Università degli Studi di Ferrara

DIPARTIMENTO DI ECONOMIA, ISTITUZIONI, TERRITORIO

Corso Ercole I D'Este n.44, 44100 Ferrara

Quaderni del Dipartimento

n. 2/2003

January 2003

Local Government Responsiveness to Federal Transfers: Theory and Evidence

Leonzio Rizzo

Local Government Responsiveness to Federal Transfers: Theory and Evidence*

Leonzio Rizzo†

January 2003

Abstract

We develop a model with two countries, producing two goods: one mobile and the other not. The mobile good is taxed according to origin. People decide to buy the good where the price is more advantageous. The two countries engage in tax competition. The introduction of an equalization transfer decreases the fiscal externality due to tax-base mobility: some of the lost tax "comes back". We test the theoretical results on tax data from Canada. We find that tax competition differs according to whether a province is, or is not, receiving the transfer.

Keywords: fiscal competition, equalization, transfer, externality, tax-rate.

JEL classification: H21, H23.

*This work has been developed during my EU Marie Curie fellowship at the STICERD, London School of Economics. I wish to thank Tim Besley for his continuous ecouragement comments and advices. I also thank Oriana Bandiera, Roberto Censolo,Valentino Larcinese, Ben Lockwood, Robert MacCulloch, Imran Rasul, Michael Smart, Myrna Wooders and all the participants to seminars at University of Ferrara, IFS, the workshop on Strategic Interaction among Local Governments: Empirical Evidence and Theoretical Insights, at the Catholic University of Milan, Warwick University, EEA 2001 conference in Lausanne, LSE, University of Bari, University of Malaga, Journées Économie Publique LAGV in Marseille, North American Econometric Society Conference in Los Angeles 2002, ESF workshop on Local Public Goods, Politics and Multijurisdictional Economies at University Paris-1 Pantheon-Sorbonne in Paris 2002, LSE research-lab conference in London 2002 for helpful comments. The usual disclaimer applies.

†University of Ferrara and London School of Economics, e-mail: l.rizzo@economia.unife.it .

1 Introduction

In a federal country, such as Canada or the US, indirect taxes are often autonomously decided by each province or state, and people can freely cross borders and buy goods at the better price.

Typically in this situation each state fixes its tax rate without taking into account the benefits in revenue and/or social welfare, due to its tax-base migration, of the other state (Mintz and Tulkens 1986; Kanbur and Keen 1993). As a consequence the equilibrium tax-rate tends to be inefficiently low or high (M. H. Wooders, B. Zissimos, A. Dhillon, 2002).

Normally transfers are needed to mitigate these inefficiencies, compensating for the loss in revenue due to mobility. Are such transfers important from a practical point of view? Do the states of a federal government take the effects on their revenue of compensating transfers into account?

This is a key issue within the European Union, where the mobility problem is related to the elimination of the fiscal borders and the implementation of the origin VAT system. The approval of a clearing compensation mechanism (Commission, 1985) would ensure that each nation has the same revenue that it would have in a destination system. Therefore it should eliminate the incentive for each nation to use its taxes strategically.

In this paper we investigate whether this last statement is really true. We ask if the states receiving a compensation transfer modify their tax-rate choice with respect to states which are not given any transfer.

In the paper we test the efficacy of a compensation transfer by looking at Canada, which has an equalization transfer among the provinces. The transfer is computed by summing up for 33 tax bases the difference between the province tax base and a standard tax base, according to a standard equalization rate. If the previous sum is positive no transfer is awarded; if it is negative, the corresponding equalization transfer is made. In the former case we have a world without transfers, in the latter a world with transfers.

We set out a theoretical model, in which we explore the welfare properties of an equalization transfer, and show that it is equivalent to a compensation transfer. The intuition is the following: if country j loses a quota of its tax base because some other country decreases its tax on it, with an equalization mechanism country j recovers part of it because the transfer received will be higher than it was before the change.

