AN EMPIRICAL ANALYSIS OF VERTICAL TAX EXTERNALITIES: THE CASE OF PERSONAL INCOME TAXATION IN CANADA*

Álex Esteller-Moré and Albert Solé-Ollé
Departament d'Hisenda Pública
Universitat de Barcelona

ABSTRACT: The article explores the empirical relevance of the so-called "vertical tax externality". This is an economic failure that can arise in a federation when two or more layers of government co-occupy the same field of distortionary taxation. Being this the case, the neglect of the interdependence in tax setting could lead governments to set higher than optimal tax rates. The article pays special attention to some institutional features that could be relevant in the case under study: the size of the region, the presence of an equalization grant and the link between federal and regional tax codes. The developed hypotheses are then tested with data corresponding to Canadian personal income taxes for the last two decades. We find that when the federal government increases taxes, there is a significant response of provincial taxes. We also find that the provinces entitled to receive equalization payments show a slightly lower reaction.

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Corresponding author: Albert Solé-Ollé
Dept. d'Hisenda Pública
Facultat de Ciències Econòmiques
Universitat de Barcelona
Avda. Diagonal, 690, Torre 4 , Pl. 2ª,
08034-Barcelona (SPAIN).
Phone: 00-34-3-4021812
Fax: 00-34-3-4021813
E-mail: asole@eco.ub.es

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1. Introduction

Fiscal externalities arising among regional governments have been a fruitful topic of research in the field of fiscal federalism. Issues of horizontal tax competition and tax exporting have been extensively analysed, both by theorists (see, among others, Gordon, 1983, Arnott and Grieson, 1984, and Mintz and Tulkens, 1986) and empirically (Stephenson and Hewett, 1983, and Case et al., 1993, on the first topic, and Bird and Slack, 1983, on the second one). However –as Keen (1997) has pointed out in a recent survey–, it also has to be recognised the relevance of externalities between levels of government. 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 have an effect on the policy outcomes of the other level. If both levels ignore such policy externalities, the resulting decentralised policy decisions could be sub-optimal from a social point of view. Those 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 this last 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 joint property of the federal and regional levels of government. That is, both levels of government have the capacity to change fundamental tax parameters of the same base. Of course, this vertical tax spillover only arises when the tax base is responsive to tax rate changes; that is, if the tax is 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 raised too much, and both may obtain less revenue than in the case of co-ordinated decision-making. The interest of public finance scholars in tax spillovers arising from concurrent taxation is recent. The first papers dealing with vertical externalities caused by uncoordinated distortionary taxation where those of

Flowers (1988) and Johnson (1988). More recently, Wagoner (1995), Wrede (1995), Boadway and Keen (1996), Dalhby (1996), Boadway et al. (1997), and Sato (1997) have also addressed this issue.

There are three papers that have tried to check the empirical relevance of vertical tax externalities: Besley and Rosen (1998), Esteller-Moré and Solé-Ollé (1999) and Goodspeed (1999). The empirical strategy is common to all three papers and consists of trying to find a statistically significant causation from the federal to the regional tax rate. The analysis by 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 positive response of state taxes, confirming the vertical externality hypothesis. The paper by Esteller-Moré and Solé-Ollé (1999) deals with interdependencies between federal and state income tax policies in the U.S. during the period 1987-96. Although they also find a positive reaction of state taxes, the magnitude of the response is lower than in the study of Besley and Rosen (1996) and embodies both the "vertical tax externality" and the effect of the deductibility of the state tax. The article by Goodspeed (1999) also focuses on income taxation and uses a panel of data coming from 10 OECD countries during the period 1975-84. It finds a negative relationship between federal and regional tax rates. Although these contrasting results –i.e: different sign and size of the reaction– may be due to differences in the taxes analysed and are consistent with the theoretical ambiguity of the comparative static (Keen, 1997) they are also somewhat odd. Taking into account all that previous literature we think, first, that further research on this topic is needed, extending the analysis to other countries in order to check the robustness of the results, and second, that this research has to be conducted being very careful about the peculiar federal institutional features when selecting the sample to study. Next, we quote some features that we consider especially relevant for the analysis.

First, the researcher has to check that the case under study conforms to 'concurrent taxation'. It has to be stressed that tax-sharing arrangements –that is, when the regional government is entitled to receive a share of the revenues raised in its territorial jurisdiction– is not equivalent 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 that case, the tax rate (or other parameters that define the tax burden) set by one level of government affects the revenues raised by the other. It also has to be checked that in the period analysed there are not significant changes in the division of tax room between layers of government. Otherwise, in a period characterised by a cession of tax room to the regional government, the empirical analysis would find a negative causation from the federal to the regional rate, even in the case where no externality arises.

Second, other federal institutions that can affect the interpretation of the results are the deductibility of regional taxes on the federal tax, the precise configuration of the system of grants to regional governments, and the degree of harmonisation between the federal and the regional tax. The first two kinds of arrangements could introduce some additional incentives to rise the tax rates, and thus the reaction to a federal tax rate change may be somewhat different. The last case refers to the common situation where the regional tax uses some federal definitions to calculate the regional tax due (e.g: they set a tax rate over the federal definition of the tax base –as in some U.S. states– or they set a tax surcharge over the federal tax liability –as in most of the Canadian provinces). In this latter case, if there is some degree of fiscal illusion, the empirical researcher should find a positive reaction of the regional tax even if there is no tax base erosion.

Third, in some stances it could be useful to relax some of the stringent behavioural assumptions of the traditional theoretical model. Although it is very common to assume

myopic behaviour by the regional government, it can not be discarded that some governments (especially the big ones) take into account part of the erosion they provoke in the federal base.

This paper provides an empirical analysis that accounts for the cited problems. On the one hand, the use of Canadian data from the last two decades picks up a case of 'concurrent taxation' that is not affected by fundamental changes in the division of tax powers among layers of government. On the other hand, the possibility of accounting for some internal institutional variation (i.e.: some provinces receive equalisation grants while others do not, some are as big as to influence federal parameters, or have taxes that do not conform so much with the federal one) allows us to devise the test for the vertical tax externality.

Moreover, the analysis of interdependent tax setting decisions regarding to personal income taxation is actually a relevant field of study in the Spanish case. Nowadays, Spanish regional governments have their own progressive personal income tax. Although the definition of the tax base can not be modified, the regional governments have the power to change the tax rates and tax credits within some limits. Up to now, the regions have not used its tax power to modify the tax burdens. Nevertheless, due to the short life of this tax arrangement (1997), it is perhaps early to derive conclusions about their tax setting behaviour. Additionally, the reform of personal income taxation undergone in 1998 by the central government will make more likely the reaction. Also, the Canadian experience in income taxation during the last 30 years has been sometimes an example during the Spanish process of tax power devolution. The focus has been placed on the way the provinces gained fiscal responsibility in that tax field, but it may be also interesting to analyse the potential negative effects of concurrent income taxation.

The structure of the paper is as follows: in the next section, we present a simple theoretical model to ascertain the sign and magnitude of the responses of each government to tax rate changes of the other. This model is developed from sections 2.1 to 2.3 according to

some institutional features that we consider relevant for the Canadian case. In the third section, we test these different hypotheses. Finally, in the fourth section, we conclude.

2. Theoretical Analysis

In this part of the paper, we want to ascertain the sign and magnitude of the reaction of each level of government to an exogenous tax rate change of the other. In order to carry out this analysis, we have to assume a certain behavioural model of federal and regional tax-setting. However, there is no consensus among the public finance scholars with respect to the most appropriate way to represent the process that generates tax decisions. The most commonly used is the median voter framework, but other politically motivated models, like probabilistic voting models (Dixit and Londregan, 1998), or rational retrospective voting models (Besley and Case, 1995) could be used. Nevertheless, as a practical device, we employ a simple characterisation of each government objective function; accordingly, we will suppose that each layer of government maximises the indirect utility of a representative agent. The different cases we study reflect different behavioural assumptions and some institutional features that later on, in the empirical analysis, will help us to explain the response of different groups of Canadian provinces.

