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Tax Setting in a Federal System: The Case of Personal Income Taxation in Canada

Alejandro Esteller, Albert Solé

Institut d'Economia de Barcelona
Edifici Florensa
Adolf Florensa, s/n
08028 Barcelona
Tel.: 93 403 46 46
Fax: 93 402 18 13
E-mail: ieb@pcb.ub.es
http://www. pcb.ub.es/ieb

TAX SETTING IN A FEDERAL SYSTEM: THE CASE OF PERSONAL INCOME TAXATION IN CANADA [a,b]

Álex Esteller, Albert Solé [c]

ABSTRACT: In a decentralised tax system, the effects of tax policies enacted by one government are not confined to its own jurisdiction. First, if the tax base is mobile, tax rate increases by one regional government will raise the amount of taxes collected by other regional governments (horizontal tax externality). Second, if both the regional and the federal levels of government co-occupy the same fields of taxation, tax rate increases by one layer of government will reduce taxes collected by the other (vertical tax externality). Third, as Smart (1998) shows, if equalisation transfers are present, an increase in the standard equalisation tax rate provides incentives to raise taxes to the receiving provinces. In order to check the empirical relevance of these hypotheses, this paper estimates provincial tax setting functions with data on Canadian personal income taxation for the period 1982-96. We find a significant positive response of provincial tax rates to changes in the federal income tax rate, the tax rates of competing provinces, and the standard equalisation rate (only for receiving provinces). We also find that the reaction to horizontal competition is stronger in the provinces that do not receive equalisation transfers.

Keywords: fiscal federalism, tax competition, equalisation grants, personal income tax
JEL Classification: H3, H21, H77

RESUMEN: En un sistema fiscal descentralizado, los efectos de las políticas impositivas llevadas a cabo por un gobierno no se agotan en su propia jurisdicción. En primer lugar, si la base impositiva es móvil, incrementos impositivos por un gobierno regional incrementarán los recursos de otro gobierno regional (externalidad fiscal horizontal). En segundo lugar, si los niveles de gobierno regional y federal comparten los mismos espacios fiscales, incrementos en el tipo impositivo de un nivel de gobierno reducirá la recaudación del otro (externalidad fiscal vertical). En tercer lugar, como Smart (1998) ha demostrado, bajo un sistema de nivelación, un incremento en el tipo impositivo estándar de la transferencia incentiva aumentos en los tipos impositivos de las provincias receptoras. Al objeto de comprobar la relevancia de estas hipótesis, estimamos funciones provinciales de fijación de tipos impositivos a partir del impuesto canadiense sobre la renta personal para el período 1982-96. Hallamos una significativa respuesta positiva de los tipos impositivos provinciales ante cambios en los tipos impositivos federales, los tipos impositivos de las provincias competidoras y el tipo impositivo estándar de la nivelación (para las provincias receptoras), así como que la reacción a la competencia fiscal horizontal es mayor para aquellas provincias que no reciban subvenciones de nivelación.

Palabras clave: federalismo fiscal, competencia fiscal, subvenciones de nivelación, impuesto sobre la renta personal

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[c] Corresponding author: Albert Solé (asole@eco.ub.es)
Dpto. Hacienda Pública- Facultad de Ciencias Económicas (Universidad de Barcelona)
Avda. Diagonal, 690, Torre 4, pl. 2ª - 08034 Barcelona (Spain)
Tel.: 00 34 93 402 18 12
Fax: 00 34 402 18 13

1. Introduction

The benefits of fiscal decentralisation are well known: mainly, the greater sensitivity to diverse regional preferences (Oates, 1972) and the possibility of preference revelation by household mobility (Tiebout, 1956)[1]. Nevertheless, against these benefits, the assignment of fiscal power to the decentralised layers of government might create inefficiencies that could more than compensate such benefits. A typology of these inefficiencies can be found in Gordon (1983) and, more recently, in Inman and Rubinfeld (1996), Dalhby (1996) and Wilson (1999). Many studies, both theoretical and empirical, have dealt with specific issues: tax competition (e.g., Zodrow and Mieskowski, 1986), tax exporting (e.g., Bird and Slack, 1983), expenditure spillovers (e.g., Case et al., 1993) and vertical externalities, both on the tax side (e.g., Keen, 1998) and on the expenditure side (e.g., Dalhby and Wilson, 1999).

In this paper we concentrate on interactions that may arise because of the decentralisation of tax power to sub-national governments. In a decentralised tax system, the effects of tax policies enacted by one government are not confined to its jurisdiction. Tax rate increases by one regional government will affect taxes collected by other regional governments as well as by the federal government. Horizontal and vertical tax externalities are the main sorts of fiscal externalities among governments pointed out in the literature and will be the focus of our empirical analysis. In addition, the federal institutional framework of each country could alleviate or exacerbate the effects of these externalities. There are many different examples of such institutions, but as our empirical analysis uses data on Canadian taxes, we will focus on the incentive effects that the Canadian equalisation program has on provincial tax policies.

Let's have a more detailed look at these problems. First, vertical tax externalities arise as a consequence of the co-occupancy of the same field of taxation by both the regional and the federal layers of government (Flowers, 1988; Boadway and Keen, 1996; Dahlby, 1996; or Keen, 1998). The

[1]Some authors have pointed that decentralisation may also help to increase accountability and, thus, improve preference revelation at the ballot box; e.g., Salmon (1987) and Seabright (1996).

necessary conditions for the existence of the externality is that both layers of government have tax power over the same distortionay tax base[2], and that they both neglect the impact of their actions on the amount of revenues collected by the other. Then, each layer of government will establish an inefficiently high level of taxation with respect to the level that would have been established by a unitary government. Two main empirical predictions derive from these models: (i) combined tax rates will be higher in federations where different levels of government share the same tax bases, and (ii) there will be interdependencies among the tax rates set by the federal and regional governments. Recently, some papers have looked for empirical evidence on vertical tax externalities using the second approach: Besley and Rosen (1998) for excise taxes in the US, Goodspeed (2000) for personal income taxes in a panel of OECD countries, Hayashi and Boadway (2000) for corporate income taxes in Canada, and Esteller and Solé (2001) for personal income taxes in the US. In all the cases, the authors are able to find a tax interaction between the lower layers of government and the federal one, though the sign of the reactions are different. However, this last result is not surprising, since the theoretical literature has shown that the expected sign of the interaction is ambiguous (Keen, 1998).

Second, horizontal tax externalities are probably the most well documented source of inefficiency in a federal system of government. In particular, we are interested in the inefficiency that comes out because of the mobility of the tax base among provincial governments. Under this situation, all provincial governments compete to attract tax base to their territory. This can only be achieved by lowering the tax burden on the mobile factor, which will provoke an inefficiently low level of public good provision in all the federation (Zodrow and Mieszkowsky, 1986; Wilson, 1986; Boadway and Wildasin, 1984). Two main empirical predictions derive from these models: (i) increased tax competition will cause tax rates to converge at lower levels, and (ii) tax rates of competing regional governments will be interdependent. Most of the papers have searched for evidence on tax competition by testing for horizontal tax interdependences (see, e.g., Ladd, 1993, Case, 1993, Besley and Case,

[2] It has to be stressed that tax-sharing arrangements –i.e., when the regional government is entitled to a share of the revenues raised in its territorial jurisdiction– do not conform with what we mean by 'concurrent taxation'; what is in fact necessary is that both levels of government share tax powers regarding that tax base.

1995, Brett and Pinske, 2000, Heyndels and Vuchelen, 1998, and Büttner, 2000)[3]. All of them have found evidence of positive interactions among tax rates of competing regions.

Third, the institutional framework can also affect the tax setting process of regional governments. For instance, tax setting decisions may be affected by the deductibility of the regional tax liability from the federal tax base (as in the US), or by the presence of a system of equalisation grants (as in Canada). In the first case, the tax deductibility lowers the regional marginal cost of taxation, which tends to raise regional tax rates (see Feldstein and Metcalf, 1987, for an empirical application). In the second case, the equalisation grant also reduces the marginal cost of public funds, and so tends to raise regional tax rates as well (Smart, 1998). This means that the tax rate will be higher in the receiving provinces under the equalisation program that under an equal-yield lump-sum transfer. We will account for this in the empirical analysis by looking for the effect of the equalisation status on the level of tax rates.

Thus, the aim of this study is to test the empirical relevance of each one of the three cited sources of tax interaction: horizontal and vertical tax externalities, and equalisation transfers. We test these hypotheses with data on personal income taxation in the Canadian provinces during the last two decades. The structure of the paper is as follows. In the next section, we provide a simple theoretical analysis of provincial tax setting decisions with the sole purpose of setting a benchmark for selecting appropriate variables to include in the econometric model. In the third section, we test the different hypotheses developed with data on Canadian personal income taxation for the period 1982-96. Finally, the last section offers the main conclusions.