In the model the reason for the tax-base mobility can be twofold: first, given a tax-differential, people can cross the border and buy elsewhere; second tax differentials can incentivate smuggling from the low-tax to the high-tax country. This is equivalent in terms of loss in revenue for the high-tax country to cross-border shopping. In our model, the mobility of the tax base leads to too low tax rates with respect to a situation without externalities. If we insert an equalization transfer, the fiscal externality decreases, the tax-rate increases and as a consequence we have a change in the slopes of the best response function.

We test the change in the slope of the reaction function by using tax rates on cigarettes and sales in a panel-data study at province level for Canada from 1984 to 1994.[1]

This can be thought of as a test of the sensitivity of state tax decisions to federal policies. Some provinces, in fact, are given a transfer, which in the theoretical model is shown to be equivalent to a compensation transfer. This transfer partially offsets the negative fiscal externality related to interprovincial tax-base mobility.

The paper is organized as follows. The second section examines the literature. The third develops the theoretical model. The fourth presents the empirical analysis. Section five concludes.

2 Related literature

Tax competition is a very widely debated phenomenon in public economics. It has recently received attention due to the worldwide liberalization process (Devereux, Griffith, Klemm, 2001). It is not our purpose to attempt a complete survey on the argument. For a synthesis of different explanations of the inefficiencies due to fiscal interdependencies in an integrated fiscal world see Lockwood (2001) and Wilson (1999).

The source of the tax externality between neighboring states is related to the way potential taxpayers are distributed among the states and to the cost of shopping abroad. Both determinants can be normally reflected in the tax-reaction function slope of each state. Scharf (1999) introduces a fixed

[1] How Canadian provinces relate their tax decisions on cigarettes seems to be an important issue, according to the provisional agenda on tobacco control of the World Health Organization meeting in 1999: "differentials in the price of tobacco....lead to both casual cross-border shopping and illegal bootlegging. Cross-border sales may occur within countries, such as Canada and United States, given the intracountry price differences among Canadian provinces and states within the United States".

transaction cost of shopping and a storage cost together with a linear transport cost to the border. This generates a cross-border shopping cost function concave in the distance from the border. This characteristic, given a uniform distribution of consumers in the country, matters in the tax-externality and the slope of the state's reaction function. Devereux, Lockwood, Redoano (2001) model corporate tax-competition with a spatial model *à la* Hotelling. They assume that each investor bears a linear cost function to invest abroad. In their case the difference in the slope of the states' reaction function is driven by the investor distribution in each state, which is assumed to be single-peaked.

In this paper we argue that another important determinant of the tax-externality level is the existence of compensation transfers and we look at its effect through the state's best reply slope.

Many federal grant systems could be designed to achieve the optimum: in an economic context where the government chooses an inefficient level of taxes and public goods, the introduction of a further instrument increases the degree of freedom of the central planner who can design the transfer to correct regional government incentives.

For example, in an optimal taxation framework with tax and expenditure externalities Dalbhy (1996) derives the matching grants which correct the distortions in government decision-making with respect to a world without externalities; Wildasin (1991) proposes a set of matching grants to correct an inefficient level of redistriution stemming from labour mobility; Wellish (2000) proposes a system of linear "Pigouvian" matching grants for local tax-rates.

In situations without mobility of the tax base, Smart (1998) studies the effect of the Canadian equalization system in an optimal taxation model, showing that equalization induces a substitution effect that lowers the effective marginal cost of public funds. The transfer lowers the taxation burden to local taxpayers. The distortionary effect of an increase in tax is partially offset by the transfer, which decreases the tax-base elasticity. If the revenue effect is not very high, equalization induces an increase in the equilibrium tax-rate, which results in an inefficiently high level of taxation.

This idea is also explored in Köthenbürgen (2002), who shows in a model with capital mobility and symmetric countries that the Canadian equalization system implements the Utilitarian optimal solution. Smart (2002) shows that the equalization system, with some "ad hoc" corrections, implements the optimal solution, even allowing for asymmetric countries in the productivity of capital or in the population[2].

