\alpha_{14}|$. On the other hand, if the coefficients on the tax codes loosely related with the federal one (α_{11} and α_{12}) are close to zero, the fiscal illusion hypothesis will completely displace the vertical tax externality as an explanation of observed interdependencies among tax rates. However, if this is not the case,

definition of tax base equal to the federal Taxable Income, three impose a tax surcharge on the federal Tax Liability, and the rest use the *AGI* as tax base.

both hypotheses will show some empirical relevance.

The information regarding the characteristics of the state tax systems that is needed to implement equations (1) and (2) come from the ACIR (various years), *Significant features of fiscal federalism.* The data used to construct the tax variables and the other control variables come from various statistical sources that are shown in Table I. In Table II we present the summary statistics of the different variables used in the analysis.

[SEE TABLES 1 and 2]

3.3 *Econometric procedure and results*

The econometric estimation of equation (1) presents two different but related technical problems. The first one is that theory suggests that the tax rates of competing States ($t_{S,jt}$) are endogenous. If this is the case, this variable will be correlated with the error term (ε_{it}) and this will lead to biased estimates of the parameter α_3. In order to account for horizontal policy interdependencies properly, we model neighbour tax rates as endogenous, using a two-stage instrumental variables approach (Besley and Case,1995, Figlio et al.,1999, Saavedra, 2000, Büettner, 2000). As suggested by Kelejian and Robinson (1993), we use as instruments the spatially lagged control variables (that is, $\sum_{j\neq i} \omega_{ij} \times Z_{k,jt}$). We test for joint exogeneity of this set of instruments using a Hausman Lagrange multiplier test (Hausman, 1978). This instrumental variables technique has an additional advantage, since by instrumenting for neighbour tax rates we could also account for the existence of spatial correlation in the residuals, as the acceptation of the null of instrument exogeneity suggests that there is little remaining spatial correlation in the instrumental variables error terms.

The second problem is the possible endogeneity of the federal tax rate ($t_{F,it}$). As we noted above, we think it will be difficult for the federal government to react to each of the States of the federation. However, even if the federal tax rate were exogenous, some correlation could remain between this variable and the error term, due to the existence of common shocks to both tax rates. Our dependent variable does not depend only on statutory parameters but also on economic conditions that have an impact, for example, on the size of the tax base or on the distribution of individuals by income classes. As these changes have an impact both on the federal and on the state effective tax rates, the estimated coefficients could pick up an spurious correlation instead of the fiscal interdependence we are testing[13].

We use three different approaches to deal with this problem. The first one is to consider that some of the variables included in the equation (e.g., personal income) do already control for cyclical variations in the tax burden[14]. The second is to include a set of time dummies to control for shocks common to all the States in a given year[15]. The third way to deal with the problem is to find an instrument that is correlated with the federal tax burden but uncorrelated with the regression error. Of course, it is difficult to find a variable that satisfies these conditions, since most of the candidates also depend on federal government policies (e.g., the size of the federal deficit). For this purpose we consider as instruments the share of U.S. population over 65 years and a dummy equal to 1 for Democrat presidents. Both instruments show independent explanatory power in the first stage regression and we are able not to reject the null of joint instrument exogeneity using a Hausman Lagrange multiplier test. Note that, in any case, it is not possible to use the two procedures (time effects and instrumental variables) simultaneously, since the only reliable instruments we have been able to find do not show cross-section variation.

We have estimated both a fixed and a random effects version of the model. However, for the different specifications we have tried, the hypothesis of no correlation between the fixed effects and the variables included in the model was rejected at 99% confidence level (that is, the Hausman test is overcome, and the utilisation of a random coefficients model is rejected). For this reason, we only report the results for the fixed effects model. We have also performed the White test to check the presence of heteroskedasticity rejecting this possibility in all the cases.