2. Theoretical background

2.1 Vertical Tax Externalities

In order to set up the hypothesis we want to test in the empirical analysis, in this section we present a simple model of personal income taxation in the presence of tax base overlapping, based on Boadway

[3] See also Saavedra (2000) and Wheaton (2000) for evidence on welfare competition among U.S. states.

and Keen (1996). Following this paper, we will suppose that each layer of government maximises the indirect utility function of a representative taxpayer subject to its budget constraint and taking as given the behaviour of the other layer of government (i.e., they behave Nash). For the provincial government, the maximisation problem is as follows,

$$\max_{t} \; \upsilon(w_n) + h(g) + H(G) \quad \text{subject to} \quad g = t.w.l(w_n) + \overline{R}$$

where $w_n=w(1-t-T)$ is the net wage rate; w is the gross wage rate; t and T are the provincial and federal personal income tax rates; g and G are the provincial and federal publicly provided private goods; and $l(w_n)$ is labour supply[4]. Therefore, $t.w.l(w_n)$ are the provincial revenues coming from income taxation while $\overline{R}$ are exogenous provincial revenues (e.g., lump-sum grants). Then, the first order condition of the maximisation problem is[5]:

$$h' = 1/\left(1 - t(l'/l)\right) \tag{1}$$

where we have supposed the marginal utility of private income is equal to one. We define the left hand side of the above expression as the marginal benefit of public goods (MB), while the right hand side is defined as the marginal cost of public funds (MCPF). Note that only the provincial tax rate enters into the calculation of the MCPF. This means that the provincial government underestimates the true marginal cost of taxation, since the income tax burden is in fact $t+T$. Because of this vertical tax externality, the provincial government will set a tax rate that is too high from the social point of view.

From the first order condition (1), we obtain the provincial tax setting function:

$$t=f(T, w, \overline{R}) \tag{2}$$

This tax-setting function is the basis for the econometric model we will estimate in section 3. The

[4] Labor supply, $l=l(w_n)$, and consumption demand $x=x(w_n)$ are obtained from the utility maximisation problem of the representative consumer, that is by maximising $u(x,l) + h(g) + H(G)$ subject to $x=w_n l$.

[5] For functions of a single variable, partial derivatives are indicated by '.

comparative static of expression (2) allows us to state that higher wage rates will translate into lower or higher tax rates[6] and that higher exogenous resources will allow provinces to set lower rates. Also, we expect there will be interdependencies in tax setting (i.e., $\partial t/\partial T \neq 0$). However, we are not able to unambiguously state the sign of the vertical interaction. We can decompose the reaction of the province in front of changes in T into two effects.

On the one hand, an effect over the *marginal benefit of public goods* (MB): an increase in the federal tax rate decreases revenue collected by the region and, therefore, the level of the provincial public good provided. To restore the previous level of utility derived from the public good, the province has to increase its tax rate[7]. On the other hand, there is an effect over the *marginal cost of public funds* (MCPF). After the increase in the federal tax rate each additional unit of tax revenue will bear a different marginal cost. If the MCPF decreases, this will reinforce the previous effect and the tax interaction will be positive. However, if the MCPF increases, this effect will point to a reduction in the provincial tax rates, thus counterbalancing the effect over MB. Nevertheless, we are not able to state whether the marginal cost will decrease or increase, but it will depend on the functional form of the labour supply with respect to the tax rate[8].

Taking both effects into account we cannot unambiguously sign the reaction of the provinces in front of changes in the federal tax rate. Thus it is necessary to perform an empirical analysis to know the direction of the vertical tax interaction.

[6] There are two effects at work. First, for a given level of public good provision, a higher wage means that the same revenue could be raised with a lower tax rate. Second, a higher wage may increase the demand of public services, if these are normal goods.

[7] As long as the marginal utility of the provincial public good is decreasing.

[8] Keen (1998) found the functional relationship of the labour supply with respect to the tax rate under which we can sign $\partial t/\partial T$ in the case the government follows a revenue maximising behaviour (so leaving aside the effects through the marginal benefit of public funds). Hence, according to his findings, log convexity is a necessary and sufficient condition for $\partial t/\partial T>0$. It can be shown that in our case that condition expresses as: $(l''/l')<(l'/l)$.

2.2 Horizontal Tax Competition

Another source of tax interaction in a federal system comes from competition in taxes among provincial governments. Any increase in a provincial tax rate will generate an outflow of tax base to other provinces in order to avoid the increase in the tax burden. Thus, in this case, the distortionary nature of the tax comes out because of the potential migration of the tax base. Usually, in order to analyse this source of tax interaction, the literature has focused on capital taxation (Zodrow and Mieszkowsky, 1986; or Wilson, 1986). However, as our empirical analysis deals with income taxation, we will suppose that labour is the mobile factor to be taxed by the provinces and the federal government (e.g., see Wildasin, 1991). In any case, horizontal tax competition results in an inefficiently low level of taxation, since provincial governments are in a "prisoner's dilemma" (Boadway and Wildasin, 1984) due to their fears of losing tax base[9].

In order to derive the tax setting function of the provinces in the presence of horizontal tax competition, we will present a rather rudimentary model based on three simplifying assumptions. First, we will suppose that the population of each province, N_i, is composed by two groups. One group is formed by those who supply labour and bear negligible migration costs (n_i). The other group is composed by those who also provide labour within the province, but bear infinitely high mobility costs, so they are immobile, $\tilde{n}_i$. Second, we suppose immobile workers are unskilled, while mobile workers are skilled. Therefore, immobile workers earn a wage rate, $\tilde{w}_i$, lower than the wage earned by mobile workers, w_i. Third, we will suppose that those citizens who are mobile do not get any benefit from the public goods provided by the regions[10]. The location decisions of the group of mobile citizens are made according to the condition:

[9] This conclusion holds as long as we adopt a welfarist approach. Otherwise, the results could be reversed. For instance, if provincial governments are a Leviathan, horizontal tax competition can be welfare enhancing (see Brennan and Buchanan, 1980, and Edwards and Keen, 1996).

[10] These assumptions are akin to those used by Wildasin (2000), with the exception that he also considers the taxation of mobile capital.

$$f_i^{'}(1-t_i-T) = f_j^{'}(1-t_j-T), \quad \forall i \neq j \tag{3}$$

Where the gross wage rate is now equal to the marginal productivity of skilled labour, $f_i'(n_i) = w_i$, and $f_i''(n_i)<0$. Then, according to expression (3), a mobile taxpayer will choose her place of living in such a way that her net wage rate in *i* is equal to the net wage rate she could achieve in any other region of the federation. Note that an increase in the tax rate of province *i* will produce an outflow of skilled workers trying to recover their previous net wage rate, which will happen until condition (3) is restored. The counter-balancing effect that avoids an infinite outflow of mobile workers from province *i* to the rest of provinces is the new higher equilibrium gross wage rate there for skilled workers[11]. From (3), we can obtain the migration function of mobile taxpayers living in *i*:

$$n_i = f(t_i, t_{-i}, T) \tag{4}$$

where the subscript *–i* indicates "the set of competing provinces of *i*", and where comparative static analysis show that $\partial n_i/\partial t_i <0$, $\partial n_i/\partial t_{-i} >0$ and the sign of $\partial n_i/\partial T_i$ is ambiguous (see Appendix). An interesting feature of this model is that the impact of a change in the tax rate on the migration of mobile population differs according to the size of the province; that is, $\partial n_i/\partial t_i \to 0$ for "big" provinces, while $\partial n_i/\partial t_i > 0$ for "small" provinces. Therefore, those "big" regions will provide a level of public good provision closer to the first-best than "small" provinces[12].

Adding the constraint imposed by the mobility of the tax base (4), the maximisation problem of the province can be re-formulated in the following way:

$$\max_t \ \upsilon(\tilde{w}_n) + h(g) + H(G) \quad \text{subject to} \quad g\,\tilde{n} = t\left(w_i n_i + \tilde{w}_i \tilde{n}_i\right) l + \overline{R} \quad \text{and} \quad n_i = f(t_i, t_{-i}, T)$$

[11] See Feldstein and Vaillant (1998) for an empirical analysis of this effect for US states.

[12] See the Appendix for a proof. However, it can be shown that "small" regions are better-off under tax competition than with identical tax rates (see Wellisch, 2000, pp. 71-74).

Note that the new budget constrain considers that the tax base of the province is now $\left(w_i n_i + \tilde{w}_i \tilde{n}_i\right) l$ [13], and that the public good is now consumed only by the immobile factor.

The first order condition of the maximisation problem is:

$$h' = \frac{1}{1 + \frac{n_i f_i'}{\tilde{n}_i \tilde{f}_i'} \left[1 + \frac{\partial n_i}{\partial t_i} \frac{t_i}{n_i} \left(1 + n_i \frac{f_i''}{f_i'} \right) \right]} \tag{5}$$

Observe that the MCPF, the right-hand side of (5), increases with the migration response to tax rate changes ($\partial n_i/\partial t_i$). This fact illustrates the horizontal tax externality. However, the fact that the outflow of citizens capitalises in a higher equilibrium wage rate for the group of "mobile" citizens that stay in *i* (accounted by f''_i/f'_i) tends to lower the MCPF. The importance of these two effects increases with the ratio of the amount of tax base produced by mobile workers to the tax base produced by immobile workers, (i.e., $n_i f_i' / \tilde{n}_i \tilde{f}_i''$).

From the first order condition (5) we can obtain the provincial tax setting function:

$$t_i = f(T, t_{-i}, N_i, \tilde{n}_i, \overline{R}_i) \tag{6}$$

That is, the tax rate chosen by a province depends on the tax rates of competing provinces (t_{-i}). However, the sign of the horizontal tax interaction is ambiguous, as in the case of the vertical tax externality. A change in the tax rate of competing provinces prompts two different effects. The revenue collected by *i* will increase after the increase in the tax rate of any other province, due to the positive externality coming from the inflow of tax base[14]. Therefore, the MB of public goods will decrease and, to restore the previous level of utility derived from the public good, the province will have to decrease its tax rate. Therefore, the sign of the reaction of province *i* in front of variations in the tax rate of any other province depends on the variation produced on the MCPF, that could be either

[13] The number of hours of work supplied by each worker, *l*, is considered as fixed in order to isolate the distortions coming from migration decisions.