All these papers find in different inefficient contexts, that the revenue sharing program, if correctly designed, can induce the local government to account for the externalities that its decisions about taxes and public expenditures impose on other governments.

In our work we examine whether these transfers, when implemented, really draw the economic system to the optimum or towards it. We do it by looking at the equalization transfer in Canada, which is easily shown to be equivalent to a compensation transfer which reallocates the mobile revenue to the country of origin.

Some empirical papers offer fiscal externality estimates. Besley, Rosen (1998) estimate the existence of vertical fiscal externalities for cigarettes and fuel in US, by relating the own state tax rate to the federal government tax rate. Two effects are identified: a revenue and a deadweight loss effect. In the first case the link between state tax rate and federal tax rate is due to the budget constraint, the second effect is due to the minimization of the deadweight loss, given the budget constraint. They find in the theory a positive relation between the tax rates in both cases. This positive sign is confirmed in the empirical analysis. Horizontal fiscal externalities due to yardstick competition are tested using US state level data (Besley, Case, 1995) for sales, income and corporate taxes: a significant relation holds between taxes set by one state and the average of the neighboring taxes, when the governor of the state runs for reelection. Horizontal externalities due to tax-base mobility have been explored empirically. Besley, Griffith, Klemm (2001) used a panel data-set 1965-97 for OECD countries and estimate tax competition for a wide range of taxes, by proxying tax-rates with tax-revenue as ratio to GDP. In particular, corporate tax competition was sharper in EU countries than in non-EU countries. Devereux, Lockwood and Redoano (2002) perform a related analysis on corporate taxes with a data-set 1979-99 for OECD countries. They consider three forms of tax rate: the statutory tax rate, the effective average tax rate and the effective marginal tax rate. They find that governments compete on the effective average tax rate and the statutory tax rate, but not over the effective marginal tax rate. This is because location choices by multinational firms are discrete. They estimate the link between the own tax country and the lagged average of the tax rate of the remaining

[2] In this latter case the equalization formula has to be corrected by a parameter linked to the elasticities of supply and demand.

nations.

There are few recent papers on the effects of transfers on fiscal externalities. Boadway, Hayashi (2001) use Canadian annual data 1963-1996. They test horizontal and fiscal interaction. Each estimate is for a single province or an average province. They find that Ontario's average tax on capital has a significant impact on that of Quebec, but that the reverse does not hold. They explain this by the equalization system: Ontario is a non-recipient country and Quebec is a recipient country, but they do not⊂ give theoretical support to this tested hypothesis. Esteller-Moré, Sollé-Ollé[3] (2002) test fiscal interactions and the effect of equalization for the average personal income tax, using a Canadian panel data-set 1982-1996. They find significant horizontal and vertical tax interactions and a significant effect of equalization on the reaction function, but they do not show in their theory why the introduction of equalization should deliver the particular effect on the reaction function slope (decreasing it) that they find in the empirical part and why this should be linked to the effect of the equalization system on the fiscal externality.

In our paper we use a Canada-US panel data-set 1984-1994 and test the effect of equalization on the slope of the cigarette tax-rate reaction function, according to four complementary different tax rate regimes and transfer regimes, after assuming and testing a concave cross-border shopping cost function in the distance from the border. To each regime corresponds a particular value of the fiscal externality exactly coherent with the idea that the introduction of an equalization system decreases the fiscal externality. All the hypotheses we test in the empirical part are derived in the theoretical part, where a structural cross-border shopping model is developed. We show that theoretically and empirically the evidence found in the previous works cited (Boadway, Hayashi (2001); Esteller-Moré, Sollé-Ollé (2002)) holds for one taxation regime and exactly the opposite holds for the other regime. Interestingly the evidence in both cases comes from the effect of the equalization on the fiscal externality, which decreases in both tax-regimes if the transfer is introduced.