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[13] Note, however, that changes in economic conditions during the cycle or changes in the distribution of income across sources and income classes affect both the numerator and denominator of the effective tax rate. Therefore, the final impact depends, for example, on the degree of progressivity of the tax with respect to personal income. Given that U.S. state income taxes are generally considered as proportional or moderately progressive and that the connection between income distribution and the tax progressivity of the federal income tax has recently been questioned (Slemrod and Bakija, 2000), automatic changes in tax burdens during the cycle should not be taken for granted.

[14] This is, in fact, the procedure used in Hayashi and Boadway (2000) to deal with this problem.

[15] This possibility has not been used in previous empirical analysis for various reasons. In Besley and Rosen (1998) t_F is measured by the federal nominal tax rate, and so it does not show cross-section variation, while the method employed by Hayashi and Boadway (2000) is time series estimation.

Table 3 presents the results of the estimation of equation (1) using time effects to control for correlated shocks between t_F and t_S. This specification has been chosen over instrumental variables (IV) after checking that although IV techniques prove useful to deal with the problem in absence of time effects, when these are included the IV estimator does not represent an improvement over Ordinary Least Squares estimation (OLS). This can be concluded from Table 5, where the first column shows OLS estimates without time effects while the second show IV estimates without time effects. Note how the coefficient of t_F is very high in the OLS estimation and is lower in the IV equation. A look at the Hausman test corroborates the fact that the OLS estimate seems to be upward biased. The first column of Table 3 shows the OLS results with time effects; in this case, the reaction is even lower than that obtained in the IV case. It seems, thus, that when time effects are introduced in the equation, IV estimation does not provide any additional gain.

Therefore, the rest of the analysis is based on the OLS with time effects results from Tables 3 and 4. Table 3 presents eight different specifications, four for the income tax rate ($t(i)_S$) and the other four for the combined state income plus sales tax rate ($t(i+s)_S$). In columns (1) and (5) we do not allow the coefficient of the variable t_F to vary among groups of States, nor do we control for horizontal interdependencies; these variables are introduced in columns (2) and (6), which are estimated by IV in order to account for the endogeneity of $t_{S,jt}$ in (3) and (7). From this set of results we can confirm some of the hypotheses advanced. First, and most important, there is a significant positive interdependence between federal and state tax rates. A 1% point change in the federal tax burden supposes an average variation in the income state tax rate around 0.10% and of 0.22% in the combined state income plus sales tax rate. Second, the States that allow for *Reciprocal tax deductibility* react less than the average; this parameter remains very similar for both definitions of the tax burden, and thus it seems that tax deductibility only makes a difference in the case of state income taxation.

In columns (4) and (8) of Table 3 we check whether the reactions of the States are based on partisan preferences. With this aim in mind, we interact the federal tax rate with three dummies that pick up the political environment of the states (i.e., *DexecD*=1 if the governor is a Democrat, and *Dlower*=1 and *Dupper*=1 if the House and the Senate are controlled by the Democrats). The results obtained show a higher average reaction to the federal tax rate but a lower reaction when political institutions are controlled by Democrats; for example, in a State fully controlled by Republicans the reaction would be around 0.14% in the case of the income tax and 0.26% in the combined tax burden case, while a State with a Democrat governor but

Republican chambers would react by only 0.10% and 0.18%, in the two aforementioned cases.

In Table 4 we present further results that aim to check the robustness of the conclusions obtained up to now regarding the relevance of the vertical tax externality hypotheses. First, we introduce in the model the possibility that States react with a lag to the federal tax policy. Columns (1) and (5) are the equivalents of (3) and (7) of Table 3 when $t(i)_{F(-1)}$ is included in the specification. The results show that in both cases (income and income plus sales) the reaction is mainly contemporaneous; the coefficient of the lag is much lower than the other and is not statistically significant[16].