[14] That is, $\partial g_i / \partial t_{-i} = (\partial n_i / \partial t_{-i}) t_i f_i' l (1 + N_i (f_i'' / f_i')) \geq 0$.

positive or negative. This makes the determination of the sign of the horizontal interaction also an empirical issue.

The are other facts that difference the tax-setting function in (6) from that in (2). First, although expression (6) also includes the federal tax rate (T), its interpretation is somewhat different. The effect of T only accounts for the fact that, when regions are different, the federal tax rate has some incidence on migration flows, as expression (4) indicates (see Appendix). The effect of T derived from vertical externalities can not work in this setting because the labour supply per worker has been supposed as fixed [see footnote (13)]. However, in a more complete setting, allowing for both types of distortions (i.e., fiscal mobility and reduction in hours worked) both horizontal and vertical externalities may be present.

Second, tax rates will be higher the higher is the number of immobile taxpayers ($\tilde{n}_i$). Third, note that the gross wage rate (w) does not appear anymore in the tax-setting function. This happens because the wage rate is now endogenous; in fact, it is the factor that re-equilibrates the labour market in front of tax differentials.

Fourth, note that tax rates will also depend on the population of each province (N_i): "big" provinces seem to be immune to tax base losses and are less affected by changes in the tax rates of the rest of provinces (i.e., $\partial n_i/\partial t_i \rightarrow 0$ and $\partial n_i/\partial t_j \rightarrow 0$, see Appendix). Also, changes in the tax rate of "big" provinces prompt bigger migration changes in the other provinces. Three different empirical predictions derive from this fact: (i) we expect "big" provinces to set higher tax rates than "small" ones, (ii) "big" provinces will react less than "small" ones in front of changes in tax rates of competitors, and (iii) the reaction in front of a tax rate change of a given province will be higher the bigger is this competing province. We will take this into account in the empirical specification.

2.3 Equalisation Grants

The tax setting behaviour of the provinces may also change as a result of the incentives provided by a system of equalisation grants, as Smart (1998) showed. These incentives arise because the equalisation

grant does not only provoke an income effect as any lump-sum grant, but also a price effect. This latter effect reduces the marginal cost of public funds of the receiving provinces and, ceteris paribus, forces them to increase its tax rate. Analytically, the Canadian equalisation grant, *E*, can be expressed as:

$$E = \bar{t}\left(\overline{w}\bar{l} - wl\right) \geq 0 \quad \text{if} \quad \overline{w}\bar{l} > wl \quad \text{and} \quad E = 0 \quad \text{if} \quad \overline{w}\bar{l} \leq wl$$

where $\overline{w}\bar{l}$ is the standard equalisation tax base, that can be defined as the tax base with respect to which the tax capacity of each province is compared. Hence, if the tax base of a province is below such level, it will be compensated in proportion to $\bar{t}$, the average tax rate of the entire federation[15]. Otherwise, the province is neither entitled to any transfer through the equalisation system nor has to contribute to the system. The equalisation grant system modifies the maximisation problem of section 2.1 for the receiving provinces in the following way:

$$\max_{t} \; \upsilon(w_n) + h(g) + H(G) \quad \text{subject to} \quad g = t\, w\, l(w_n) + \bar{t}(\overline{w}\bar{l} - wl(w_n)) + \bar{R}$$

The first order condition of this problem can be expressed as follows:

$$h' = 1/\left(1 - (t - \bar{t})(l'/l)\right) \tag{7}$$

Thus, ceteris paribus, the equalisation grant reduces the marginal cost of public funds, and so tends to increase the provincial personal income tax rate above the level that would have been set with a lump-sum grant (Smart, 1998). From the expression above, we obtain the provincial tax setting function for equalisation-receiving provinces:

$$t = f(T, w, \bar{t}, \overline{w}\bar{l}, \bar{R}) \tag{8}$$

[15] We consider the variables $\bar{t}$ and $\overline{w}.\bar{l}$ as fixed in the analysis, though some authors have considered that changes in provincial tax rates could affect them (see, e.g., Courchene and Beavis, 1974). For these effects to be relevant, the province has to be relatively "big". This is not the case for the provinces receiving equalisation, with the exception of Quebec. However, note that when Quebec increases its tax rate, the average tax rate raises, but the standard tax base shrinks (if the tax is distortionary), producing an ambiguous net effect on the revenues of this province.

There are two main differences between this tax-setting function and the one in (2). The first one refers to the inclusion of the standard tax base ($\overline{wl}$).The effect of this new variable on the tax rates set by the provinces is similar to the effect of the other exogenous revenues ($\overline{R}$). The second refers to the inclusion of the average tax rate ($\bar{t}$); the sign of the reaction of the provincial tax rate to changes in this variable ($\partial t/\partial \bar{t}$) is ambiguous, since there are two effects at work. First, an increase in $\bar{t}$ will lower the marginal cost of public funds, so forcing an increase in the provincial tax rate (Smart, 1998). However, there will also be an income effect that will reduce the marginal benefit of public goods (as any lump-sum grant), so prompting a decrease in the provincial tax rate. It is necessary to perform an empirical analysis in order to ascertain the sign of the reaction.

However, this is not the only hypothesis regarding the impacts on tax setting of equalisation grants that we will take into account in the empirical analysis. Note that we have treated the effects of that grant in isolation from the two kinds of externalities (vertical and horizontal) analysed in the previous sections. In fact, some authors have suggested that equalisation payments may have some potential to alleviate or exacerbate these externalities. For example, the capacity of equalisation transfers to mitigate tax competition is an old argument of the literature (see, e.g., Reschovsky, 1980). The reason of the reduced incentives to compete is that under this kind of programs the revenue gains coming from the attraction of tax bases to a jurisdiction must be shared with all the federation. The relationship between equalisation and vertical externalities is less clear. However, as Hayashi and Boadway (2000, p.3) argue, "the fact that recipient provinces are insulated (at least partly) from the adverse consequences that raising their tax rates has on their tax bases might intensify the vertical fiscal externalities".

Two additional empirical predictions derive from the discussion in the last paragraph: first, the impact of horizontal tax competition will be lower for the receiving provinces, and second, the impact of vertical tax competition may be higher in the receiving provinces.

3. Empirical implementation

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

To test the different tax interdependence hypothesis developed in section 2, we will use data corresponding to the personal income tax in Canada during the last two decades. 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 increased 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 going to the provincial governments –roughly 30%– and also the average provincial income tax burden –6.72% of Personal Income in 1982 and 8.74% in 1993– are high by international standards. These facts make the Canadian personal income tax a natural focus for an empirical study on vertical and horizontal interactions.

There is also some concern among Canadian economists over externality problems in the field of income taxation. For example, the increase in provincial income tax rates during the last two decades (and the introduction of surcharges on high income taxpayers) has been interpreted by some authors as evidence of excessive taxation caused by interactions between layers of government (see, e.g., Dalhby, 1996). Many papers have shown the empirical relevance of personal income tax rates and other fiscal factors as determinants of interprovincial migration (see, e.g., Winer and Gauthier, 1982 or Day, 1992), showing thus that horizontal tax competition may also be of concern. Boadway and Flatters (1982) have shown that this fiscally induced migration could end up in an inefficient allocation of labor across provinces, providing a justification for equalisation transfers. Nevertheless, analyses of tax interactions among provincial or local governments are very rare; Hayashi and Boadway (2000) on provincial business income taxes and Brett and Pinkse (1999) on local property taxes are the

exceptions. This fact contrasts with the growing U.S. literature on personal horizontal tax interactions (see, e.g., Case, 1993; Besley and Case, 1995; and Brueckner and Saavedra, 2001).

The advantage of focusing on the Canadian case also rests in the possibility of testing the incentive effects introduced by the equalisation program. There are few countries in the world where such a transfers system operates jointly with a high degree of provincial tax autonomy and tax base overlap between federal and regional governments. Also the exact design of the program helps us to devise the empirical test. The Canadian equalisation system transfers funds from the federal government to those provinces whose capacities to raise revenues fall below a national standard. The amount of transfer is calculated by applying the average provincial tax rate, i.e., the standard tax rate, to the difference between the standard tax base and the tax base of the province, while the rich provinces do not receive equalisation funds. Thus, the transfer system is not zero sum, i.e., the rich provinces do not fill the revenue capacity gap of the poor ones. Therefore, the incentive to raise tax rates is experienced only by the receiving provinces and, as Smart (1998) demonstrates, increases with the standard or average tax rate.

In addition to the equalisation program, other institutional features of the Canadian federal system should be taken into account when interpreting the evidence on personal income tax interactions. In particular, the empirical test of vertical tax externalities should consider the very high degree of harmonisation of the provincial income tax with the federal one. For instance, Quebec is the only province whose personal income tax does not conform at all to 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. But since the beginning of the eighties the provinces have tried to gain degrees of freedom in tax setting using surcharges over the tax liability of high income taxpayers[16].

[16] 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 Brunswick, Nova Scotia and Newfoundland in 1991, 1993 and 1996 (source: Provincial Budget Roundup, Canadian Tax Foundation).

More recently some provinces have begun to set a flat tax rate over net taxable income[17]. This 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 will be even higher for the provinces that use a high income surcharge[18].