[3]While our paper differs from Esteller-Moré, Sollé-Ollé (2002) in many substantial aspects, we would like to stress that we were able to consult that paper only after its publication, when the present work had already been developed. The same consideration applies to Kothenburgen (2002) and to the draft of Smart (2002).

3 The model

Consider a federation with two member countries with equal populations. Consumers in the two countries differ in their utility function for preference for the public good and in income endowment. Two goods are produced: a mobile taxed good and an immobile good whose price we take as numeraire. The two goods are produced by using one input with constant returns to scale. Each resident can decide where to buy the consumption good, according to the post-tax price and a cross-border shopping cost.[4] Each country decides upon a tax level on the mobile good and a local public good.

Let us index the two countries as 1 and 2. Both have the same number of residents, normalized to 1 and uniformly distributed over $n \in [0, 1]$. We assume that the extremum 0 is the border of the country. Since the residents are uniformly distributed, the distance of each resident from the border is $d \in [0, 1]$ coinciding with the distribution of the residents.

Assume that each consumer in country 1 has the following utility function:

$$U(x, y) = u(x) + y + \gamma_1 \ln g$$

where $x \in \{0, 1\}$; y is the numeraire no-mobile good, g is the public good and $\gamma_1 > 0$.

3.1 The second stage

Each consumer who lives in 1 and shops in 1, solves:

$$\max_{x,y} U(x, y, g) \tag{1}$$

s.t.:

$$(p + t_1)x + y = m_1 - f \tag{2}$$

where p is the production price of the mobile good, which is the same in country 1 and 2, t_1 is the specific unit tax on the mobile good in country 1

[4] This action can be legal or illegal. In the former case we talk of cross-border shopping (as in the remainder of the paper), whose level is constrained by distance from the border and the related transport cost. In the latter case the tax-base mobility is due to smuggling. A way to interpret the cost linked to the illegal tax-base mobility is the remuneration of the risk smugglers bear of being caught, which is higher, the greater the number of residents to be served. If the residents are uniformly distributed, the risk and so the cost increases with distance from the border.

of the mobile good, f is a federal lump-sum tax on income and m_1 is the income endowment in 1. We assume throughout that there are two types of country, poor and rich, depending on income endowment:

Assumption 1: *Country type can be either poor if* $m < M - 1$ *or rich if* $m \geq M + 1$ *and* $m \notin [M-1, M+1[$.

The meaning of this assumption is that there is always a meaningful difference in income endowments between a rich and a poor country. *We assume in the model that if country 1 is poor, country 2 is rich and vice-versa.* Moreover:

Assumption 2: $r = u(1) - p > 0$, where r is the reservation price for the mobile good, net of production cost, of a consumer living either in 1 or 2.

The meaning of this assumption is that it is always worth it for the consumer to buy the good x when it is not taxed.

Problem (1)-(2) leads to the following:[5]

$$V_1^1(p + t_1, m_1, f, g) =$$

$$= \max \{u(1) + m_1 - f - (p + t_1) + \gamma_1 \ln g; \; m_1 - f + \gamma_1 \ln g\}$$

therefore if assumption 2 holds and $t_1 \in [0, r]$:

$$V_1^1(p + t_1, m_1, f, g) = u(1) + m_1 - f - (p + t_1) + \gamma_1 \ln g. \tag{3}$$

3.1.1 The cross-border shopping decision

Let us define t_2 as the specific unit tax on the mobile good in country 2 and make the following:

Assumption 3: *The transport cost for each consumer crossing the border is given by:*

$$\phi(d) = \frac{\ln(1 + d)}{A} \tag{4}$$

[5] The utility function is quasilinear in the non-mobile good, resulting in a constant marginal utility of income, which allows us to underline the substitution effect in the choice of the tax-rate.

where d is the distance of the consumer from the border and $A > 1$ is a fixed parameter.

Notice that this is an increasing and concave function of d and that $\phi(0) = 0$.