The specification in columns (2) to (4) and (6) to (8) of Table 4 allow for the possibility of a different reaction among States according to the degree of conformance between state and federal income tax codes. Columns (2) and (6) present the results corresponding to the contemporaneous reaction of each group of States. Note that those States in which income tax has strong formal links with the federal income tax tend to react much more. Also, the coefficient of those States in which tax codes do not conform at all to the federal one (*DNC*) is not statistically different form zero. In columns (3) and (7) we repeat the exercise introducing a lag for each of the groups of States. We find that *DNC* States react with a lag to federal tax rates while the rest react mainly contemporaneously. These facts are summarised in columns (4) and (8). This second set of results leads us to confirm the robustness of the vertical tax externality hypothesis but also to distinguish its effects on vertical interdependencies from those of the fiscal illusion hypothesis. Note that the reaction of income tax rates in States with tax codes that are strongly linked to the federal (*DTI* and *DTL*) is on average 0.14% while those with more independent income tax codes (*DNC* and *DAGI*) the reaction is only around 0.08%[17]. We attribute this differential reaction to the effect of fiscal illusion in front to automatic revenue changes. This is reinforced by the fact that the States with fully independent tax codes (*DNC*) react with a lag, while the rest react contemporaneously.

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[16] We also tried the specification including only the lagged variable, but the coefficient was roughly the same magnitude as in the contemporaneous reaction (see columns (3) and (7) of Table 3). We also included a second lag in the specification of Table 4, but the coefficient was not statistically significant and the point value was near zero.

[17] These results are consistent with those in Ladd (1993); in that paper fiscal illusion derived from wind-fall gains accounted for between 50% and 70% of state tax adjustment to federal tax reform.

Next, we will discuss the results obtained for the control variables. It is worth mentioning the effect of horizontal interdependencies on state income tax policies. A 1% point change in the tax burden of neighbouring States is followed by a reaction of 0.20% in the state income effective tax rate. However, the combined income plus sales reaction of the States is not statistically significant from zero. These results have been obtained after instrumenting the neighbours' tax rates. In any case, the Hausman test allows us not to reject the null hypothesis of instrument exogeneity. Note that the econometric approach followed has led to very different results, since OLS estimation was not able to detect any statistically significant horizontal interdependence in the income tax equations.

Finally, we should note that the results obtained for the other control variables are generally as expected. First, the coefficients of income and income squared are significant; the negative parameter on income may suggest that richer populations tax heavily but at a decreasing rate, but these variables may also pick up cyclical variations in effective tax rates. Second, richer governments return a highest amount of the transfers received to its citizens (the sign of *Grant* is negative but not significant). Third, the size of the population results is not significant in any of the models, but the density of population seems to impact negatively on effective income tax rates, showing perhaps the effect of scale economies, a higher cost due to the dispersion of the population, or higher possibilities to tax other bases in urban settings. Fourth, the States with a high proportion of population over 65 and with a high proportion of population under 18 use income tax more intensively, possibly due to the higher demand of those two groups. Finally, with respect to the dummy variables that characterise the political environment of the State, the two versions of the model (income or income plus sales) have different effects. In the case of state income taxation, only the proportion of House members that are Democrat is significant, though the sign is negative in this case. In the case of state income plus sales taxation, this latter effect is maintained but now the level of taxation is higher both in States with Democrat governors and with a high proportion of Democrat senators. This result is consistent with the differential reaction obtained for the Democrats: Democrat governors and upper houses tend to set higher tax rates but to react less to federal tax changes.

[SEE TABLES 3 to 5]

4. Conclusions

In this paper, our main aim was to test empirically the relevance of the vertical tax externality in the case of personal income taxation. We designed an empirical test based on the reaction of state taxes to the federal tax rate. We tested the model with data corresponding to personal income and general sales taxation in the U.S. for the period 1987-96.