2.1. The Basic Case

We assume that both levels of government, the Federal and the Regional[1], co-occupy the same tax base. This is the fact that provokes the vertical tax externality. They both

[1] No without loss of generality, we assume that there is just one regional government. Otherwise, in addition to the vertical tax externality, we should also have to take into account the horizontal tax externalities. For a complete analysis of this last problem, see the classical work of Gordon (1983), while for a treatment of both kinds of externalities at the same time, see Wrede (1996).

maximise the indirect utility function of a representative agent –which already embodies her maximising behaviour– subject to their respective budget constraints. In this section, we also suppose that both layers take as given the tax rate and level of provision of the other layer of government. That is, they behave Nash. Analytically, the problem for the regional government is[2]

$$\underset{t_R}{Max}\; V(1+t_R+t_F)+h(g)+H(G)$$
$$s.t. \qquad t_R B = g$$

being the consumer price $q=1+t_R+t_F$. Its components are the following: t_R, the regional specific tax rate, t_F, the federal tax rate, and the producer price that has been normalised to the unity. The rest of components are described as follows: B is the tax base; g is the regional public good; and G is the federal public good. The utility derived from regional and federal public good provision is represented by the functions $h(g)$ and $H(G)$, which are concave, i.e., $h_g \geq 0 \geq h_{gg}$[3], and enter in an additively and separable manner into the indirect utility function[4]. After the introduction of the regional budget constraint into the objective function, the problem becomes a direct one. The first order condition (F.O.C.) is the following,

$$t_R: \quad -B\frac{\partial q}{\partial t_R}+\frac{\partial h}{\partial g}\left\{B+t_R\frac{\partial B}{\partial q}\frac{\partial q}{\partial t_R}\right\}=0 \qquad (1)$$

where we used Roy's Identity, $\partial V/\partial q=-B$, assuming the marginal utility of private income to be equal to one. We also suppose; the partial derivative $\partial B/\partial q \leq 0$, and so define the price elasticity as $e=-(\partial B/\partial q)(q/B) \geq 0$, which is supposed to be constant. Substituting this last definition, and rearranging equation (1), we get the traditional Samuelson condition of public goods allocation in the presence of distortionary taxation.

[2] In this basic setting, the problem of the Federal government can be analogously solved for t_F.
[3] Partial derivatives will be indicated along the paper by subscripts.
[4] This assumption is important to isolate the tax externality from spillovers in public consumption.

$$h_g = \frac{1}{1 - t_R \dfrac{e}{q}} \equiv RMCPF \geq 1 \qquad (2)$$

This expression states that, at the optimum, the regional government equates the marginal benefit from public good provision (on the left hand side) to the regional marginal cost of public funds (*RMCPF*, on the right hand side). This last term indicates the marginal income loss for the representative citizen for each additional unit of revenue the government collects. *RMCPF* is greater than 1 (the marginal utility of income) as long as $e \geq 0$. This F.O.C. has the same structure for the federal government. When there is a marginal change in the federal tax rate, the regional government reacts in order to rebalance expression (2). We differentiate two effects that work in the same direction. The first one is what we call *expenditure effect*, and acts on the left-hand side of expression (2). The tax base erosion due to the federal tax rate increase requires an increase in the regional tax rate in order maintain public revenues, and so the level of public good provision. This effect is reinforced by the fact that we have assumed that *h(g)* is concave, and so increases in *g* are always positively valued, though decreasingly. The second one, which operates on the right hand side of expression (2), is the *dead-weight loss effect*, and implies that the region reacts also increasing its tax rate in order to keep the desired ad valorem tax rate t_R/q. Analytically, all these effects express as follows,

$$\frac{h_{gg}}{RMCPF}\left\{\frac{\partial g}{\partial t_F}dt_F + \frac{\partial g}{\partial t_R}dt_R\right\} + h_g\left\{\frac{\partial RMCPF^{-1}}{\partial t_F}dt_F + \frac{\partial RMCPF^{-1}}{\partial t_R}dt_R\right\} = 0 \qquad (3)$$

where the *expenditure effect* is the first part of the expression, and the *dead-weight loss effect*, the second one. Rearranging that equation, and substituting the partial derivatives, we express the slope of the regional reaction function with respect to the federal tax rate,

$$\frac{dt_R}{dt_F} = \frac{\dfrac{e}{q^2}t_R - \dfrac{e}{q}\dfrac{t_R B}{RMCPF}\dfrac{h_{gg}}{h_g}}{\dfrac{-B}{RMCPF^2}\dfrac{h_{gg}}{h_g} + \dfrac{e}{q^2}(1 + t_F)} \geq 0 \qquad (4)$$

which is always positive, since both numerator and denominator are positive[5]. Expression (4) shows the interdependency between the tax rates of both levels of governments owed to the vertical tax externality. Note that if $e=0$, there would not be any reaction, $dt_R/dt_F=0$, since the tax base would have not been affected. In consequence, in our model, the existence of the vertical tax externality crucially depends both on the co-occupancy of the same tax base, and also on the distortionary nature of the tax. Precisely, an empirical test of the vertical tax externality consists of testing whether such reaction is significantly different from zero[6].

2.2. The case of Non Myopic Behaviour

In this section we will suppose instead that both layers of government do consider the revenue change their tax policies cause on the other layer of government. Given that the population that enter the objective function of each government is to some extent the same, it is somewhat odd to suppose that they do not consider the effects of their own taxes on the level of service provision of the other layer[7]. This consideration seems specially plausible for the federal government but could also be suitable for some regional governments that account for a high share of the population. Therefore, this new behaviour supposes the regional maximisation's problem transforms into[8]

[5] Note that although we have not developed the federal reaction function, by symmetry can be checked that also its slope will be positive, $dt_F/dt_R > 0$.

[6] The sign we have found depends on the assumption of constant elasticity as Keen (1997) has properly noted. However, in order to test empirically the existence of the vertical tax externality the important point is not the sign of the reaction but the reaction itself. Moreover, this assumption proves useful in order to compare the magnitude of the reaction in the cases analysed in section 2.1 to 2.3.

[7] The assumption of myopic behaviour is very common in models of horizontal tax competition, since in that case it is clear that different governments take care of different population subsets.

[8] Note that to consider the regional tax rate as given makes the problem above differ from the characterisation of the regional government as a Stackelberg leader. In that case, the fact that the regional government is a Stackelberg leader would provoke that when it optimally chooses its actions takes also into account how the regional government will react, i.e., there would be an extra constraint, $t_R=t_R(t_F)$.

$$\underset{t_R}{Max}\ V(1+t_R+t_F)+H(G)+h(g)$$
$$s.t.\ \ t_R B = g;\ \ G = G(B(t_F));\ \ t_F = \bar{t}_F$$

From the problem above, the first order condition becomes

$$h_g = \frac{1+H_G\dfrac{t_F}{q}\boldsymbol{e}}{1-\dfrac{t_R}{q}\boldsymbol{e}} \tag{6}$$