This assumption is consistent with the idea that cross-border shopping involves fixed transaction costs (Scharf, 1999) which makes the average cost per unit of purchased good decrease with distance from the border. The intuition[6] is the greater the distance from the border, the lower the number of storage periods and the lower the fixed transaction cost per unit of consumption.[7]

In a stylized discrete choice model such as the one presented here, this reasoning can be summarized in a concave cross-border shopping cost in the distance from the border. Notice that the intensity of the scale economies in the cross-border shopping technology is captured by A: the higher A, the lower the transport cost. Moreover, the higher A, the smaller the increase in the transport cost, when the distance increases.

Suppose $t_1 > t_2$. Then a consumer in country 1 who buys in country 2 solves the following problem:

$$\max_{x,y} U(x, y, g)$$

s.t.:

$$(p + t_2)x + y = m_1 - \phi(d) - f.$$

This gives:

$$V_1^2(p + t_2, m_1, g) =$$

[6]In Scharf (1999) there is a third stage where the optimal number of trips is decided. The total cost of shopping abroad is given by a variable cost of shopping linked to the distance from the border and a fixed transaction cost for each trip.

People decide the optimal number of trips by comparing this total cost with the storage cost. The greater the distance from the border, the higher the total cost and the lower the optimal number of storage periods and thus the higher the total amount bought in one shopping trip. This lowers the fixed transaction cost per unit of consumption, which means that the greater the distance from the border, the smaller the increase in the unit cost of shopping per unit increase in distance.

[7]Fitz Gerald et al.(1995) show evidence of this. They analyzed two case-studies: Germany-Denmark and Ireland-Northern Ireland. In both cases the greater was the distance from the border, the greater the amount of goods purchased and the fewer the trips in any given period.

$$= \max\{u(1) + m_1 - f - (p + t_2) - \phi(d) + \gamma_1 \ln g;\ m_1 - f - \phi(d) + \gamma_1 \ln g\}$$

therefore if assumption 2 holds and $t_2 \in [0, r]$:

$$V_1^2(p + t_2, m_1, g) = u(1) + m_1 - f - (p + t_2) - \phi(d) + \gamma_1 \ln g. \quad (5)$$

When $t_1 > t_2$, if assumption 2 holds and $t_1 \in [0, r]$, we can equate (3) and (5) and get:

$$\phi(k) = t_1 - t_2.$$

If we use (4):

$$k = [\phi(t_1 - t_2)]^{-1} = e^{A(t_1 - t_2)} - 1 \quad (6)$$

where k is the distance from the border of the consumer in country 1, who is indifferent between shopping in 1 or 2. Moreover, since the consumers in 1 are uniformly distributed on $[0, 1]$, k is also the number of residents in 1, crossing the border for a given $t_1 - t_2$. Note that k is convex in t_1.

Note that the higher t_1, the greater the increase in the number of people going to 2, for a given increase in t_1 ($\frac{\partial k}{\partial t_1} > 0$ and $\frac{\partial^2 k}{\partial t_1^2} > 0$). This is because the higher t_1, the further from the border the indifferent consumer is, the smaller the increase in transport cost ($\phi'' < 0$).

If $t_1 \leq t_2$, by symmetry we obtain:

$$\phi(l) = t_2 - t_1.$$

If we use (4):

$$l = [\phi(t_2 - t_1)]^{-1} = e^{A(t_2 - t_1)} - 1 \quad (7)$$

where l is the distance from the border of the consumer in country 2, who is indifferent between shopping in 2 or 1. l is also the number of residents in 2, that cross the border for a given $t_2 - t_1$. Note that l is convex in t_2. In this second regime the higher t_1, the smaller the increase in the number of people coming back to 2, for any given increase in t_1 ($\frac{\partial l}{\partial t_1} < 0$ and $\frac{\partial^2 l}{\partial t_1^2} > 0$). This is because the higher t_1, the nearer to the border the indifferent consumer is, and the smaller the decrease in trasport cost ($\phi'' < 0$).