The evidence we have found seems to confirm that hypothesis. In our econometric analysis we found that a one point increase in the federal effective tax rate is followed by an increase of approximately 0.10 points in the state income tax rate, and 0.22 when considering income and general sales taxes together. Thus, personal income and general sales taxes seem to be complementary for the state policy makers, confirming that both sources of tax revenue should be taken into account when analysing state reactions to federal tax reforms. We also found that States that allow for *Reciprocal tax deductibility* react slightly less than the average. This result suggests that the aforementioned reaction may be due, in the U.S. case, both to a vertical tax externality and to the *Tax deductibility* of state taxes in the federal income tax base. The lack of institutional variation regarding tax deductibility did not permit us to disentangle those two effects.

We checked the robustness of our results by introducing the competing hypothesis of interdependencies owed only to passive adaptation to windfall gains or losses caused by federal tax reforms. We found evidence that the reaction of the States with stronger links with the federal income tax code is stronger than that of States with more independent income tax codes. Moreover, the reaction of the States with income tax codes linked to the federal code is contemporaneous while that of States with fully independent tax codes is lagged one year. This result suggests that interdependencies due to the vertical tax externality (or to tax deductibility) only account for half of the total reaction, and the rest is due to fiscal illusion in state tax setting.

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Table 1: *Definition of the variables and statistical sources*

Variable	*Definition*	*Statistical sources*
$t(i)_S$	*State effective income average tax rate as a percentage of personal income*	*U.S. Bureau of the Census, State Government Tax Collections by State*
$t(i+s)_S$	*State effective income plus sales average tax rate as a percentage of personal income*	*U.S. Bureau of the Census, State Government Tax Collections by State*
$t(i)_F$	*Federal effective income average tax rate as a percentage of personal income*	*U.S. Internal Revenue Service, Statistics of Income Bulletin, quarterly*
DRec	*=1 if the state personal income tax allows for the deductibility of federal income taxes*	*A.C.I.R. Significant Features of Fiscal Federalism, Vol. 1.*
Inc	*Personal income per capita in 1986 Dollars*	*Bureau of Economic Analysis, Regional Accounts Data*
Grant	*Federal grants per capita in 1986 Dollars*	*U.S. Bureau of the Census, Federal Expenditures by State for Fiscal Year, annual*
Pop	*State population*	*U.S. Bureau of the Census, Current Population Reports*
Den	*State population per square Km*	*U.S. Bureau of the Census, Current Population Reports*
Pop(>65)	*Proportion of population over 65*	*U.S. Bureau of the Census, Current Population Reports*
Pop(<18)	*Proportion of population under 18*	*U.S. Bureau of the Census, Current Population Reports*
DNC	*=1 if the state base does not conform with any federal definition*	*A.C.I.R. Significant Features of Fiscal Federalism, Vol. 1.*
DAGI	*=1 if the state base is the federal AGI*	*A.C.I.R. Significant Features of Fiscal Federalism, Vol. 1.*
DTI	*=1 if the state base is the federal TI*	*A.C.I.R. Significant Features of Fiscal Federalism, Vol. 1.*
DTL	*= 1 if the state applies a tax surcharge over the federal tax liability*	*A.C.I.R. Significant Features of Fiscal Federalism, Vol. 1.*
DexecD	*=1 if the state governor is a Democrat*	*Congressional Quarterly Inc., America Votes, biennial*
UpperD	*Proportion of the state senators that are Democrats*	*The Council of State Governments, State Elective Officials and the Legislatures, biennial*
LowerD	*Proportion of the state house representatives that are Democrats*	*The Council of State Governments, State Elective Officials and the Legislatures, biennial*

Table 2: *Summary statistics(1987-1996)*

Variable	*Mean*	*St. Dev.*	*Minimum*	*Maximum*
$t(i)_S$	2.302	0.754	0.910	4.159
$t(i+s)_S$	4.351	0.821	2.700	7.081
$t(i)_F$	9.464	0.935	7.608	13.661
Drec	0.231	0.422	0.000	1.000
Inc	18.935.891	4.136.715	10.301.000	33.785.024
Grant	665.150	221.741	326.020	2.153.305
Pop	5.074.283	5.345.164	2.916.025	10.162.185
Den	68.649	88.488	2.097	393.591
Pop(>65)	12.705	1.547	8.210	15.954
Pop(<18)	26.384	2.276	22.610	38.178
DexecD	0.512	0.500	0.000	1.000
UpperD	73.391	75.065	43.478	97.059
LowerD	62.081	69.872	44.843	92.619