Nevertheless, the wind-fall gains (or losses) arising from this kind of direct effect we have related above should not have any influence on the optimal tax rates derived from the theoretical tax model developed in section 2. 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 the estimation results indicate that the provinces do not react to the windfall gains or losses, this would suggest the existence of some sort of fiscal illusion[19]. 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

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

[18] The size of this direct impact (dt/dT) can be expressed in the three cases as: 0 (non-conforming), b (fully harmonized), and $b+\alpha.s$ (high income surcharge); where we have defined t=provincial tax burden, T=federal tax burden, b=provincial basic rate, s=provincial surcharge, α=share of federal revenues coming from high income taxpayers. Let suppose, for example, that b=0.50 and s=0.30; if α=0.20, then the surcharge will increase the direct impact from 0.50 (fully harmonized) to 0.59.

[19] Several recent analysis on the effects of personal income tax reforms in the U.S. document substantial empirical evidence of this kind of automatic interdependency, and thus of the existence of certain degree of fiscal illusion in tax setting behaviour (see, e.g., Gold, 1991, Ladd, 1993, and Tannelwald, 1991).

illusion is to allow the slope of the reaction function to differ among the three groups of provinces previously defined.

Finally, in the Canadian case the period of analysis should be carefully chosen in order to ensure that the test of tax interactions makes sense. The empirical analysis is carried out with data on the ten provinces during the period 1982-96[20]. 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 cash payments for additional tax room (mainly in personal income taxation)[21]. In this setting the data would show an interdependence between federal and provincial tax rates that is not directly related to the vertical tax externality hypothesis[22].

The interest of the period analysed is also justified by the substantial changes in 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 federal marginal tax rate was also reduced form 43% to 34% in 1981 and to 29% in 1987 (Doak, 1996), but some surcharges were introduced in the following years (Howard *et al.*, 1995). Although these changes translate into a lesser extent to

[20] We exclude Yukon and the NorthWestern Territories from the analysis because, though they are entitled to enter the field of income taxation, they have a special status in the federation (Perry, 1989).

[21] The Tax Collection Agreements (1962-1976) represented the beginning of a trend toward increased fiscal responsibility. The new provincial income taxes of 1962 were 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.

[22] Note, for instance, that the coefficient of correlation between average effective federal and provincial income tax rates is -0.92 for the period 1965-81 and 0.91 for the period 1982-96 (source: Revenue Canada, Taxation Statistics). This correlation does not of course tell us anything about causation, but the negative sign for the first period seems to reflect the cession of tax room.

modifications of average effective tax rates (Davies and Zhang, 1996), this variable also shows periods of decrease and increase during the sample analysed, providing thus enough variation to carry out the empirical analysis.

3.2 *Empirical framework*

Our empirical purpose is to estimate the magnitude of the reaction of provincial income tax rates to exogenous changes in federal income tax rates, changes in income tax rates in competing provinces and changes in the standard income tax rate used in the equalisation program. This amounts to estimating the slope of the reaction function of a representative provincial government vis a vis the federal government and the rest of the provinces. We take into account that all these tax decisions are made simultaneously and, thus, that both the federal tax rate and the tax rates of the competing provinces are potentially endogenous. However, we postpone the discussion of this issue to the next section. The basic specification to test these hypotheses is:

$$t_{it} = \alpha_1 \, \mathrm{X} \, T_{it} + \alpha_2 \, \mathrm{X} \sum_{j \neq i} \omega_{ij} \, \mathrm{X} \, t_{jt} + \alpha_3 \, \mathrm{X} \bar{t}_t \, \mathrm{X} \, deq_{i,t} + \sum_k \alpha_k \, \mathrm{X} \, Z^k_{it-1} + \alpha_{0i} + \varepsilon_{it} \qquad (9)$$

Where $t_{i,t}$ and $T_{i,t}$ are the provincial and federal tax rates, and subscripts i and t indicate province and year. We use the average effective tax rates as the definition of our tax variables. These tax rates are constructed as the ratio of income tax revenue to the Personal Income Component of GDP[23]. Data for this calculation has been obtained from the CANSIM database (see Table 1). We have chosen personal income instead of taxable income to avoid the effects that changes in the definition of the tax base between provinces (basically differences between Quebec's and federal tax laws) and over time have on the average effective tax rate. This procedure is supported by the way income tax reductions are usually carried out. Although in many cases the change in effective tax rates has 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

[23] This includes salaries, wages, and supplementary labour income; interest and miscellaneous investment income; and net income of farmers and other unincorporated businesses.

accurate, reliable or stable the definition of tax base given by federal or provincial governments in Canada.

There are two main reasons for the use of average effective tax rates instead of using, for example, statutory marginal tax rates[24]. First, given that personal income taxes in Canada are progressive, no single marginal tax rate accounts for the incentives faced by every household. Even provincial income taxes, once a basic proportional rate applied over the federal tax liability, is now characterised by a variety of surcharges, flat rates and deductions that make them fairly more complex. The limitation of the empirical analysis requires us to describe tax policies in terms of a single summary statistics – average effective tax rates–. Some authors defend this position (see, e.g. Mendoza *et al.*, 1994) and argue that average tax rates are a good way to take into account the effective, overall tax burden of a tax. In addition, other analyses of fiscal interactions use similar measures of tax rates (see, e.g., Goodspeed, 2000, for the personal income tax, and Hayashi and Boadway, 2000, for the business income tax). Second, average tax rates are often employed to represent interjurisdictional differences in taxation. If tax bases respond to taxes because of interprovincial mobility of workers, it is primarily the average tax rate, and not the marginal tax rate, that influences migration decisions (see, e.g., Carrol and Wasylenko, 1994).

However, there is a main problem in the utilisation of average effective tax rates. Observed average tax rates reflect two types of influences. They have a policy component, arising from deliberate choices by government officials and based on information available to them, but they also have an unexpected one. That is, for example, actual provincial average tax rates 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 rates may also reflect, for example, the effect of exogenous factors affecting the level and

[24] Some authors have advocated the use of marginal tax rates computed directly from the statutory tax function (Barro and Sahasakul, 1986), or using the top marginal tax rate (Tannewald, 1991, and Mullen and Williams, 1993).

distribution of personal income. We consider how to deal econometrically with this issue in section 3.3.

Horizontal tax interdependencies are controlled for in our empirical analysis with the inclusion in equation (9) of a weighted average of the tax rates of competing provinces, where t_{jt} is the tax rate set by province j and ω_{ij} is the weight of region j in the set of competing regions of region i. To compute these weights (ω_{ij}) we need to consider the issue of which provinces are most likely to be the ones from which one province can expect to loose or gain employment. The easiest way to handle this problem is to consider that distance matters for horizontal competition. In fact, some papers that estimate the impact of tax differentials on migration in Canada (see, e.g., Winer and Gauthier, 1983, and Day, 1992) have also found a high and significant impact of distance on interprovincial flows of residents. As Day (1992) points, this could be interpreted as evidence that "people prefer to move short distances if at all"[25]. The use of distance to compute these weights has also been common practice in recent analyses of horizontal tax interactions among U.S. states (see, e.g., Case, 1993; Besley and Case, 1995). Following this literature, we consider the contiguous provinces as the source of immigration and emigration of residents. This means that the Atlantic provinces belong to the same set of reciprocal competitors and are also influenced by Quebec. The competitors of Quebec are the Atlantic provinces and Ontario. The competitors of Ontario are Quebec and Manitoba. Finally, each of the Western provinces (to the exception of British Columbia) has two potential competitors, one on each side. Note, however, that the set of competitors of some provinces is composed of very different provinces: in some of them the main population centre is located really far away while in others is very close, some are very big and some very small. In order to consider further the impact of distance and to account for the possible asymmetric impact of big and small neighbours[26], we weight each

[25] This author carefully quantifies the moving costs among provinces, taking into account the travel cost of people and belongings, and the average time needed to move between provinces times the foregone wage (see Day, 1992, p. 17).

[26] This is consistent with the fact that in the tax competition model of section 2, the impact of the change in the tax rate of a competing province is higher the higher its size (see Appendix).

contiguous province by population and inverse distance. Thus the weights attached to each province (ω_{ij}) are:

$$\omega_{ij} = \frac{w_{ij}}{\sum_{j \neq i} w_{ij}} \qquad \text{where} \qquad w_{ij} = \frac{c_{ij} \cdot n_j}{d_{ij}}$$

Where c_{ij}=1 if provinces *i* and *j* are contiguous, d_{ij}=distance in miles between the main population centre of provinces *i* and *j*, and n_j=resident population of province *j*. Note that the weights (ω_{ij}) are standardised and, thus, sum up one. This procedure is common in this kind of analyses (Anselin, 1988) and allow us to interpret the estimated coefficients as the response to the average tax rates of competing provinces.[27]

The effects of equalisation grants are accounted for in equation (9) by including the standard income tax rate used for equalisation purposes ($\bar{t}_t$) interacted with $deq_{i,t}$, a dummy variable equal to one if the province is entitled to receive equalisation in that year. 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 average provincial tax rate of the federation ($\bar{t}_t$) has been computed for each province after the exclusion of its own tax rate, in order to avoid endogeneity problems. Although $\bar{t}_t$ only changes yearly, the fact that only a fraction of the Canadian provinces receive equalisation transfers, allows the variable ($\bar{t}_t$) to have cross-section variation. As we stated in section 2, the parameter α_3 can be either positive or negative, depending on which effect (income or price) dominates.

[27] We also tested other weight definitions, but they did not perform as well as this one (contiguity alone, contiguity with inverse of distance, contiguity with population) or that prove totally ineffective (add a second order set of contiguous provinces).