Therefore, if we compare this optimality condition with that stated in the myopic case (2), we check how the federal marginal cost is higher, and thus, the federal tax rate is lower. This is due to the fact that now the regional government takes into account to what extent the provision of federal public good is decreased when t_R varies. Note, however, that in the case G were already big enough, and so $H_G \to 0$, the regional marginal cost would not be different from expression (2). In this setting, the regional government reacts to variations in the regional tax rate in the following manner

$$\frac{dt_R}{dt_F} = \frac{[*]-\dfrac{H_G}{h_g}\dfrac{1}{q}\left(\dfrac{FMCPF-1}{FMCPF}\right)\left[\dfrac{1+t_R}{t_F}+qB\left(\dfrac{1}{FMCPF}\right)\dfrac{H_{GG}}{H_G}\right]}{[**]-\dfrac{H_G}{h_g}\dfrac{1}{q}\left(\dfrac{FMCPF-1}{FMCPF}\right)\left[1+qB\left(\dfrac{FMCPF-1}{FMCPF}\right)\dfrac{H_{GG}}{H_G}\right]} \gtrless 0 \tag{7}$$

where [*] and [**] are the expressions appearing in the numerator and denominator of the slope shown in (4), and FMCPF is the marginal cost for the federal government in the basic case. Hence, two effects of different sign appear in brackets additively both to the numerator and denominator of the slope of the reaction function. The first effect shows how the regional government internalises part of the deadweight-loss caused on the federal government. This leads to a lower reaction. The second one reflects the fact that the regional government now attaches a lower utility loss to any decrease in the federal public good provision. Recall that H_G appears in the numerator of expression (6) so now after an increase of t_F (and so an increase in G) the regional marginal cost decreases. This leads to a higher reaction. In any

case, the net effect is reinforced when the federal public good is relatively more valued than the regional one (that is, when H_G/h_g is higher). However, since the second effect depends on second marginal valuations (H_{GG}), we expect the first one to dominate, and so the slope to be lower than in the basic case.

2.3. The case of Equalisation grants

In many federal countries, there exist intergovernmental transfer programs that attempt to equalise the revenues of regional governments. The main equity objective of these type of transfer programs is to ensure every regional government be able to provide a similar level of public services without having to resort to very different tax burdens. To achieve this outcome, resources ought to be redistributed in direct proportion to the provincial needs –usually identified by the population–, and inversely to their tax capacity.

The analysis of the equalisation grant case is relevant for our study because it is quite possible that the funds received by the regional governments distort their tax policies. The main reason why an equalisation program can create perverse tax-setting incentives is the practical procedure used to calculate the transfers. This could happen, for instance, when the transfer formula employs as indexes of tax capacity variables that are in fact under the influence of the regional government (i.e.: actual regional tax bases are used in many countries, like Canada or Australia, and, if taxes are distortionary, these variables change in response to tax rate variations). Thus, in order to test the vertical tax externality hypothesis in real settings, it is important to carefully analyse the links between the tax-setting behaviour of the different levels of government created by intergovernmental grants. Given that in Canada there operates an equalisation formula of that kind, the theoretical analysis carried out in this section will prove useful in the empirical analysis.

Under the Canadian system, the federal government compensates the provinces eligible for equalisation for the difference between the revenues they could potentially raise if they applied the average tax rate of the federation and a standard level of tax revenues. This standard of revenues is obtained by applying this average tax rate to a weighted average of the tax base of a group of standard provinces [9]. Equalisation entitlements are actually calculated for all revenue categories. A province entitlement in a particular revenue category is equal to the revenue deficiency of the province in that category; that is, the difference between the standard per capita tax base and its tax base, multiplied by the average rate of that tax. On the whole, the transfer is the net sum of the entitlements for all categories. If the sum were negative, the transfer would equal zero. That is, the Canadian equalisation program is not a zero-sum distribution scheme: transfers are funded by the federal government. Note that the cost of the equalisation program for the federal government is open, and depends on the evolution of the tax deficits the provinces suffer each year[10].

Assuming for the purpose of this paper that there is only one revenue category, the equalisation formula can be analytically expressed as follows:

$$E = \begin{cases} \bar{t}\left(\tilde{B} - B\right) \geq 0, & iff \quad \tilde{B} \geq B \\ 0, & iff \quad \tilde{B} \leq B \end{cases}$$

where E is the equalisation transfer, $\tilde{B}$ is the standard tax base, B is the tax base of the province, and $\bar{t}$ is the average tax rate. In order to analyse the influence of equalisation transfers on tax-setting interdependence between the two layers of government, we set up their decision-making problems as in previous sections. Obviously, for those provinces that are not entitled to receive equalisation grants, that is, for those that $\tilde{B} < B$, the analysis does

[9] Actually, the standard provinces are Quebec, Ontario, Manitoba, Saskatchewan, and British Columbia. For a survey and a critical revision of the workings of the Canadian system see Boadway and Hobson(1993).

[10] Since 1982, the growth of the equalisation program cost cannot exceed the growth of the GNP. However, this limit has only been reached in 1991 [Perry (1997)].

not vary from that already conducted in section 2.1. Keeping in mind all this, the problem for a provincial government receiving equalisation funds is[11]

$$\underset{t_R}{Max}\ V\left(1+t_R+t_F\right)+H(G)+h(g)$$
$$s.t. \qquad t_R B+\bar{t}\left(\tilde{B}-B\right)=g$$

Note first that the consumer price has not varied from the base case, and second how the equalisation transfer enters positively into the provincial budget constraint. Then, for those regions that are entitled to receive an equalisation grant, the FOC becomes[12]:

$$h_g=\frac{1}{1-\frac{e}{q}(t_R-\bar{t})}\equiv RMCPF \tag{8}$$

The equalisation grant puts two effects at work. First, there is a *dead-weight loss effect* that gives an incentive to the regional government to increase its tax rate. We can see in expression (8) how the ad valorem tax rate changes from t_R/q *to* $(t_R-\bar{t})/q$. Therefore, now the *RMCPF* faced by the regional government is lower[13]. Intuitively, this happens due to the fact that a greater tax rate does not only erode the tax base, but also increases the equalization transfer received. That is, the regional government only perceives a portion of the reduction in the tax base. Second, there is an *expenditure effect* provoked by the revenues coming from the

[11] The federal maximisation problem is analogous with the only difference that the equalisation grant enters with a negative sign in its budget constraint, as in the Canadian case it is precisely funded by this latter level of government.

[12] Note that along the analysis we have considered that both the average tax rate and the standard tax base are not influenced by the tax rate of the province. As Courchene and Beavis(1973) noted, this assumption may not be always appropriate; since both parameters are calculated as an average (of all the provinces for the tax rate and of five provinces for the standard tax base), a big province could affect them to a great extent. However, note that if a province belongs to both sets, an increase in its tax rate has countervailing effects on the equalisation grant received: it increases the average tax rate and erodes the standard tax base (reducing its deficit). Quebec is the only big province that receives equalisation payments, so it is the only one having the capacity to alter those parameters; but, since it belongs to the five representative provinces we hypothesise that even in that case the effect over the reaction function would be negligible. Thus, it seems appropriate to leave aside variations in $\bar{t}$ and $\tilde{B}$.

[13] This effect has already been noted by Smart (1996). The analysis of this author isolates the *dead-weight loss effect* from the other effects in motion and also ignores the reaction of the federal government.

equalisation transfer: a share of the funds received by the regional government is given to the regional citizens, lowering the regional tax burden[14].