Table 3*: Estimation of federal-state tax inderdependences: Vertical Tax Externality; Individual and Time effects; Dependent variable t_S (%), Nº Obs.= 410 (N = 41, T=10)*

Variable	*Income, $t(i)_S$*				*Income & Sales, $t(i+s)_S$*			
	(1) OLS	*(2) OLS*	*(3) IV(2)*	*(4) IV(2)*	*(5) OLS*	*(6) OLS*	*(7) IV(2)*	*(8) IV(2)*
$t(i)_F$	0.076	0.103	0.093	0.140	0.193	0.234	0.225	0.240
	(1.989)**	(2.177)**	(1.996)**	(4.689)**	(2.720)**	(3.229)**	(3.114)**	(4.616)**
$t(i)_F$ x Drec	--.--	-0.021	-0.020	-0.020	--.--	-0.022	-0.022	-0.022
		(-2.812)**	(-2.693)**	(-2.862)**		(-1.994)**	(-1.945)*	(-2.036)**
t_S x $W_{(-1)}$	--.--	-0.023	0.244	0.242	--.--	-0.115	-0.048	-0.051
		(-0.548)	(2.268)**	(2.342)**		(-1.822)*	(-0.632)	(-0.552)
$t(i)_F$ x DexecD	--.--	--.--	--.--	-0.036	--.--	--.--	--.--	-0.078
				(-4.129)**				(-2.967)**
$t(i)_F$ x DupperD	--.--	--.--	--.--	-0.048	--.--	--.--	--.--	-0.076
				(-4.099)**				(-2.307)**
$t(i)_F$ x DlowerD	--.--	--.--	--.--	0.020	--.--	--.--	--.--	0.021
				(1.876)*				(0.451)
Income (x 10^{-2})	-0.336	-0.333	-0.362	-0.241	-0.289	-0.271	-0.269	-0.147
	(-5.026)**	(-4.994)**	(-5.407)**	(-3.549)**	(-2.858)**	(-2.688)**	(-2.635)**	(-1.887)*
$Income^2$ (x 10^{-4})	0.671	0.662	0.713	0.405	0.610	0.593	0.589	0.271
	(6.258)**	(6.298)**	(6.674)**	(3.442)**	(3.788)**	(3.709)**	(3.585)**	(1.715)*
Grant (x 10^{-2})	-0.145	-0.148	-0.163	-0.158	-0.204	-0.203	-0.198	-0.178
	(-1.330)	(-1.376)	(-1.521)	(-1.515)	(-1.244)	(-1.246)	(-1.218)	(-1.089)
Population (x 10^{-5})	-0.172	-0.228	-0.232	-0.291	-0.129	-0.192	-0.180	-0.249
	(-1.099)	(-1.456)	(-1.521)	(-1.934)**	(-0.546)	(-0.815)	(-0.758)	(-1.089)
$Population^2$ (x 10^{-10})	0.126	0.230	0.229	0.288	0.178	0.299	0.278	0.346
	(0.483)	(0.879)	(0.883)	(1.775)*	(0.451)	(0.757)	(0.701)	(0.882)
Density	-0.530	-0.520	-0.473	-0.359	-0.431	-0.435	-0.452	-0.329
	(-6.082)**	(-5.989)**	(-5.368)**	(-4.087)**	(-3.274)**	(-3.318)**	(-3.366)**	(-2.397)**
% Population over 65	0.073	0.058	0.025	0.041	0.279	0.272	0.288	0.312
	(1.374)	(1.095)	(0.458)	(0.791)	(3.500)**	(3.407)**	(3.482)**	(3.794)**
% Population under 15	0.052	0.050	0.055	0.022	0.019	0.017	0.013	0.019
	(1.834)*	(1.789)*	(1.992)**	(0.807)	(0.442)	(0.421)	(0.301)	(0.463)
DexecD	0.003	0.003	0.003	0.011	0.007	0.008	0.008	0.013
	(1.121)	(1.215)	(0.935)	(4.174)**	(1.690)*	(1.987)**	(1.983)**	(3.130)**
UpperD	0.003	0.002	0.000	0.014	0.012	0.012	0.011	0.013
	(0.602)	(0.422)	(0.174)	(4.049)**	(1.709)*	(1.777)*	(1.723)*	(2.480)**
LowerD	-0.007	-0.007	-0.006	-0.071	-0.014	-0.013	-0.014	-0.039
	(-1.760)*	(-1.799)*	(-1.756)*	(1.826)*	(-2.199)**	(-2.139)**	(-2.217)**	(-0.606)
Adjusted R^2	0.750	0.764	0.876	0.838	0.708	0.720	0.711	0.742
White (Heterosk.)	1.251	1.207	1.657	1.542	2.341	2.025	2.369	2.441
Durbin-Watson (Autocorr.).	1.998	1.956	1.976	1.908	2.002	1.996	1.909	2.101
F(C vs. C_i), Individual effects	79.90**	81.39**	82.53**	89.01**	82.12**	61.07**	60.43**	59.67**
F(C vs. C_i), Time effects	56.21**	63.21**	48.85**	53.01**	38.65**	44.21**	42.02**	46.87**
χ^2(Hausman) Fixed vs.Random	81.37**	82.92**	82.54**	75.79**	35.68**	49.63**	49.89**	45.69**
χ^2(Hausman), OLS vs. IV	--.--	--.--	25.04**	24.32**	--.--	--.--	6.36	6.40