The other variables included in equation (9) are a vector of other control variables *Z*, indexed by *k*. These controls are needed because tax interactions are just some 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 may be correlated with the tax rates of the federal and competing provincial governments, thwarting any direct inference about its effects on provincial tax rates. As a result of this, and in order to isolate the effects of tax interdependences, it is necessary to control for all the other relevant variables that affect the regional tax-setting process. In order to avoid endogeneity problems all these variables are introduced into the equation with one lag. We include several groups of control variables (see Table 1 for definitions and statistical sources):

Economic resources. Richer populations will demand more regional public goods and, in 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. 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 that income taxes will be lower, the higher the amount of transfers received. To account for this effect, we include three variables that control for the amount and type of transfers received. These are: the per capita amount received from *General purpose transfers* (mainly equalisation payments), the per capita amount received from *Other transfers*[28], and the revenue from *Natural resources* per capita. Note that it is necessary to introduce these variables with a lag. This is due to the potential endogeneity of per capita income (i.e., if the tax

[28] One could argue that some federal specific grants are matching while they are implicitly considered as lump-sum. However, year-to-year changes in the structure of matching grants affect all provinces similarly; hence their impact may be controlled by time effects.

is in fact distortionary, the base shrinks when the provincial tax rate increases)[29] and equalisation received (i.e., the grant increases when the tax base shrinks)[30].

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, will be burdened more heavily through income taxes. We include as explanatory variables the size of the *Population* and its increase in the last five years (% Δ *Population*)[31]. We also introduce in this group of variables the size of various groups of potentially intensive service users: the proportion of population over 65 (% *Population over 65*) and under 15 (% *Population under 15*) and the proportion of population unemployed (% *Unemployed*).

Political environment. Although many politically motivated models of public policy generation suggest that parties converge at the same platforms regardless of its ideology, 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[32]. We include a dummy that accounts for the ideology of the regional executive (i.e., *dleft*=1 if the executive is on the left wing of the provincial political arena[33])

[29] Recall also that *w* has been considered endogenous in the horizontal externality case, and thus has not been included in that tax-setting function.

[30] Recall that the tax-setting function presented in section 2 for the equalisation case includes the size of the standard tax base ($\hat{w}\tilde{l}$) as a control. However, in order to avoid problems derived from the colinearity with other variables (mainly the payments received from the remaining categories considered by the equalisation program) we add the equalisation payment in income taxation to other categories' payments, but one period lagged to avoid endogeneity problems.

[31] As we stated in section 2.2, the size of the population also reflects the fact that bigger provinces are able to set higher tax rates due to its market power.

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

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

and a variable that accounts for the fragmentation of the government (i.e., *dminority*=1 if the government is in minority in the legislative)[34].

The coefficient $\alpha_{0,i}$ represents a provincial time-invariant individual effect. The estimation of a fixed effects model by OLS will give us consistent estimates of the tax interaction parameters whenever the provincial effects are correlated with the explanatory variables included in the equation (Mundlak, 1978, Hausman and Taylor, 1987). Provincial 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 (e.g., geography, climate) 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). Of course, if some of the regressors of the equation were endogenous, these statistical properties of the fixed effects model would no longer hold.

This basic specification is then extended to account for the possible interaction among the Equalisation Program and intensity of the two kinds of externalities analysed. To account for this possibility the federal tax rate (T_{it}) and the tax rates of the competing provinces ($\Sigma_{j\neq i}\omega_{ij}$ x t_j) are interacted with a dummy that indicates whether a province is entitled or not to receive equalisation transfers (deq_{it}).

$$t_{i,t} = \alpha_{11} \text{ X } T_{i,t} + \alpha_{12} \text{ X } deq_{i,t} \text{ x } T_{i,t} + \alpha_{21} \text{ X } \sum_{j\neq i} \omega_{ij} \text{ X } t_{j,t} + \alpha_{22} \text{X } deq_{i,t} \text{ X } \sum_{j\neq i} \omega_{ij} \text{ X } t_{j,t} + \alpha_3 \text{ X } deq_{i,t} \text{ X } \bar{t}_t + \sum_k \alpha_k \text{ X } Z^k_{i,t-1} + \alpha_{0,i} + \varepsilon_{i,t} \quad (10)$$

The parameters α_{11} and α_{21} indicate the strength of vertical and horizontal tax interactions, respectively, in the provinces not receiving equalisation transfers. The sum of parameters (α_{11}+α_{12})

[34] The results of some empirical studies suggest 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 to eliminate loopholes from the tax code.

and (α_{21}+α_{22}) measure the intensity of both types of interactions in the equalisation-receiving provinces.

With this procedure we are testing for a differential impact of vertical and horizontal interactions across groups of provinces. In the case of the horizontal tax interactions this can also help us to test if the common weighting scheme employed is too restrictive and if we should allow the provinces to show different sensibilities to tax competition[35]. With this purpose we will estimate a second version of equation (10) introducing interactions between $\Sigma_{j\neq i}\omega_{ij}$ X t_j and some dummies grouping the provinces in sets according to three characteristics: equalisation status, size, and geographical position. The five sets of provinces analysed are: (i) Atlantic provinces, all of them small and receiving equalisation (Newfoundland, Prince Edward Island, New Brunswick and Nova Scotia), Quebec (a big equalisation receiving province), the Western-receiving provinces (Manitoba and, during some years, Saskatchewan), Ontario (a big non-receiving) and the Western-non-receiving provinces (Alberta, British Columbia and, in some years, Saskatchewan). We define one dummy for each set, with the exception of the last one, that will be considered the basic category: $daeq_{it}$, $dque_{it}$, $dweq_{it}$ and $dont_{it}$, respectively.

Finally, we include an third specification only with the purpose of checking the robustness of the results regarding the vertical tax externality against an alternative hypothesis. More concretely, we want to test if the interaction between the tax rates of the federal and provincial governments is due to the interrelationship between their tax codes (i.e., to fiscal illusion) or to the vertical tax externality. To achieve this objective we allow the federal tax rate to interact with a set of dummies that indicate the type of provincial tax code.

$$t_{it} = \alpha_{11}\ \mathrm{X}\ T_{i,t} + \alpha_{12}\ \mathrm{X}\ dque_{it}\ \mathrm{X}\ T_{it} + \alpha_{13}\ \mathrm{X}\ dsur_{it-1}\ \mathrm{X}\ T_{i,t} + \alpha_2\ \mathrm{X} \sum_{j\neq i} \omega_{ij}\ \mathrm{X}\, t_{jt} + \alpha_3\ \mathrm{X} deq_{it}\ \mathrm{X}\ \bar{t}_t + \sum_k \alpha_k\ \mathrm{X}\ Z^k_{i,t-1} + \alpha_{0,i} + \varepsilon_{i,t} \qquad (11)$$

[35] Remember that the asymmetric results of the model in section 2.2 imply that "big" provinces tend to react less in front of competitors' tax changes.

Where $dque_{it}$ is one in the case of Quebec (i.e., the only province with a completely independent tax code) and zero otherwise, and $dsur_{i,t-1}$ is one if the province has a high income surcharge. This last dummy appears in the equation with a lag in order to avoid endogeneity problems (e.g., imagine a province reacting to a change in the federal tax rate by introducing the surcharge). A value of zero for the parameters α_{12} and α_{13} will indicate that the only explanation is the vertical tax externality, since neither Quebec nor the high income surcharge provinces react in a different way to federal tax rates changes. A negative value for α_{12} and a positive value for α_{13} will indicate that fiscal illusion is present; $\alpha_{11}=\alpha_{12}$ will indicate that fiscal illusion is a pervasive phenomenon, and the only valid explanation for the observed tax interactions.

In order to gain further insight on the "fiscal illusion" hypothesis we also re-estimate equation (11) adding a lag of the federal tax rate (T_{it-1}). The reason the basic specification of equation (9) did not allow for lagged provincial responses is that most provincial tax codes are strongly linked to the federal one. As a consequence of this fact, when the federal government increase taxes, the provinces can not wait until next year to change the tax parameters because this would increase the provincial tax burden the same year. Therefore, we expect the reaction of provincial taxes to be mainly contemporaneous. However, we recognise that this hypothesis needs a formal test and include T_{it-1} in a new version of the equation. Note also that Quebec is the only province that is not constrained to respond immediately to federal tax changes, since its income tax code is completely independent. Because of this, we expect that there will be longer lags in the reaction of Quebec to federal tax changes. To test for this effect, we also include in equation (11) an interaction between $dque_{it}$ and T_{it-1}. In this new setting, a lower long term response of Quebec (i.e., the sum of the coefficients of $dque_{it}$ X T_{it} and $dque_{it}$ X T_{it-1}) will indicate the presence of fiscal illusion.

The information regarding the characteristics of provincial income taxes has been obtained from the *Canadian Tax Foundation* (various years), *Provincial Budget Roundup*. The data used to construct the tax variables and the other control variables come from various statistical sources that are shown in Table 1. In Table 2 we present the summary statistics of the different variables used in the analysis.