Working on expression (8), we analyse how the regional government will react in front of variations of the federal tax rate in order to discern any additional effect due to the equalization grant. Using once more the structure in expression (3), we can then sort out any differences that now arise from the two effects previously identified. First, concerning the effect on the regional marginal cost of public funds (*dead-weight loss effect*), the effect of a variation in the federal tax rate is as follows:

$$\frac{\partial (RMCPF)^{-1}}{\partial t_F} = \frac{e(t_R - \bar{t})}{q^2} \begin{matrix} \geq \\ < \end{matrix} 0 \quad if \quad (t_R - \bar{t}) \begin{matrix} \geq \\ < \end{matrix} 0 \tag{9}$$

Hence, the regional marginal cost of public funds will increase when the federal tax rate varies as long as the regional tax rate is below the provincial average tax rate, and viceversa. In any case, what is worth noting is that this effect is lower than in the Basic Case. This is due to the inclusion of $\bar{t}$ with a negative sign in the expression (8). Such decrease is provoked by the fact that now an increase in the federal tax rate does not need to be compensated as much as in the basic case in order to rebalance the ad-valorem tax rate. Second, we have the so-called *expenditure effect*, which operates on the regional budget constraint:

$$\frac{\partial g}{\partial t_F} = t_R \frac{\partial B}{\partial t_F} + \bar{t}\left(\frac{\partial \tilde{B}}{\partial t_F} - \frac{\partial B}{\partial t_F} \right) \begin{matrix} \geq \\ < \end{matrix} 0 \tag{10}$$

so we can distinguish two sub-effects. The first summand clearly supposes a reduction in the regional income through the erosion of its tax-base. However, the second one represents an ambiguous effect, since the erosion does not only affect its own tax base, but also the standard

[14] The incentives for the federal government are just the reverse. This is due to the fact that it has the same FOC than the regional government but now $\bar{t}$ enters with a negative sign (so it increases the FMCPF).

tax base. If we re-express all the effects in terms of elasticities (recall we have supposed they are constant for all levels of tax-base), we have

$$\frac{\partial g}{\partial t_F} = \frac{e}{q}\left[\bar{t}\left(B - \tilde{B}\right) - t_R B\right] \leq 0 \qquad (11)$$

Therefore, for a given elasticity, the reduction in the regional budget constraint will be greater the greater the fiscal deficit of the province, defined as $\bar{t}.\left(B - \tilde{B}\right) \leq 0$. Obviously, such effect on the budget constraint would not operate in the case the province has a relative surplus in the equalisation grant, i.e., $\bar{t}.\left(B - \tilde{B}\right) = 0$. On the whole, through the *expenditure effect*, the reduction in the revenues will be greater in those provinces receiving equalization, and so they will be incited to react more in front of changes in the federal tax rate.

All those effects are embodied in the slope of the reaction function,

$$\frac{dt_R}{dt_F} = \frac{\frac{e}{q^2}\left(t_R - \bar{t}\right) - \frac{e}{q}\frac{t_R B}{RMCPF}\frac{h_{gg}}{h_g}\left[\frac{t_R B + \bar{t}(\tilde{B} - B)}{t_R B}\right]}{\frac{-B}{RMCPF^2}\frac{h_{gg}}{h_g} + \frac{e}{q^2}\left(1 + t_F + \bar{t}\right)} \gtrless 0 \qquad (12)$$

Comparing expressions (12) and (4), we can see that there are three differences. On the one hand, we observe $\bar{t}$ appearing both lowering the first term in the numerator and increasing the denominator. Thus, these effects reduce the slope of the reaction function. On the other hand, the second term in the numerator is multiplied by the inverse of the share of revenue coming from own taxes. Since $B \langle \tilde{B}$ this share is always lower that one, and thus the effect on the slope is positive. Thus, the effect of the equalization grant on the sign of the regional reaction is an empirical matter. Note, however, that the possibility of a higher reaction of the regions receiving equalization funds depends again on second marginal valuations, h_{gg}. So, if this term is small the reaction of provincial tax rates will be smaller than in the basic case[15].

[15] Note that when $h_{gg}=0$ the regional government behaves as a Leviathan, maximizing its revenue. In that case, and where $e>0$, the slope of the reaction function without equalization grant (4) reduces to $t_R/(1+t_F)$; the slope with equalization (12) is $(t_R - \bar{t})/(1+t_F+\bar{t})$ and is, thus, lower than in the first case.

3. Empirical implementation

3.1 Country, tax and period: Canadian Personal Income Tax 1982-96

To test the tax interdependence hypothesis, we will use data corresponding to the personal income tax in Canada during the period 1982-96. As we noted in the introduction, the Canadian personal income tax is particularly interesting for our purpose because there are not many countries where regional governments have tax powers over that field. In Canada, the personal income tax is the main tax both for the federal and provincial governments. For the federal government the share of revenues coming from that source was 43,7% in 1982 and raised to 47,2% in 1993. The corresponding figures for the provincial governments are lower –21,5% in 1982 and 25,9% in 1993–, since they also obtain revenues from sales and natural resources taxation and from various types of transfers. The share of personal income tax revenues coming to provincial governments –roughly a 30%– and the provincial income tax burden –6.72% of Taxable Income in 1982 and 8.74% in 1993– are on average also notable[16].

The analysis of provincial personal income taxes in Canada has to take into account the very high degree of harmonisation with the federal one. Quebec is the only province which personal income tax does not conform at all with federal definitions. In the rest of the provinces, the personal income tax consists of an application of a basic proportional rate over the federal tax liability. This basic rate ranged in 1993 from the highest 69% in Newfoundland to the lowest 45.5% in Alberta. This fact constrains provincial income taxes to have the same distributional impact that the federal one. Since the beginning of the eighties the provinces

[16] Note that the Personal Income Tax plays a more important role in Canada than in the US. For example, the average state income tax burden in the US for 1993 was only 2,44%, while the federal average tax burden in that year was 9,42%; the share of income taxation in overall federal and state revenues was in 1993 40% and 14%, respectively (source: ACIR, 1995, *Significant Features of Fiscal Federalism*).

tried to gain degrees of freedom in tax setting using surcharges over the tax liability of high income taxpayers[17]. More recently some provinces began to set a flat tax rate over net taxable income[18]. That means that the direct impact on provincial revenues of a federal tax reform is different for those groups of provinces. On the one hand, for Quebec, there is not any direct impact on revenues collected. On the other hand, for the rest of the provinces, all the changes in 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. Moreover, the impact on revenues would be even higher for the provinces that use a high income surcharge[19]. Nevertheless, the wind-fall gains (or losses) arising from this kind of direct effects we have related above should not have any influence on the optimal tax rates derived from our theoretical tax model. This is due to the fact that a government that maximises the utility function of the representative citizen would react to the changes passed by the federal government adopting the necessary legal actions to keep effective tax rates at the optimum. If we checked in the empirical model that the provinces just take as given the wind-fall gains or losses without any additional legal tax change, that would suggest the existence of some sort of fiscal illusion. However, in some cases it would be difficult to disentangle the passive adjustment from the active reaction due to the vertical tax externality. That would happen if both reactions go in the same direction. The only way to test if the reaction is due to economic behaviour or to fiscal illusion is to allow the slope of the reaction

[17] The first provinces to make use of these surcharges where Saskatchewan, British Columbia and Manitoba; Ontario, Alberta and Prince Edward started in 1986, 1987 and 1988, and New Brunsbick, Nova Scotia and Newfoundland in 1991, 1993 and 1996 (source: Provincial Budget Roundup, Canadian Tax Foundation).

[18] The use of the flat tax began in Saskatchewan in 1985, was followed in 1986 by Manitoba and Alberta and has been set also recently in 1996 in British Columbia and Ontario (source: Provincial Budget Roundup, Canadian Tax Foundation).

[19] The size of this direct impact (dt_P/dt_F) can be expressed in the three cases as: 0 (non-conforming), B_P (fully harmonized), and $b_P + a.S_P$ (high income surcharge); where we have defined t_P=provincial tax burden, t_F=federal tax burden, B_P=provincial basic rate, S_P=provincial surcharge, a=share of federal revenues coming from high income taxpayers. Let suppose, for example, that B_P=0.50 and S_P=0.30; if a=0.20, then the surcharge will increase the direct impact from 0.50 (fully harmonized) to 0.59.

function to differ among the three groups of provinces previously defined. In the case there is some degree of fiscal illusion we would expect the following ordering in the size of the reaction: non-conforming < fully harmonized < with high income surcharge. If we check that the reaction is similar for all of them we could conclude that the cause is owed to the vertical tax externality, and not to fiscal illusion.