Notes: (1) *t* statistics are shown in brackets; * & **=significantly different from zero at the 90 and 95% levels.
(2) Instruments for t_S $W_{(-1)}$ are spatially lagged exogenous variables.

Table 4: *Estimation of federal-state tax inderdependences; Vertical Tax Externality vs. Fiscal Illusion; Individual and Time effects; Dependent variable t_S (%), Nº Obs.= 410 (N = 41, T=10)*

Variable	*Income, $t(i)_S$*				*Income & Sales, $t(i+s)_S$*			
	(1) $IV^{(2)}$	*(2) $IV^{(2)}$*	*(3) $IV^{(2)}$*	*(4) $IV^{(2)}$*	*(5) $IV^{(2)}$*	*(6) $IV^{(2)}$*	*(7) $IV^{(2)}$*	*(8) $IV^{(2)}$*
$t(i)_F$	0.073	--.--	--.--	--.--	0.174	--.--	--.--	--.--
	(2.796)**				(1.987)**			
$t(i)_{F(-1)}$	0.026	--.--	--.--	--.--	0.074	--.--	--.--	--.--
	(1.074)				(1.521)			
$t(i)_F$ x DNC	--.--	0.078	0.034	--.--	--.--	0.125	0.044	--.--
		(0.703)	(0.440)			(1.250)	(0.741)	
$t(i)_{F(-1)}$ x DNC	--.--	--.--	0.075	0.084	--.--	--.--	0.109	0.112
			(1.968)**	(1.996)**			(2.175)**	(2.389)**
$t(i)_F$ x DAGI	--.--	0.078	0.112	0.080	--.--	0.120	0.111	0.102
		(1.987)**	(2.164)**	(2.532)**		(1.977)**	(1.774)*	(1.974)**
$t(i)_{F(-1)}$ x DAGI	--.--	--.--	0.001	--.--	--.--	--.--	0.002	--.--
			(0.041)				(0.001)	
$t(i)_F$ x DTI	--.--	0.125	0.125	0.130	--.--	0.175	0.164	0.180
		(2.310)**	(2.742)**	(2.965)**		(2.654)**	(2.531)**	(2.789)**
$t(i)_{F(-1)}$ x DTI	--.--	--.--	0.020	--.--	--.--	--.--	0.057	--.--
			(0.432)				(1.335)	
$t(i)_F$ x DTL	--.--	0.149	0.141	0.146	--.--	0.205	0.180	0.201
		(3.519)**	(3.215)**	(3.507)**		(3.277)**	(2.802)**	(3.269)**
$t(i)_{F(-1)}$ x DTL	--.--	--.--	0.028	--.--	--.--	--.--	0.061	--.--
			(0.792)				(1.477)	
$t(i)_F$ x Drec	-0.021	-0.021	-0.022	-0.020	-0.022	-0.021	-0.024	-0.021
	(-2.795)**	(-2.845)**	(-2.951)**	(-2.841)**	(-1.989)**	(-1.889)*	(-2.094)**	(-2.034)**
t_S x $W_{(-1)}$	0.240	0.200	0.187	0.185	-0.025	-0.027	-0.030	-0.034
	(2.246)**	(1.877)*	(1.747)*	(1.747)*	(-0.361)	(-0.339)	(-0.451)	(-0.654)
Income (x 10^{-2})	-0.386	-0.332	-0.349	-0.332	-0.287	-0.231	-0.276	-0.227