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

Variable	*Definition*	*Statistical sources*
t	*Provincial average effective income tax rate as a percentage of personal income*	*Revenue collected and Personal Income Component of GDP, from Provincial Economic Accounts, CANSIM, Statistics Canada.*
T	*Federal average effective tax rate as a percentage of personal income*	*Revenue collected and Personal Income Component of GDP, from Provincial Economic Accounts, CANSIM, Statistics Canada.*
Deq	=1 *if the province is entitled to receive equalisation transfers*	*Federal Transfers to the Provinces, Canadian Tax foundation*
Dque	=1 *for Quebec*	--.--
Dont	=1 *for Ontario*	--.--
Daeq	=1 *for the Atlantic provinces*	--.--
Dweq	=1 *for the Western provinces entitled to receive equalisation*	*Federal Transfers to the Provinces, Canadian Tax foundation*
Dsur	=1 *for the provinces with high income surcharge the previous year*	*Provincial Budget Roundup, Canadian Tax Foundation*
Income	*Personal income component of the GDP, per capita in 1981 dollars*	*Provincial Economic Accounts, CANSIM, Statistics Canada.*
General purpose transfers	*Federal general purpose Transfers per capita in 1981 dollars*	*Federal Transfers to the Provinces, Canadian Tax Foundation*
Other Transfers	*Other Federal general purpose Transfers per capita in 1981 dollars*	*Federal Transfers to the Provinces, Canadian Tax Foundation*
Natural Resources	*Natural Resource Revenues per capita in 1981 dollars*	*Revenue Collected From Public Sector Finance, CANSIM, Statistics Canada*
Population	*Provincial population*	*CANSIM, Statistics Canada*
% Population over 65	*Proportion of population over 65 years old*	*CANSIM, Statistics Canada*
% Population under 15	*Proportion of population under 15 years old*	*CANSIM, Statistics Canada*
% Unemployed	*Proportion of population unemployed*	*CANSIM, Statistics Canada*
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 Web Sites*
Dminority	=1 *if the party in the provincial government is in minority in the provincial parliament*	*The Canadian Parliamentary Guide & Provincial Web Sites*

Table 2: *Summary statistics(1982-1996)*

Variable	*Mean*	*St. Dev.*	*Minimum*	*Maximum*
t	0.068	0.021	0.036	0.134
T	0.103	0.014	0.074	0.142
$\bar{t}$	0.068	0.007	0.0581	0.079
Dsur	0.509	0.456	0	1
Income	15005.519	3518.494	7720.789	26454.948
General purpose transfers	659.636	555.444	0	1699.238
Other Transfers	768.303	185.397	437.449	1484.661
Natural Resources	267.092	496.024	2.415	2632.390
Population	2698.398	3082.854	123.79	11100.3
% Population over 65	11.37	1.80	7.14	16.31
% Population under 15	22.07	1.72	18.98	29.17
% Unemployed	0.113	0.037	0.039	0.208
Dleft	0.314	0.636	0	1
Dminority	0.562	0.498	0	1
Dleft(F)	0.037	0.190	0	1

3.3 Econometric issues and results

The econometric estimation of equation (9) presents two different but related technical problems. The first one is that theory suggests that the tax rates of competing provinces (t_{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_2. Note that this problem may also be present in the case of the standard tax rate ($\bar{t}_t$), since this variable has been computed as an average of provincial tax rates. In order to account for horizontal policy interdependencies properly, we model neighbour tax rates (i.e., $\sum_{j \neq i} \omega_{ij} t_{jt}$ and $\bar{t}_t \, deq_{i,t}$) 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), the matrix of instruments contains the exogenous variables of equation (1) and the spatially lagged control variables (i.e., $\sum_{j \neq i} \omega_{ij} Z^k_{it-1}$). 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 (Figlio *et al.*, 1999), since by instrumenting for neighbour tax rates we can also account for the existence of spatial correlation in the residual, as the null hypothesis 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_{it}). Note that if, as we assumed in the theoretical section, the federal government is also a Nash competitor, both provincial and federal tax rates are determined endogenously, making the federal tax rates in equation (9) correlated with the error term (ε_{it}). Note also that even if the federal tax rate was exogenous, some correlation could remain between this variable and the error term, due to the existence of common shocks to both tax rates. As we stated in the previous section, our dependent variable does not only depend 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 provincial effective tax rates, the estimated coefficients could pick up a spurious correlation instead of the fiscal interdependence we are looking for[36].

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, unemployment) already control for cyclical variation in the tax burden[37]. The second one is to include a set of time dummies to control for shocks common to all the provinces in a common year[38]. The third way to deal with the problem is to find an instrument that is correlated with the federal effective tax rate but uncorrelated with the regression error[39]. 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 use as instruments the share of Canadian population over 65 years old, under 15 and unemployed, Canadian personal income per capita, and a dummy equal to one for federal liberal governments. All these instruments show independent explanatory power in the first stage regression and we are not able to reject the null of joint exogeneity using a Hausman Lagrange multiplier test. Note that, in any case, it is not possible to use the last 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.

[36] Note 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, e.g., on the degree of progressivity of the tax with respect to personal income.

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

[38] This possibility has not been used in previous empirical analyses for various reasons. In Besley and Case (1998) *T* 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) consists of the estimation of each time series separately.

[39] Another possible way to deal with the problem of endogeneity is to consider the federal tax rate as predetermined and, accordingly, to introduce this variable in the equation with one lag (see, e.g., Hayashi and Boadway, 2000). However, this procedure has two main drawbacks: first, common shocks may be still of concern and, second, it does not allow for a contemporary reaction. This latter fact may be important in our case because of institutional factors, as we explained in the previous section.

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 the 99% confidence level (that is, the Hausman test is overcome, and the utilisation of a random effects model is rejected). For this reason, we only report the results for the fixed effects model. We have also performed a White test and a panel Durbin-Watson test to check the presence of cross-section heteroskedasticity and first order serial autocorrelation, respectively, rejecting these possibilities in all the cases.

Table 3 presents the results of the estimation of equation (9). The first four columns show estimates without time effects, while the fifth and sixth columns show estimates with time effects. The first column shows OLS estimates while columns (2) to (4) show IV estimates. In column (2) only the neighbours' tax rates are considered endogenous (i.e., $\sum_{j \neq i} \omega_{ij} t_{jt}$ and deq_{it} X $\bar{t}_t$ but not T_{it}) while in column (3) only T_{it} is considered endogenous. In column (4) all three variables are considered endogenous. A look at the Hausman test corroborates the fact that the OLS estimates seem to be biased; this test is overcome for equations (2) to (4) showing the appropriateness of the IV technique. The preferred specification is thus equation (4), that accounts for the endogeneity of the three tax interaction variables. Comparing equations (4) and (1) it can be checked that the OLS coefficients on T_{it} and deq_{it} X $\bar{t}_t$ seem to be upward biased while the bias in the OLS coefficient on $\sum_{j \neq i} \omega_{ij} t_{jt}$ seems to be negative.

Table 3*: Tax-setting functions, basic parameter estimates;*

dependent variable $t_{,t}$ (%), nº obs.= 150 *(N* = 10, *T*=15*)*

Variable	(1) OLS	(2) IV	(3) IV	(4) IV	(5) OLS	(6) IV
T_{it}	0.441 (8.999)**	0.339 (4.866)**	0.181 (3.288)**	0.184 (2.231)**	0.168 (2.100)**	0.199 (2.517)**
$\sum_{i \neq i} \omega_{ij} Xt_{jt}$	0.173 (3.499)**	0.483 (9.870)**	0.221 (3.368)**	0.356 (2.450)**	0.095 (1.389)	0.318 (2.451)**
deq_{it} X $\bar{t}_t$	0.079 (3.809)**	0.034 (1.961)**	0.086 (3.775)**	0.023 (1.776)*	0.014 (0.600)	0.027 (1.852)*
Income$_{(-1)}$ (X 10^{-3})	-0.912 (-3.481)**	-0.779 (-3.085)**	-0.725 (-3.062)**	-0.703 (-3.004)**	-0.897 (-1.568)	-0.725 (-1.738)*
General Purpose Transfers$_{(-1)}$ (X 10^{-3})	-0.952 (-3.716)**	-0.852 (-6.562)**	-0.866 (-4.511)**	-0.843 (-5.890)**	-0.953 (-4.173)**	-0.931 (-4.511)**
Other Transfers$_{(-1)}$ (X 10^{-3})	-0.158 (-2.299)**	-0.212 (-3.306)**	-0.205 (-3.338)**	-0.234 (-3.452)**	-0.171 (-3.188)**	-0.205 (-3.338)**
Natural Resources$_{(-1)}$ (X 10^{-3})	-0.282 (-6.477)**	-0.340 (-8.412)**	-0.308 (-5.909)**	-0.365 (-7.665)**	-0.291 (-5.621)**	-0.307 (-5.909)**
Population$_{(-1)}$ (X 10^{-3})	0.054 (0.633)	0.099 (2.861)**	0.070 (1.709)*	0.097 (2.964)**	0.041 (1.019)	0.070 (1.709)*
% Δ Population$_{(-1)}$	0.241 (2.878)**	0.112 (1.389)	0.150 (1.674)*	0.132 (1.552)	0.173 (1.903)*	0.149 (1.674)*
% Population over 65$_{(-1)}$	-0.039 (-1.155)	-0.017 (-0.522)	-0.039 (-0.075)	-0.020 (-0.096)	-0.015 (-0.295)	-0.039 (-0.074)
% Population under 15$_{(-1)}$	0.087 (4.794)**	0.099 (6.209)**	0.113 (3.338)**	0.109 (4.226)**	0.109 (3.162)**	0.113 (3.388)**
% Unemployed $_{(-1)}$	-0.007 (-0.513)	-0.032 (-2.649)**	-0.006 (-0.289)	-0.014 (-1.854)*	-0.008 (-0.396)	-0.007 (-0.289)
Dleft	0.173 (2.094)**	0.242 (3.205)**	0.184 (2.456)**	0.213 (2.864)**	0.142 (1.797)*	0.184 (2.455)**
Dminority	0.222 (1.874)*	0.157 (2.023)**	0.156 (1.888)*	0.150 (1.984)**	0.111 (1.234)	0.157 (1.900)*
Individual effects	YES	YES	YES	YES	YES	YES
Time effects	NO	NO	NO	NO	YES	YES
Adjusted R^2	0.832	0.756	0.720	0.704	0.801	0.700
White (Heterosk.)	7.564	5.854	6.951	5.336	7.321	6.885
Durbin-Watson (Autocorr.).	1.845	1.959	2.011	2.104	1.875	2.006
F(C vs. C_i*), Individual effects*	1,375.6**	4,250.3**	2,143.0**	3,396.9**	1,541.2**	2,133.5**
F(C vs. C_i*), Time effects*	--.--	--.--	--.--	--.--	247.4**	364.8**
χ^2*(Hausman test) Fixed vs.Random*	52.4**	52.3**	47.2**	61.2**	64.2**	51.3**
χ^2*(Hausman test), OLS vs. IV*	--.--	3.84**	16.55**	7.99**	--.--	6.41**

Notes: (a) t statistics are shown in brackets; *, significantly different from zero at the 90% level and **, Significantly different form zero at the 95% level.