The first year of the period we analyse is 1982 because in the previous years a feature of the Canadian federal system was the substitution of additional tax room (mainly in income taxation) for cash payments[20]. As we noted in the introduction, in this setting the data will show an interdependence between federal and provincial effective tax rates that is not directly related to the vertical tax externality hypothesis[21]. The interest of the period analysed is also justified by the substantial changes experienced by the structure of the Canadian Federal Personal Income Tax. The 1981, 1987 and 1991 tax reforms reduced the number of tax brackets from 13 to 10 and 3, respectively; the top marginal tax rate was also reduced form 43% to 34% in 1981 and to 29% in 1987 (Doak, 1990), but some surtaxes where introduced in the following years (Howard et al., 1995). Although these changes translate into a lesser extent to reductions in tax burdens (Davies and Zhang, 1996), this variable shows periods of decrease and increase during the sample analysed, providing thus enough variation to carry out the empirical analysis.

[20] The Tax Collection Agreements(1962-1976) represented the beginning of a trend toward increased fiscal responsibility. The new provincial income taxes of 1962 where accommodated with an abatement in the federal income tax that was increased in subsequent years (1965 and 1966). Later on (1965-67), under increased pressure for fiscal autonomy, an additional abatement (in exchange for some specific grant programs) was given to Quebec and then extended partly to the other provinces. The Tax Transfers Agreements (1976-1982) saw the substitution of the tax abatement for the reduction in federal tax rates, and an additional cession of tax room in exchange for a reduction in specific grants (Established Programs Financing, in 1976). In the arrangements of 1982-1986 more emphasis was given to cash payments, and no further tax changes were made. See Perry(1989, chapter 16) for a more detailed analysis of all these institutional changes.

[21] Note, for instance, that the coefficient of correlation between average federal and provincial income tax rates is - 0.92 & 0.91 for the periods 1965-82 and 1983-96 (source: Revenue Canada, Taxation Statistics); that correlation does not of course tell us nothing about causation, but the negative sign for the first period does certainly reflect the cession of tax room.

To test the tax interdependence hypothesis for the Canadian case, we will use a panel of data corresponding to the ten provinces during the period 1982-96. We exclude Yukon and the NorthWestern Territories from the analysis because, although they are entitled to enter the field of income taxation, they have a special status in the federation (Perry, 1989).

3.2 Empirical framework

Our main empirical purpose is to estimate the magnitude of the reaction of provincial income tax rates to exogenous changes in federal income tax rates; that is, to estimate the slope of the reaction function of the provincial government. We choose as our dependent variable the provincial tax rate –and not the federal tax rate– because in practice there exists more than one provincial government. With many provincial governments and having 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 provincial governments, but to a weighted sum of all of them[22].

We use the effective average tax rate as the definition of our tax variables. Those tax rates are calculated as the ratio of income tax revenue to personal income. That is the so-called tax burden[23]. 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

[22] The possibility of an endogenous federal tax rate will be ruled out later in the empirical analysis with the help of a instrumental variables estimator.

[23] Although this variable is not the best alternative to account 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. 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 usual statistical sources. Some authors have also argued in favour of the use of marginal tax rates computed directly from the statutory tax function (Barro and Sahasakul (1986)), or to use the top marginal tax rate (Tannenwald (1991), and Mullen and Williams (1993)). However, this last approach seems better suited to analyse 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 regional government does not have to be affected by its income distribution or the composition of the tax base - as are effective tax rates. Nevertheless, as we are mainly interested in vertical spillovers, we can not employ simple characterisations of the statutory regional tax function.

the tax base between provinces (basically differences between Quebec's and federal income tax laws) and over time 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 that way means that we do not accept as accurate, reliable and stable the definition of tax base given by the federal or provincial governments of Canada.

The comparative static results derived in section 2 for the specific Canadian institutional features allow us to develop complementary hypothesis to test. In the Canadian setting we expect the reaction to exogenous federal tax rate increases to differ among the provinces depending on its population size and equalisation status. The provinces considered as big are Ontario and Quebec[24]. Three provinces did not receive equalisation payments throughout the period analysed (Alberta, British Columbia and Ontario), one province (Saskatchewan) received payments only in the fiscal years 1980-81 and 1986-87 to 1994-95, and the rest have been entitled to the equalisation program all the years. The general specification of the equation employed to test all these hypothesis is the following:

$$t_{P,it} = \alpha_1 \, t_{F,it} + \alpha_2 \, (DEqualization_{it} \, t_{F,it}) + \alpha_3 \, (DBig_i \, t_{F,it}) + \sum_k \alpha_k \, Z_{k,it} + \alpha_{0,i} + \varepsilon_{it} \quad (13)$$

$t_{P,it}$ and $t_{F,it}$ are the effective average provincial and federal tax rates, where the subscript i and t indicates province and year; $DEqualization_{it}$ is a dummy variable equal to one if the province is entitled to received equalisation in that year; $DBig_i$ is a dummy variable equal to one for the two big provinces; and Z is a vector of control variables. This set of controls is 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

[24] The share of these provinces in the population of Canada accounts for a 37,5% and 24,8%, respectively; none of the rest of the provinces accounts for a share of population much bigger than 10%.

preferences of voters, electoral interests of politicians, and economic, institutional and cultural constraints. Many of those influences are correlated with federal effective tax rates, thwarting any direct inference about its effects on regional tax rates. As a result of this, and in order to isolate the effect of tax interdependence, it is necessary to control for all the other relevant variables that affect the regional tax-setting process. We include several groups of control variables[25]:

Economic resources. Richer populations will demand more regional public goods and, as a consequence, will tolerate higher income taxes; we include personal income per capita 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 regional government can have an effect on the income tax rate. In the case of lump-sum grants, we would expect recipient governments will spend more but they will return part of the amount received to its citizens. Nevertheless, if grants are conditional on the amount spent, the tax reduction will probably be lower or there could even be a tax increase[26]. As we have shown in the theoretical analysis, an equalization grant could provide incentives to increase the regional tax rate. So, we expect that the effect of equalization funds on the income tax rate to be higher than the effect of a lump-sum transfer of the same amount. We include three variables that control for the amount and type of transfers received: the revenue per capita collected from natural resources, the equalization grant per capita, and the per capita amount received from all other grants.

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,

[25] See Table III for summary statistics, definitions and statistical sources.

[26] The lower capacity of lump-sum grants to stimulate expenditure has been questioned by the strand of literature devoted to the so called "flypaper effect"; see, for example, Hines and Thaler (1995), Turnbull (1998). However, in a recent survey, Reiter and Weichenrieder (1997) conclude that the empirical evidence on the topic is mixed.

therefore, will be burdened more heavily through income taxes. We include as explanatory variables the size of two groups of potential intensive service users: the proportion of population over 65 and under 15; we also introduce as cost variables the size of the population, its squared, and the unemployment rate.

Political environment. Although many politically motivated models of public policy formation suggest that parties converge at the same platform regardless of its ideology, many others suggests that if politicians are policy-motivated and do not only care about winning elections the policies implemented need not be the same. We include a dummy variable that account for the ideology of the regional executive (*DLeft*, which takes the value of one if the executive is on the left wing of the provincial political arena[27]), and another variable that accounts for the fragmentation of the government (*DMinority*, which takes the value of one if the government is in minority in the legislative)[28].