	(-5.704)**	(-5.006)**	(-5.108)**	(-5.059)**	(-2.774)**	(-2.252)**	(-2.607)**	(-2.229)**
$Income^2$ (x 10^{-4})	0.727	0.662	0.687	0.664	0.595	0.516	0.570	0.507
	(6.849)**	(6.279)**	(6.421)**	(6.383)**	(3.657)**	(3.157)**	(3.445)**	(3.139)**
Grant (x 10^{-2})	-0.159	-0.118	-0.129	-0.146	-0.196	-0.150	-0.138	-0.187
	(-1.498)	(-1.408)	(-1.553)	(-1.533)	(-1.296)	(-1.309)	(-1.324)	(-1.208)
Population (x 10^{-5})	-0.214	-0.226	-0.205	-0.201	-0.165	-0.104	-0.086	-0.073
	(-1.377)	(-1.490)	(-1.347)	(-1.324)	(-0.695)	(-0.886)	(-0.798)	(-0.631)
$Population^2$ (x 10^{-10})	0.173	0.193	0.163	0.161	0.235	0.109	0.077	0.069
	(0.664)	(0.765)	(0.646)	(0.639)	(0.588)	(0.279)	(0.196)	(0.177)
Density	-0.454	-0.468	-0.472	-0.484	-0.437	-0.479	-0.464	-0.499
	(-5.144)**	(-5.416)**	(-5.355)**	(-5.599)**	(-3.237)**	(-3.573)**	(-3.399)**	(-3.716)**
% Population over 65	0.022	0.013	0.007	0.004	0.285	0.269	0.259	0.267
	(0.405)	(0.023)	(0.135)	(0.080)	(3.453)**	(3.194)**	(3.077)**	(3.204)**
% Population under 15	0.056	0.042	0.042	0.042	0.013	0.007	0.007	0.008
	(2.032)**	(1.504)	(1.494)	(1.492)	(0.316)	(0.161)	(0.179)	(0.189)
DexecD	0.003	0.003	0.003	0.003	0.008	0.009	0.009	0.009
	(1.001)	(1.027)	(1.156)	(1.148)	(1.868)*	(2.037)**	(2.195)**	(2.000)**
UpperD	0.001	-0.002	-0.001	-0.001	0.011	0.007	0.008	0.009
	(0.094)	(-0.339)	(-0.331)	(-0.235)	(1.685)*	(1.724)*	(1.741)*	(1.749)*
LowerD	-0.006	-0.005	-0.005	-0.004	-0.014	-0.014	-0.013	-0.013
	(-1.768)*	(-1.761)*	(-1.751)*	(-1.784)*	(-2.243)**	(-2.109)**	(-2.134)**	(-2.042)**
Adjusted R^2	0.783	0.799	0.802	0.808	0.716	0.715	0.719	0.719
White (Heterosk.)	3.036	2.546	2.650	2.541	1.554	1.684	1.669	1.765
Durbin-Watson (Autocorr.).	2.014	2.100	1.981	1.995	1.965	2.000	2.003	1.980
F(C vs. C_i), Individual effects	73.49**	79.32**	67.12**	80.42**	58.21**	52.19**	50.51**	52.53**
F(C vs. C_i), Time effects	54.21**	60.32**	57.20**	63.11**	46.65**	50.20**	44.65**	46.31**
χ^2(Hausman) Fixed vs.Random	102.33**	86.55**	102.95**	89.52**	54.83**	60.67**	65.36**	62.92**
χ^2(Hausman test), OLS vs. IV	24.40**	19.08**	18.79**	18.82**	6.32	6.44	6.57	6.17