(b) Columns 1 to 4 show estimates without time effects, while columns 5 and 6 show estimates with time effects.

(c) In columns 2 and 6 only $\Sigma\omega_{ij}$ x $t_{j,t}$ is considered endogenous; in column 3 only T_{it} is considered endogenous; in column 4 both $\Sigma\omega_{ij}$ x t_{jt} and T_{it} are considered endogenous. In any case, instruments for $\Sigma\omega_{ij}$ x t_{jt} are spatially lagged exogenous variables, while instruments for T_{it} are Canadian personal income per capita, Canadian % of population over 65 and under 15, % of Canadian population unemployed and a dummy equal to one if the party in the federal government is on the left.

Table 4*: Tax-setting functions, interactions and alternative hypotheses; dependent variable t_{it} (%), nº obs.*= 150 *(N* = 10, *T*=15*)*

Variable	(1) IV	(2) IV	(3) IV	(4) IV	(5) IV	(6) IV
T_{it}	0.174 (2.314)**	0.194 (2.157)**	0.164 (2.264)**	0.160 (2.259)**	0.174 (2.433)**	0.170 (2.554)**
$\Sigma\ \omega_{ij}\ X\ t_{jt}$	0.337 (2.537)**	0.370 (2.249)**	0.301 (2.310)**	0.294 (2.004)**	0.324 (2.471)**	0.301 (2.261)**
$deq_{it}\ X\ \bar{t}_t$	0.035 (1.828)*	0.022 (1.986)**	0.024 (1.874)*	0.025 (1.887)*	0.031 (1.811)*	0.028 (1.800)*
$deq_{it}\ X\ \Sigma\ \omega_{ij}\ X\ t_{jt}$	-0.169 (-2.548)**	--.--	--.--	--.--	--.--	--.--
$daeq_{it}\ \Sigma\ \omega_{ij}\ X\ t_{jt}$	--.--	-0.090 (-1.599)	--.--	--.--	--.--	--.--
$dque_{it}\ X\ \Sigma\ \omega_{ij}\ X\ t_{jt}$	--.--	-0.130 (-1.696)*	--.--	--.--	--.--	--.--
$dweq_{it}\ X\ \Sigma\ \omega_{ij}\ X\ t_{jt}$	--.--	-0.144 (-1.677)*	--.--	--.--	--.--	--.--
$dont_{it}\ X\ \Sigma\ \omega_{ij}\ X\ t_{jt}$	--.--	0.692 (5.075)**	--.--	--.--	--.--	--.--
$deq_{it}\ X\ T_{it}$	--.--	--.--	-0.015 (-1.841)*	-0.004 (-0.247)	--.--	--.--
$dque_{it}\ X\ T_{it}$	--.--	--.--	--.--	-0.054 (-1.425)	--.--	-0.165 (-2.366)**
$dsur_{it}\ X\ T_{it}$	--.--	--.--	--.--	0.022 (1.860)*	--.--	0.024 (1.877)*
$T_{it(-1)}$	--.--	--.--	--.--	--.--	0.038 (0.204)	0.027 (0.781)
$dque_{it}\ X\ T_{it(-1)}$	--.--	--.--	--.--	--.--	--.--	0.110 (2.224)**
$Income_{(-1)}$ (x 10^{-3})	-0.755 (-1.268)	-1.131 (-1.979)**	-0.787 (-1.909)*	-0.792 (-2.241)**	-0.722 (-1.731)*	-0.799 (-1.755)*
General Purpose Transfers$_{(-1)}$ (x 10^{-3})	-0.896 (-4.434)**	-0.809 (-4.509)**	-0.744 (-3.254)**	-0.764 (-2.960)**	-0.930 (-4.512)**	-0.865 (-3.654)**
Other Transfers$_{(-1)}$ (x 10^{-3})	-0.189 (-2.909)**	-0.138 (-4.509)**	-0.130 (-4.119)**	-0.132 (-4.004)**	-0.215 (-3.330)**	-0.174 (-3.216)**
Natural Resources$_{(-1)}$ (x 10^{-3})	-0.323 (-5.411)**	-0.291 (-4.799)**	-0.274 (-4.014)**	-0.281 (-3.774)**	-0.322 (-5.957)**	-0.290 (-4.667)**
Population$_{(-1)}$ (x 10^{-3})	0.083 (1.777)*	0.077 (1.761)*	0.081 (1.789)*	0.085 (1.741)*	0.075 (1.721)*	0.082 (1.741)*
%Δ Population$_{(-1)}$	0.129 (1.411)	0.192 (2.324)**	0.154 (2.142)**	0.154 (2.141)**	0.149 (1.574)	0.133 (1.500)
% Population over 65$_{(-1)}$	-0.029 (-0.044)	-0.029 (-0.042)	-0.020 (-0.033)	-0.024 (-0.050)	-0.038 (-0.055)	-0.021 (-0.042)
% Population under 15$_{(-1)}$	0.096 (2.295)**	0.135 (3.243)**	0.099 (2.987)**	0.097 (2.990)**	0.115 (3.375)**	0.099 (2.751)**
% Unemployed$_{(-1)}$	-0.006 (-0.294)	-0.002 (-0.011)	-0.004 (-0.206)	-0.004 (-0.241)	-0.007 (-0.287)	-0.007 (-0.267)
Dleft	0.198 (2.492)**	0.175 (2.006)**	0.188 (2.336)**	0.184 (2.304)**	0.185 (2.443)**	0.187 (2.303)**
Dminority	0.141 (1.614)	0.071 (1.085)	0.087 (1.436)	0.084 (1.224)	0.156 (1.921)*	0.144 (1.774)*
Individual effects	YES	YES	YES	YES	YES	YES
Time effects	YES	YES	YES	YES	YES	YES
Adjusted R^2	0.726	0.732	0.740	0.759	0.695	0.724
White (Heterosk.)	5.209	5.345	5.559	5.654	6.870	6.541
Durbin-Watson (Autocorr.).	2.011	2.160	2.009	1.974	2.016	2.100
F(C vs. C_i), Individual effects	3,201.2**	3,447.0**	3,556.0**	3,014**	2,225.0**	2,442.9**
F(C vs. C_i), Time effects	268.9**	299.5**	366.0**	298.5**	311.6**	333.3**
χ^2*(Hausman test) Fixed vs.Random*	55.1**	50.6**	53.2**	55.1**	52.5**	50.0**

Column (5) shows the OLS results with time effects and column (6) shows the IV estimation with time effects. This last equation only treats $\sum_{j\neq i}\omega_{ij}t_{jt}$ as endogenous, since $\sum_{j\neq i}\omega_{ij}Z^{k}_{i,t-1}$ are the only instruments not present in equation (1) that do not show cross-section variation. Comparing equation (5) and (1) we can check that the introduction of time effects reduces considerably the three parameters of interest. However, comparing columns (6) and (4), we can check that time effects do not have a substantial effect on the tax interaction estimates when instrumenting the neighbour tax rates. In fact, the coefficient on T_{it} is of a similar magnitude in both equations; thus, the use of IV in the case of T_{it} does not represent a big improvement over time effects.

From the results of either of the two specifications (4 or 6) we can confirm the basic hypotheses on tax interactions advanced along the paper. First, there is a significant positive interdependence between provincial and federal tax rates. A 1% point change in the federal income tax rate supposes an average variation in the provincial income tax rate around 0.18-0.20%. Second, there is also a positive reaction of provincial tax rates to changes in the tax rates of its neighbours. A 1% point change in the tax rates of the set of competing provinces supposes an average change in the tax rate of the province around 0.3-0.35%. Third, the equalisation grant pushes the tax rates of the receiving province up. This means that the price effect dominates the income effect of the equalisation grant. A 1% point change in the standard equalisation tax rate supposes an increase in the tax rate of a representative receiving province around 0.02-0.03%. This effect is thus smaller than the one derived from neighbour's tax changes and, in addition to this, the parameter estimate is only significant at the 90% confidence level.

Table 4 presents the results of the estimation of equations (10) and (11). The first two columns show estimates of equation (10) accounting only for interactions among horizontal competition and the equalisation grant. Column 3 shows the estimates of equation (10) accounting only for interactions among vertical competition and the equalisation grant. Column 4 expands the previous equation by adding the interactions between the federal tax rate and the tax code status dummies, as in equation (11). The last two columns show the results of the introduction of the federal tax rate lagged, in equations (9) and (11).