The coefficient $a_{0,i}$ in expression (13) represents a provincial individual effect. The estimation of a fixed effects model by OLSQ will give us consistent estimates of the parameters whenever the state effects are correlated with the explanatory variables included in the equation (Mundlak(1978)). Provincial individual effects represent specific circumstances of each state that stay relatively constant during the analysed period: characteristic of the local political market, specific differences in the cost of local public or a permanent inflow of revenue from other tax resources. Otherwise, if these were correlated with the variables included in the empirical model, the obtained parameters would be inconsistent (Holtz-Eakin(1986)).

[27] The parties considered on the left are the New Democratic Party and the Parti Québécois .

[28] The results of some empirical studies suggested that divided governments are more vulnerable to redistributive pressures, and this fact results in difficulties to undertake reforms to cut spending or deficits; see, for example, Roubini and Sachs (1989) and Alt and Lowry (1994). In the case of income taxation, divided governments could find more difficult, for example, to eliminate loopholes from the tax code.

3.2 Econometric procedure and results

Observed tax burdens (t^o) reflect two types of influences. They have a planned component (t^p), representing deliberate choices (included mainly in the yearly budget document) by government officials based on information available to them, but they also have an unexpected one (t^u). That is, for example, actual provincial tax burdens are the result of the tax parameters that were chosen by public officials (basic provincial rate, surcharges, flat tax, tax credits), given their anticipation of the size of the base and the structure of the federal income tax. However, actual tax burdens also reflect the effect of unanticipated fluctuations in the tax base. The estimating equation in (13) has been presented as relating actual values of provincial tax burdens with actual values of federal tax burdens and control variables. However, since the estimating equation has to be grounded on some behavioural model, it must be expressed in terms of planned tax burdens:

$$t_{P,it}^{\ p} = \alpha_1 \times t_{F,it}^{\ p} + \alpha_2 Z_{it}^{\ p} + \varepsilon_{it} \qquad (14)$$

where ε_{it} is an error term with the standard properties of zero mean, constant variance and no-correlation with the explanatory variables. Note that the estimation of the equation in (13) with observed tax burdens would mean that:

$$t_{P,it}^{\ o} = \alpha_1 \times t_{F,it}^{\ o} + \alpha_2 Z_{it} + \eta_{it} \qquad (15)$$

where $\eta_{it} = (t_{P,it}^{\ u} - \alpha_1 \times t_{F,it}^{\ u}) + \varepsilon_{it}$ is the new error term. If the unexpected events only refer to the size of the tax base, the error term can be expressed as $\eta_{it} = (t_{P,it}^{\ p} - \alpha_1 \times t_{F,it}^{\ p})(B_{it}^{\ u}/B_{it}^{\ o}) + \varepsilon_{it}$, where $B_{it}^{\ u}$ and $B_{it}^{\ o}$ are the unexpected and observed tax bases. Note that the error term η is now correlated with the federal tax burden, leading to a bias in the estimation of α_1. Since under reasonable conditions $\eta_{it} > \varepsilon_{it}$ and $corr(t_{Fit}^{\ o}, (B_{it}^{\ u}/B_{it}^{\ o})) > 0$, the expected direction of the bias is positive. There are three possible ways to handle this problem and, thus, obtain unbiased estimates of the degree of fiscal interdependence:

Planned values. If we were able to find some variable that proxies t_P^p and t_F^p the problem would disappear. With this purpose in mind, we elaborate a measure of t_P^p with data corresponding to the income tax revenue and GDP estimates included in the yearly provincial budgets. Since we have not been able to construct a similar measure for t_F^p, we use as a forecast its one year lagged value. We use the same approach in the case of the control variables, and thus they enter in the estimating equation with one lag. However, it is possible that these lags do not account for the full set of information that provincial governments have when set the budget and, thus, some bias could remain in the estimated parameters.

Control for unexpected changes. This consists of using some proxy of B^u/B as a control variable. We use as a proxy of this unplanned component the difference between planned and realized provincial income tax revenues and name this variable "Budgetary Surprise". However, note that this variable will only pick up the first part of h_{it}-e_{it}, as it is equivalent to $t_{P,it}^p(B_{it}^u/B_{it}^a)$.

Use of Time effects. The use of dummy variables for each year of the sample would control for shocks common to all the provinces in a given year. If the size of the bias is fairly constant across provinces and only changes yearly this will be a good solution. Nevertheless, for this to be true both (B_{it}^u/B_{it}^a) and $t_{F,it}^p$ have to be roughly similar across provinces. Even if this is true for the business cycle, the impact of unexpected changes in income is not necesarilly the same. That is because the federal tax burden on each province ($t_{F,it}^p$) does not depend only on the federal income tax code (common to all provinces) but also depends on other intrinsic factors as the distribution of income and the share of different income sources.

Instrumental variables. Another 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. For this purpose we select two different sets of instruments. The first one contains exogenous determinants of the federal tax policy: population over 65 years old, income per capita, and a

dummy equal to 1 for liberal governments. The second set includes two measures of the statutory impact of federal tax reforms: weighted average federal tax rates and weighted federal tax elasticity (defined as the ratio between marginal and average tax rates). These variables have been calculated from federal tax statistics by income class (Taxation Statistics, Revenue Canada). To obtain an overall measure for each of these variables we weighted the values of each income class by its share in total taxable income. These shares have been calculated as the average shares for the period 1982-96 to avoid non-legal impacts on the instruments. Note that both sets of instruments do not show variation across provinces; this precludes the use of time effects in the IV equations. To be able to estimate an IV equation with time effects we create an additional set of instruments that is simply the average federal tax rate and tax elasticity interacted with the full set of provincial dummies. Summing up, the different specifications we try are: OLSQ with time effects, IV without time effects and the two sets of time varying instruments, and IV with time variables and time and cross-section varying instruments. We include the "budgetary surprise" variable in all the specifications. The Hausman χ^2 statistic will be used to decide between OLSQ and IV equations[29].

Table I presents the results of the OLSQ estimation with individual and time effects. This specification has been chosen over IV estimation after checking that although IV techniques prove useful to control for common shocks in absence of time effects, when these are included the IV estimator does no represent any improvement over OLSQ. This can be concluded from Table II. The first column shows OLSQ estimates without time effects while the second and third columns show IV estimates without time effects. Note how the coefficient of $t_{F(-1)}$ is very high in OLSQ estimation and is reduced in both IV equations. A

[29] See Hausman(1978); this a test of the hypothesis that the instruments are uncorrelated with the residual and so that OLSQ are unbiased. Under the null, the OLSQ is efficient and unbiased, but under the alternative OLSQ is biased while IV is not. If there is no correlation the difference between OLSQ and IV estimates divided by the standard error of the difference will converge to zero. The statistic is distributed as a χ^2 with degrees of freedom equal to the number of instruments.

look at the Hausman test corroborates the fact that the OLSQ estimate seems to be upward biased. The first column of Table I shows the OLSQ results with time effects for this basic specification and the last column of Table II shows the IV results with time effects (thus, with cross-section varying instruments). Now the coefficient of $t_{F(-1)}$ is very similar in both equations and the Hausman test does not reject the null hypothesis of no correlation between $t_{F(-1)}$ and the residual. 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 OLSQ with time effects results of Table I. We present six different specifications. The first three equations try to test the hypothesis developed in the theoretical analysis. In the first one we do not allow the coefficient of the variable $t_{F(-1)}$ to vary among groups of provinces. In the second one also include the interaction between $t_{F(-1)}$ and *DEqualization*. In the third one we include the interaction between $t_{F(-1)}$ and *DBig*. From these results we can confirm some of the hypothesis developed up to now. First, and most important, the sign of the provincial reaction to federal tax changes is positive and statistically significant. A 1% point change in the federal tax burden supposes a variation in the provincial tax rate around 0.16%. Second, the provinces that receive equalization payments react a little bit less than the rest (see column 2); in that case the reaction will be around 0.14%. Third, the big provinces don not seem to react differently from the rest; although the negative sign is consistent with the hypothesis that big provinces internalise part of the vertical tax externality, the coefficient is not statistically significant.