Notes: (1) See Table I

Table 5*: Estimation of federal-state tax interdependences: Vertical Tax Externality; Instrumental variables with Individual effects; Dependent variable t_S (%), Nº Obs.= 410 (N = 41, T=10)*

Variable	*Income, $t(i)_S$*		*Income & Sales, $t(i+s)_S$*	
	(1) OLS	*(2) $IV^{(2)}$*	*(3) OLS*	*(4) $IV^{(2)}$*
$t(i)_F$	0.221 (12.745)**	0.123 (1.997)**	0.331 (10.542) **	0.236 (2.541)**
Income (x 10^{-2})	-0.085 (-1.214)	-0.061 (-1.548)	-0.074 (-1.324)	-0.055 (-1.621)
$Income^2$ (x 10^{-4})	0.410 (1.541)	0.271 (2.638)**	0.321 (1.429)	0.198 (1.907)*
Grant (x 10^{-2})	-0.185 (-1.014)	-0.157 (-1.238)	-0.210 (-1.364)	-0.184 (-1.510)
Population (x 10^{-5})	-0.294 (-1.218)	-0.230 (-0.566)	-0.210 (-0.641)	-0.185 (-0.440)
$Population^2$ (x 10^{-10})	0.641 (1.247)	0.519 (0.256)	0.754 (0.965)	0.682 (0.301)
Density	-0.359 (-2.141)**	-0.364 (-3.497)**	-0.325 (-2.001)**	-0.311 (-2.543)**
% Population over 65	0.201 (2.221)**	0.151 (2.360)**	0.184 (2.341)**	0.177 (2.260)**
% Population under 15	0.028 (1.741)*	0.015 (1.771)*	0.014 (0.214)	0.019 (0.354)
DexecD	0.002 (0.048)	0.001 (0.678)	0.004 (1.510)	0.005 (1.354)
UpperD	-0.005 (-0.101)	0.001 (0.180)	0.010 (0.412)	0.006 (0.214)
LowerD	-0.029 (-1.974)**	-0.002 (-0.805)	-0.015 (-2.346)**	-0.008 (-2.101)**
Adjusted R^2	0.868	0.725	0.801	0.716
White (Heterosk.)	1.230	2.036	0.698	1.002
Durbin-Watson (Autocorr.).	1.956	1.989	1.998	1.955
F(C vs. C_i), Individual effects	110.21**	220.36**	100.34**	170.45**
χ^2(Hausman) Fixed vs.Random	68.54**	62.0**	55.21**	65.09**
χ^2(Hausman test), OLS vs. IV	--.--	6.82**	--.--	5.17**

Notes: (1) See Table I; (2) Instruments for *$t(i)_F$* are: *% Population over 65 (F), DLeft(F)*