Notice, finally that the higher A is, the larger the number of people who decide to buy good x in the other country, if the tax rate in their own country is higher. This is because the higher A is, the lower is the transport cost for the indifferent consumer.

3.2 The first stage

If assumption 2 holds and $t_1 \in [0, r]$ and $t_2 \in [0, r]$, it will always be economic for consumers in 1 to buy good x. In this case, taking account of the initial assumption that the number of people is normalized to 1 and using the results from the second stage, we have that if $t_1 > t_2$, $B_1 = 1 - k(t_1, t_2)$ and if $t_1 \leq t_2$, $B_1 = 1 + l(t_1, t_2)$, where B_1 is the tax base faced by country 1. We can simplify the notation by defining:

$$n(t_1, t_2) = \begin{cases} -k(t_1, t_2) & \text{if } \ t_1 > t_2 \\ l(t_1, t_2) & \text{if } \ t_1 \leq t_2. \end{cases} \tag{8}$$

It follows that:

$$B_1 = 1 + n(t_1, t_2)$$

where n is the mobile tax-base quota coming in or going out depending on which tax regime we are dealing with.

The same reasoning applies to country 2.

3.2.1 The federal transfer

The budget constraint faced by the government in country 1 in the first stage is:

$$g - B_1 t_1 \leq 0. \tag{9}$$

The budget constraint changes if the country is in a federation, which makes it eligible for an equalization transfer. In particular, think of a simple transfer such as:

$$T = \begin{cases} \max\left[0, \alpha\left[(1 - B_1) + (M - m_1)\right]\right] & \text{if } \ 0 \leq t_1 \leq r \\ 0 & \text{if } \ t_1 > r \end{cases} \tag{10}$$

where T is the total transfer to the country, 1 is a standard mobile tax base, which coincides with the average-tax base of the federation if assumption 2 holds, and M is a standard income level. It is reasonable to think that in reality tax rates would never be so high as to prevent people from buying the good. To preclude this possibility in our model with the federal transfer, we assume that $T = 0$ if $t_1 > r$: the local government is punished by not getting the transfer if the taxation is too high. This assumption rules out the possibility of a country choosing $t_1 > r$, for a given t_2, because the transfer mechanism would let the country have a higher pay-off than if it chose $t_1 \leq r$.

The structure of this transfer is interesting because it is linked to the mobile tax base, so if it enters into the budget constraint it modifies the mobile elasticity tax base of the country. The following assumptions and definitions are useful:

Assumption 4: $r < \frac{1}{A}$.

The intuition for this inequality is that the larger the scale economies (the higher A) in the cross-border shopping technology, the lower the unit net reservation price can be. The higher A is, the less costly it is to buy the good abroad.

Assumption 5: $\alpha < \frac{1}{A}$.

The intuition, looking at Canada, is that the higher A is, the greater the potential mobility is. This should drive equilibrium tax rates too low if the revenue effect is not very great (Wooders, B. Zissimos, A. Dhillon, 2002). Since α in Canada is the tax-rate average, a higher A should lower α; morever the tax-rate average should always be below r, which is the upper bound tax-rate level beyond which the consumers will not buy the good.

Assumptions 4 and 5, given assumptions 2 and 3, are sufficient to guarantee the strict concavity of the pay-off function and thus the existence of a tax-rate and local-public-expenditure Nash equilibrium.

Definition 1: *The transfer T is "active" if* $\alpha > 0$ *and "not active" if* $\alpha = 0$.

Definition 2: *If a federal transfer like (10) is introduced in the federation, country 1 can be "recipient" if* $\alpha\left[(1 - B_1) + (M - m_1)\right] > 0$*, or "non-recipient" if* $\alpha\left[(1 - B_1) + (M - m_1)\right] \leq 0$*.*

Using this last definition we can state the following:

Lemma 1: *In a federation where a transfer T is introduced and assumptions 1-5 hold, country 1 will be "recipient" if and only if it is poor and it will be "non-recipient" if and only if it is rich.*

Proof: We first prove the lemma for the poor type country.