The last three equations check the robustness of the original results against alternative explanatory hypotheses. The first hypothesis to test is the potential presence of fiscal illusion. As we noted earlier, if the provinces adapt passively to federal tax changes, we would expect that provinces which tax is linked to the federal one to react more than provinces with fully

not conforming taxes, and that provinces with high income surcharge to react even more. We try to control for these facts by including interactions of $t_{F(-1)}$ with two dummies, *DQuebec* and *DSurcharge* (1 if the province has a high income surcharge). From the results of column(4) it can be concluded that the size of the reaction does not differ much between groups of provinces. Although the signs obtained for the interactions are consistent with the existence of certain degree of illusion, the coefficients are very small and in the case of Quebec it is not statistically significant. This does not mean that having an independent tax structure does not embody any different behaviour. In column (5) we re-estimate the fiscal illusion equation allowing Quebec to react with one more period delay. From the results we can check that although the magnitude of the reaction has not changed, Quebec reacts fully with two periods of delays while the rest of the provinces do it just with one lag. Therefore, it seems that the link between provincial and federal taxes exerts some pressure to accelerate the reactions in order to avoid part of the direct impact on revenues. The second hypothesis we have tested is the possibility of a reaction simply based on partisan preferences. We introduce in column (6) an interaction between $t_{F(-1)}$ and *DLeft* (=1 if the party in the provincial government is on the left). We find a lower reaction by leftist governments; while the point estimates for rightists is 0.195%, the one for leftists is 0.12%. A possible explanation of this different reaction is that leftist governments are more dependent on the income tax (note that the coefficient of dummy *DLeft* is positive and significant in all the equations) and because of that they could be more reluctant to reform this tax.

The results obtained for the control variables are generally as expected. It is worth mentioning the estimated effects of the different types of grants on the provincial tax burden. The revenue coming from Natural Resources exerts a downward pressure on the provincial tax burden while the other grants have a positive effect. This is consistent with the consideration of Natural Resources revenues as a lump-sum grant while the grants seems to

have also a price effect. The fact that the Equalization Grant has roughly the same effect over the tax burden than Other Grants (that are mainly specific grants) is consistent with Smart(1996)'s result. Thus, provinces receiving equalization grants tend to have a higher privincial income tax burden but tend to react to a lesser extent to changes in the federal tax.

4. Conclusions

In this paper, our main aim was to test empirically the relevance of the vertical tax externality for personal income taxation. The evidence we have found seems to confirm that hypothesis. The theoretical model predicted a positive reaction of the provincial governments to changes in the federal tax burden, a different reaction for the big provinces and those receiving equalization payments. In the empirical analysis we have found that 1% point increase in the federal tax burden is followed by an increase of approximately 0.14% in the provincial tax burden for the provinces receiving equalization, and of 0.16% for the rest. The big provinces seem not to react differently. These point estimates are lower than those obtained by Esteller and Solé(1999) for the state personal income tax in the U.S. (between 0.20 and 0.25%), although in that case the reaction also embodies the effect of tax deductibility. The results are much lower than those obtained by Besley and Rosen (1998) for the state excises in the U.S. (around 0.30%).

We are able to reject other possible explanations and so confirm the robustness of these results; in particular, we show that the reaction we find does not stem from the link between federal and provincial income tax codes. However, it seems that the size of the reaction is quite different depending on the partisan preferences of the provincial government; in fact, the leftists tend to react less than the rightist. This last result suggests that the theoretical framework should be widened to account for different redistributive preferences.

If our guesses about the empirical relevance of the vertical tax externality are true, useful political economy insights can be derived. As commented in the introduction, the Spanish regions have recently achieved relatively important powers on the personal income tax. The critics of this reform have only emphasised the negative effects of potential horizontal tax competition. However, as we have shown, the vertical tax externality can provoke distortions on tax decisions that could be equally harmful. In any case, the potential negative effects of the vertical tax externality should be balanced with the positive effect of greater fiscal responsibility at the regional level of government.

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Table I: Least Squares Estimates, Individual and Time effects; dependent variable $t_{R(P)}$ (%), Nº Obs.= 150 (N = 10, T=15)

Variable	*(1)OLSQ*	*(2) OLSQ*	*(3) OLSQ*	*(4) OLSQ*	*(5) OLSQ*	*(6) OLSQ*
$t_{F(-1)}$	0.155 (2.281)**	0.159 (2.487)***	0.163 (2.489)***	0.166 (2.291)**	0.170 (2.403)***	0.195 (2.456)***
$t_{F(-1)}$ *x Dequalization*	--.--	-0.019 (-1.961)**	--.--	--.--	--.--	--.--
$t_{F(-1)}$ *x Dbig*	--.--	--.--	-0.005 (-0.381)	--.--	--.--	--.--
$t_{F(-1)}$ *x Dsurcharge*	--.--	--.--	--.--	0.023 (1.869)*	0.023 (1.877)*	--.--
$t_{F(-1)}$ *x Dquebec*	--.--	--.--	--.--	-0.013 (-0.717)	-0.164 (-2.380)***	--.--
$t_{F(-2)}$ *x DQuebec*	--.--	--.--	--.--	--.--	0.153 (2.244)**	--.--
$t_{F(-2)}$ *x DLeft*	--.--	--.--	--.--	--.--	--.--	-0.075 (-2.255)**
Income (x 10^{-3})	-0.077 (-3.122)***	-0.082 (-3.326)***	-0.066 (-3.097)***	-0.071 (-2.681)***	-0.071 (-2.855)***	-0.084 (-3.409)***
Equalization Grant (x 10^{-3})	0.441 (2.035)**	0.459 (2.093)**	0.419 (2.070)**	0.433 (1.824)*	0.528 (2.292)**	0.399 (1.995)**
Other Grants (x 10^{-3})	0.402 (1.967)**	0.339 (1.659)*	0.430 (1.681)*	0.385 (1.801)*	0.494 (2.395)**	0.369 (1.821)*
Natural Resources (x 10^{-3})	-0.193 (-2.731)***	-0.181 (-1.838)*	-0.169 (-1.380)	-0.182 (-1.762)*	-0.173 (-1.782)*	-0.186 (-2.186)**
Population (x 10^{-6})	1.201 (5.598)***	0.919 (4.649)***	1.100 (3.667)***	1.017 (4.663)***	1.429 (4.579)***	1.198 (5.744)***
Population^2 (x 10^{-12})	-0.101 (-1.960)*	-0.076 (-1.980)*	-0.081 (-3.172)***	-0.012 (-2.341)**	-0.012 (-2.365)**	-0.010 (-2.374)**
DPopulation (x 10^{-6})	0.300 (2.267)**	0.282 (1.850)*	0.416 (1.785)*	0.386 (1.965)**	0.360 (2.279)**	0.333 (1.743)*
% Population over 65	-0.458 (-4.381)***	-0.474 (-4.266)***	-0.387 (-2.579)***	-0.348 (-3.486)***	-0.351 (-3.521)***	-0.445 (-4.414)***
% Population under 15	-0.062 (-1.759)*	-0.057 (-1.569)	-0.032 (-0.712)	-0.035 (-0.939)	-0.046 (-1.274)	-0.064 (-1.825)*
% Unemployment Rate	0.016 (1.029)	0.015 (0.935)	0.026 (1.591)	0.024 (1.483)	0.022 (1.583)	0.014 (1.467)
% Budgetary surprise	-0.001 (-0.799)	-0.001 (-0.813)	-0.001 (-0.745)	-0.001 (-0.850)	-0.001 (-0.411)	-0.001 (-0.860)
DLeft	0.124 (2.074)**	0.153 (2.399)**	0.096 (2.009)**	0.116 (1.688)*	0.122 (2.014)**	0.138 (2.607)***
DMinority	0.130 (1.746)*	0.145 (1.888)*	0.152 (1.036)	0.154 (1.202)	0.111 (1.985)**	0.144 (1.789)*
Adjusted R^2	0.685	0.689	0.663	0.670	0.687	0.685
Breusch-Pagan (Heterosk.)	7.699	8.875	5.489	10.590	9.421	9.981
Durbin-Watson (Autocorr.).	1.799	1.884	1.903	2.110	2.228	2.015
F(C vs. C_i), Ind.effects	1,375.6***	1,423.8***	4,250.3***	3,711.5***	3,736.3***	2,985***
F(C vs. C_i), Time effects	425.5***	569.4***	520.0***	467.5***	496.5***	541.3***
c^2(Hausman) Fixed vs.Random	52.4**	43.4**	52.3**	71.8**	56.8**	52.4**