The results in column (1) are quite interesting. The tax interaction parameters have similar values to those in Table 3. However, the parameter on the interaction between horizontal tax competition and equalisation status is negative and significant. This means that the reaction to tax rates changes in the competing provinces is much lower in an equalisation-receiving province than in the remaining ones. A 1% point change in the tax rates of the set of competing provinces supposes an average change of roughly 0.30% if the province does not receive equalisation funds, but of only around 0.15% if the province is entitled to equalisation. The equalisation grant seems to avoid, at least in part, that the receiving provinces engage in a tax competition race. This conclusion is reinforced when looking at column (2). Theses estimates show that the lower reaction to the tax rates of competitors holds across the different groups of receiving provinces. The reactions of Atlantic, Quebec and Western-receiving provinces is lower than the ones of the basic category (i.e., Western-non-receiving provinces, that show a reaction of 0.37%), although the coefficients are imprecisely estimated. Note also the high sensibility of Ontario in front of changes in the tax rates of its neighbours: a 1% point change in the neighbour's tax rate leads to a 1% point change reaction. That is, the income tax rate of Ontario is strongly linked to the one in Quebec[40]. Note that this effect is not symmetric. Although Ontario is also the main neighbour of Quebec, the reaction of Quebec to changes in Ontario's tax rate is much lower and similar to the other equalisation-receiving provinces to its neighbours. Thus, although other differences may explain this asymmetric result, we believe the equalisation grant is its main cause.

Column 3 shows the result on the interaction among vertical externalities and equalisation[41]. The parameter estimated is negative and significant at the 90% level. Column 4 shows the results when the interactions according to the tax code status are added to the previous specification. Note that now the

[40] Recall that our definition of the set of competitors is based on contiguity criteria weighted by population and inverse distance. This means that Ontario's competitors are Quebec and Manitoba. However, given the low population of Manitoba and the high distance between Toronto and Winnipeg, the weight of Quebec is much higher than the one of Manitoba.

[41] Note that although equation (10) included interactions between vertical and horizontal externalities together, these have been presented in different specifications in Table 4. However, the combined specification was also estimated and the results (available upon request) are roughly the same than those presented.

differential reaction to federal tax rate changes of equalisation-receiving provinces is no longer significantly different from zero. Also note that Quebec seems to have a lower reaction to federal tax changes than the representative province (although not significant), and that the provinces that use high income surcharges have a higher reaction than the average (but significant only at the 90% level). Note that although the lower reaction of Quebec and the higher reaction of the high-income surcharge provinces suggest that fiscal illusion may play some role in explaining vertical tax interactions, the point estimates for the interactions are quite modest.

Columns 5 and 6 introduce one lag in the federal tax rate both in the basic specification (column 6 of Table 3) and in the specifications with tax code status interactions. The results of Column 5 show that the reaction to federal tax changes is mostly contemporaneous. The coefficient of $T_{it(-1)}$ is positive, but quite low and, in any case, not significant[42]. The results of column 6 show that the coefficient of $T_{it(-1)}$ remains statistically equal to zero both for all the provinces with the exception of Quebec. In the case of Quebec, the results show that the reaction is mainly one year lagged. The contemporaneous reaction of Quebec is zero (i.e., the equality between the coefficients of T_{it} and $dque_{it}$ X T_{it} can not be rejected at the 95% level) while the one-year lagged reaction is around 0.10%. Therefore, while the reaction to a 1% point change in the federal tax rate of the representative province is around 0.17%, the long-term reaction of Quebec is 0.10%, and the reaction of the high-income surcharge provinces is around 0.20%. This finding suggests that only a portion of vertical tax interdependence can be explained in the case of Canada by automatic adjustments of provincial tax burden caused by links among tax codes at different levels of governments. This result reinforces the conclusion regarding the relevance of vertical externalities obtained from the results of Table 3.

Finally, we should note that the results obtained for the control variables are generally as expected. First, the coefficient of personal income per capita is negative and significant (albeit only at the 90% levels in some of the specifications); the negative parameter on income may suggest that richer populations tax heavily but at a decreasing rate, but this variable may also pick up cyclical variations

[42] We also tried the specification including only the lagged variable, but the coefficient was roughly of the same magnitude than in the contemporaneous reaction.

in effective tax rates. Second, richer governments return a highest amount of the transfers received to its citizens; the sign of the three types of resources at disposal of provincial governments are negative and strongly significant. Note that the point estimate is much higher in the case of *General purpose transfers* (that includes, mainly, the equalisation funds received) than in the case of *Other transfers* (specific grants) and revenues coming from *Natural resources*. Third, the size of the population has a positive impact on the provincial tax rate (although in most of the specifications is significant only at the 90% level). This may indicate that big provinces have market power and are able to set higher tax rates, or that the costs of providing public services are higher therein. Fourth, the provinces with a high rate of population growth and a high share of young people use the income tax more intensively, possibly due to the higher demand derived from these factors. The sign of the share of unemployed people is negative but is not significant in some of the specifications, and in all of them when time effects are included. These facts are consonant with the role of this variable as a control for the effects of cyclical variations on effective tax rates. Fifth, the results regarding to the dummy variables that characterise the political environment of the province show that leftist governments and governments with lack of internal cohesion tend to tax more heavily than governments on the right and/or with majority.

4. Conclusions

In this paper, our purpose was to test empirically the relevance of different kinds of tax externalities that may occur in a federation. In particular, we have analysed the cases of vertical and horizontal tax externalities, and the effects of equalisation grants. The methodology employed in the analysis consists of looking for the reaction of regional tax rates to changes in the federal tax rate, in the tax rate of competing provinces, and in the standard equalisation tax rate, respectively. To test these hypothesis we have used data from personal income taxation in Canada during the period 1982-1996.

The evidence we have found seems to confirm the existence of tax interactions due to all of the aforementioned causes. First, we have found that 1% increase in the federal tax burden is followed by an increase of approximately 0.20%. These point estimates are similar to those obtained in Esteller and

Solé (2000) for the US personal income tax, and lower than those obtained by Besley and Rosen (1998) in the case of US excise taxation. Second, there is also evidence of a positive reaction of provincial tax rates to changes in the tax rates of their neighbours. A 1% point change in the tax rates of the competing provinces forces a change in the tax rate of one province of 0.3%. This reaction is of a similar magnitude than the one found, for example, in Besley and Case (1995) for the US case.

Third, we have found that the equalisation grant pushes the tax rates of the receiving provinces up. A 1% change in the standard equalisation tax rate provokes an increase in the tax rate of the receiving provinces of 0.02%. The equalisation grant also seems to mitigate horizontal tax competition, since the reaction to their neighbours' tax changes is lower in the equalisation receiving provinces. Therefore, though our results seem to confirm Smart's (1998) results about the incentive to raise taxes provided by the equalisation, this may not be bad from a social point of view if the previous level of taxation were too low because of tax competition.

Appendix

Migration responses of workers in front of tax changes can be obtained from total differentiation of expression (3):

$$\frac{dn_i}{dt_i} = \frac{(1-\alpha_i)(N-1)f_i^{'}}{(1-\alpha_i)(N-1)f_i^{''}(1-T-t_i)+\sum_{j\neq i}^{N-1}\alpha_j f_j^{''}(1-T-t_j)} \leq 0$$

where α_i is the population share of province *i* and *N* is the number of provinces of the federation. For "big" provinces, $\alpha_i \to 1$, and so $dn_i/dt_i \to 0$. Assume all provinces are identical ($f_i(N_i) = f(N_j)$, and $N_i = N_j$, $\forall i \neq j$). Then, in the case province *i* changes its personal income tax rate, there will be a migration response of its citizens according to:

$$\frac{dn_i}{dt_i} = \left(1-\frac{1}{N}\right)\frac{f^{'}}{f^{''}(1-T-t)} < 0$$

since at equilibrium being all provinces identical $t_i = t_{-i} = t$, and $(1/N)$ is the share of workers of a province. An increase in the tax rate produces an outflow of workers in order to recover their pre-tax level of private consumption. Then, in order to re-balance the migration condition (expression (3) in the main text), the gross wage rate in province *i* has to increase enough.

Instead, in front of tax variations in anyone of the rest of provinces, there is an inflow of workers into province *i*:

$$\frac{dn_i}{dt_j} = -\frac{-(1-\alpha_i)(N-1)f_j^{'}}{(1-\alpha_i)f_i^{''}(1-T-t_i)+\alpha_j N f_j^{''}(1-T-t_j)-\sum_{j\neq i}^{N-1}\alpha_j f_j^{''}(1-T-t_j)} \geq 0$$

In the case that all provinces are identical:

$$\frac{dn_i}{dt_{-i}} = -\frac{1}{N}\frac{f^{'}}{f^{''}(1-T-t\ )} > 0$$

Finally, the migration response in front of a change in the federal tax rate will be equal to zero in the case all provinces are identical, $dn_i/dT = 0, \forall i$. Otherwise, if provinces are not identical:

$$\frac{dn_i}{dT} = \frac{(1-\alpha_i)(N-1)f_i^{'}-(1-\alpha_i)\sum_{i\neq j}^{N-1}f_j^{'}}{(1-\alpha_i)(N-1)f_i^{''}(1-T-t_i)+\sum_{j\neq i}^{N-1}\alpha_j f_j^{''}(1-T-t_j)} \lesseqgtr 0$$

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