Assume that if country 1 is poor, it does not get the transfer. If country 1 is poor: $m_1 < M-1$. Moreover when it does not get the transfer: $-n(t_1, t_2)+(M - m_1) \leq 0$, which implies $m_1 \geq M - n(t_1, t_2)$. This is a contradiction because this last inequality cannot hold in the poor-type case, as defined in assumption 1, being $k < 1$ and $l < 1$ for $\forall t_1 \in [0, r]$, given any $t_2 \in [0, r]$.

We now show that being poor is also a necessary condition to be "recipient". Assume that if country 1 does not get the transfer, it is poor. If country 1 does not get the transfer, it means that: $-n(t_1, t_2)+(M - m_1) \leq 0$, which implies $m_1 \geq M - n(t_1, t_2)$; moreover, since the country is also poor: $m_1 < M - 1$, but since $k < 1$ and $l < 1$ for $\forall t_1 \in [0, r]$, given any $t_2 \in [0, r]$, this is in contradiction with the initial assumption that country 1 does not get the transfer.

The second part of the lemma is proved in the appendix.

Notice that lemma 1 proves that, given the country type, there will never be a level of t_1, given t_2, such that a switch in the transfer regime occurs.

Notice that if country 1 is a "recipient" jurisdiction, its budget constraint changes in the following way:

$$g - B_1 t_1 - \alpha \left[(1 - B_1) + (M - m_1)\right] \leq 0. \tag{11}$$

The transfer is federally budget-balanced through the lump-sum federal tax:

$$2f = n(t_1, t_2) + M - m_1.$$

3.2.2 The government problem

Assume from now onwards that a transfer T exists in the federation. If $t_1 \in [0, r]$ and $t_2 \in [0, r]$, in the first stage, the country 1 government maximizes the indirect utility function of a representative resident shopping at home, subject to a budget constraint, by solving the following problem:[8]

$$\underset{t_1, g, \mu}{Max}\ u(1) + m_1 - (p + t_1) - f + \gamma_1 \ln g + \tag{12}$$

[8]In the case where a transfer mechanism exists, lemma 1 rules out the possibility of a country being in two different transfer regimes ("recipient" or "non recipient"), according to the chosen tax on the mobile good. Such a possibility would make the pay-off function not differentiable in the tax that induces the switch of the transfer regime, for a given tax of the other country.

$$-\mu\left\{g - B_1 t_1 - \max\left\{0, \alpha\left[(1 - B_1) + (M - m_1)\right]\right\}\right\}$$

where $\gamma_1 > 0$ is a parameter which determines the preference for the public good in country 1, and g is the local public good.[9]

The following lemma is useful:

Lemma 2: *If assumption 2 holds, the tax-rate equilibrium strategies must necessarily belong to $t_1 \in [0, r]$ and $t_2 \in [0, r]$.*

Proof: We first prove the lemma for the "recipient" country.

Assume that $t_1^* \in]r, +\infty)$ is a feasible strategy for some t_2, then $W(t_1^*, t_2, T) > W(t_1^{**}, t_2, T)$, where $t_1^{**} \in [0, r]$.

This a contradiction in fact $W(t_1^*, t_2, T) = m_1 + \gamma_1 \ln(0) = -\infty$, because when $t_1 > r$, $T = 0$. Moreover assumption 2 implies $W(t_1^{**}, t_2, T) = u(1) - p - t_1^{**} + m_1 + \gamma_1 \ln\left\{(1+n)\, t_1^{**} + \max\left[0, \alpha\left(-n + (M - m_1)\right)\right]\right\} > 0$.

The proof proceeds in the same way for the "non recipient" country.

The previous assumptions and the lemma let us state:

Proposition 1: *If assumptions 1-5 hold, then the tax game where the two countries, given the existence of the equalizing transfer T, choose their tax rates and public expenditure by maximizing their welfare function, subject to a budget constraint, has a Nash equilibrium.*

Proof: *see appendix.*

We are interested in checking the effects on the tax rate decisions of the compensation properties of the transfer as in (10). To do this we need to compare the tax rate responsiveness within the federation of the "recipient" and the "non-recipient".