Notes: *t* statistics are shown in brackets; *, ** & *** =significantly different from zero at the 90, 95 and 99% levels.

Table II: Instrumental Variables Estimates;dependent variable $t_{R(P)}$ (%), Nº Obs.= 150 (N = 10, T=15)

Variable	*(7) LSQ*	*(8) IV*	*(9) IV*	*(10) IV*
$t_{F(-1)}$	0.415	0.149	0.181	0.150
	(8.342)***	(2.201)**	(3.288)***	(1.998)**
Income (x 10^{-3})	-0.063	-0.106	-0.107	-0.111
	(-0.639)	(-1.303)	(-0.816)	(-2.922)***
Equalization Grant (x 10^{-3})	0.640	1.002	0.960	0.255
	(2.627)***	(3.361)***	(2.664)***	(2.005)**
Other Grants (x 10^{-3})	0.353	0.264	0.227	0.333
	(1.711)	(0.628)	(0.715)	(1.935)*
Natural Resources (x 10^{-3})	-0.232	-0.314	-0.334	-0.220
	(-2.673)***	(-3.005)***	(-2.104)**	(-2.250)**
Population (x 10^{-6})	0.820	0.901	0.531	1.151
	(3.385)***	(2.236)**	(1.201)	(2.699)***
Population^2 (x 10^{-12})	-0.010	-0.008	-0.033	-0.099
	(-1.545)	(-1.658)*	(-0.535)	(-1.667)*
DPopulation (x 10^{-6})	0.425	0.583	0.549	0.231
	(2.202)**	(3.269)***	(0.436)	(2.121)**
% Population over 65	-0.282	-0.417	-0.114	-0.554
	(-2.272)***	(-0.449)	(-0.156)	(-3.168)***
% Population under 15	-0.058	-0.087	0.071	-0.102
	(-1.862)*	(-1.429)	(0.427)	(-1.759)*
% Unemployment Rate	0.018	0.016	0.016	0.005
	(1.355)	(1.210)	(0.713)	(1.268)
% Budgetary surprise	-0.001	-0.001	-0.001	-0.001
	(-0.639)	(-0.983)	(-0.542)	(-0.945)
DLeft	0.130	0.171	0.145	0.138
	(1.968)**	(1.356)	(0.783)	(1.967)*
DMinority	0.077	0.110	0.150	0.140
	(0.700)	(0.684)	(0.900)	(1.789)*
Individual effects	YES	YES	YES	YES
Time effects	NO	NO	NO	YES
Adjusted R^2	0.565	0.425	0.410	0.644
Breusch-Pagan (Heterosk.)	7.564	5.854	6.951	6.098
Durbin-Watson (Autocorr.).	1.845	1.959	2.011	1.960
F(C vs. C_i), Individual effects	1,375.6***	4,250.3***	2,143.0***	1,569.0***
F(C vs. C_i), Time effects	--.--	--.--	--.--	300.5***
c^2(Hausman) Fixed vs.Random	52.4**	52.3**	47.2**	43.4**
c^2(Hausman test), LSQ vs. IV	--.--	16.8***	3.84**	0.01

Notes: (1) See Table I; (2) First stage regressions (LSQ, Individual effects):

Equation (8):

t_F=-0.037 + 0.066 x (% Population over 65 (F)) + 0.111 x (Income(F) x 10^{-3}) + 0.004x (DLeft(F))
(-3.589)*** (2.377)*** (6.405)*** (3.632)***

Adjusted R^2=0.804, F-est=86.29***

Equation (9):

t_F=-0.162 + 0.544 x (Weighted Average Tax Rate (F)) + 0.099 x (Weighted Tax Elasticity (F))
(-8.361)*** (14.179)*** (9.362)***

Adjusted R^2=0.897, F-est=95.729***

Equation (10):

t_F=-0.207+Σ(0.207 to 0.765) x (Individual Effects x Weighted Average Tax Rate(F)) +
Σ(0.054 to 0.132) x (Individual Effects x Weighted Tax Elasticity (F))

Adjusted R^2=0.904, F-est=49.547***

TableIII: Summary statistics, definition and statistical sources of the variables

Variable	*Mean*	*Std.Dev.*	*Definition*	*Statistical sources*
t_P			*Provincial estimated effective average tax rate as a percentage of GDP*	*Revenue & GDP estimates, from Provincial Budget Roundup, Canadian Tax Foundation*
t_F			*Federal effective average tax rate as a percentage of GDP*	*Revenue Collected & GDP, from Provincial Economic Accounts, Statistics Canada*
Dequalization			*=1 if the province is entitled to receive equalization grants*	*Federal Transfers to the Provinces, Canadian Tax Foundation*
Dbig			*=1 for Ontario & Quebec*	--.--
Dquebec			*=1 for Quebec*	--.--
Dsurcharge			*=1 for the provinces & years with high income surcharges*	*Provincial Budget Roundup, Canadian Tax Foundation*
Income			*GDP per capita in 1981 dollars*	*Provincial Economic Accounts, Statistics Canada*
Equalization Grants			*Equalization grants per capita in 1981 Dollars*	*Federal Transfers to the Provinces, Canadian Tax Foundation*
Other Grants			*Other grants per capita in 1981 Dollars*	*Federal Transfers to the Provinces, Canadian Tax Foundation*
Natural Resources			*Provincial Revenue from Natural Resources in 1981 Dollars*	*Revenue Collected from Public Sector Finance, Statistics Canada*
Population			*Provincial Population*	*CANSIM, Statistics Canada*
Population over 65			*% of Provincial Population over 65 years old*	*CANSIM, Statistics Canada*
Population under 15			*% of Provincial Population under 15 years old*	*CANSIM, Statistics Canada*
Unemployment Rate			--.--	*CANSIM, Statistics Canada*
Budgetary Surprise			*% Deviation of Collected from Estimated Total Revenues*	*Revenue estimates & collections, from Provincial Budget Roundup, Canadian Tax Foundation*
DLeft			*=1 if the party in the provincial government is on the left of the provincial political spectrum. Parties on the left were defined to be the New Democratic Party (NDP) and the Parti Québécois(PQ).*	*The Canadian Parliamentary Guide & Provincial WebSites*
DMinority			*=1 if the party in the provincial government is in minority in the provincial parliament*	*The Canadian Parliamentary Guide & Provincial WebSites*
DLeft(F)			*=1 if the party in the federal government is on the left of the federal political spectrum. The Partie on the left were defined to be the Liberal Party (LP)*	*The Canadian Parliamentary Guide*
$t_{F(A)}$			*Average effective tax rate, calculated from federal tax statistics by income class*	*Taxation Statistics, Revenue Canada*