We finally assume that:

Assumption 6: *If $\gamma_2 \geq \frac{M - m_1}{A}$ then $\gamma_1 > \gamma_2$, and if $\gamma_2 < \frac{M - m_1}{A}$ then $\gamma_1 < \gamma_2$.*

[9] In this problem the budget constraint is always binding ($\mu > 0$), otherwise the FOC with respect to t_1 could not be satisfied:

$$\frac{\partial L}{\partial t_1} = -1 - \mu\left[-\frac{\partial n}{\partial t_1}(t_1 - \alpha) - (1 + n)\right] = 0$$

Where $\gamma_2 > 0$ is a parameter which determines the preference for the public good in country 2. Of course the reverse holds if we assume that country 2 is recipient and the other non-recipient.

The intuition for the first part of this assumption is that we are in a federation with a great average propensity to consume public good. Moreover the poor country wants more public good than the rich country. One can think of a very "public-good-oriented" federation, where the poor country prefers more public good provision than a rich country, because it can need more infrastructure or public services. The second part of the assumption refers to a "private-good-oriented" federation: in this case the rich country will provide the essential public sevices and the poor country prefers less public good, hoping so to stimulate the needed private investment, which is publicly provided in the previous case.

This assumption is useful to rule out the symmetric equilibria, which would not allow us to make any comparative statics, since the derivative of the FOC of problem (12) does not exist in $t_1 = t_2$ (see proof of proposition 1 and the study of the reaction function in the appendix). It follows:

Proposition 2: *If assumption 1-6 hold, then the tax game where the two countries, given the existence of the equalizing transfer T, choose their tax rates and public expenditure by maximizing their welfare function, subject to a budget constraint, cannot have a symmetric Nash equilibrium.*

Proof: See appendix.

The following is useful:

Lemma 3: *A "non-recipient" country with a federal transfer T, for a given μ and a given fixed tax rate of the other country, chooses the same tax rate as a "recipient" country, if the federal transfer is "not active" ($\alpha = 0$).*

Proof: If we take the FOC of (12) with respect to t_1, we get $\frac{\partial L}{\partial t_1} = -1 - \mu\left[-\frac{\partial n}{\partial t_1}t_1 - (1+n)\right] = 0$, either the country is "non-recipient", or it is "recipient" and the transfer is "not active" ($\alpha = 0$).

Since the introduction of the equalization transfer will let the recipient country perceive that an increase in its own tax rate, given the tax rate of the other country, induces a smaller loss of tax base, than it would if there were no federal transfer, we can state the following:

Proposition 3: *If assumptions 1-6 hold, the introduction of a federal transfer, for a given marginal cost of public funds, μ, implies for the "recipient" country a higher tax rate than the one chosen by the "non recipient", the tax-rate of the other country being fixed. Moreover, the increase in tax rate will always be less than the increase in the equalization rate.*

Proof: Assume that country 1 is a "recipient" and solve problem (12), for a given μ and g:

$$\frac{\partial L}{\partial t_1} = -1 - \mu \left[-(1+n) - (t_1 - \alpha) \frac{\partial n}{\partial t_1} \right] = 0 \tag{13}$$

by totally differentiating (13) with respect to t_1 and α:

$$\left(2\frac{\partial n}{\partial t_1} + (t_1 - \alpha) \frac{\partial^2 n}{\partial t_1^2} \right) dt_1 - \frac{\partial n}{\partial t_1} d\alpha = 0$$

gives:

$$\frac{dt_1}{d\alpha} = \frac{\frac{\partial n}{\partial t_1}}{2\frac{\partial n}{\partial t_1} + (t_1 - \alpha) \frac{\partial^2 n}{\partial t_1^2}}. \tag{14}$$

If $t_1 > t_2$, using (14), (8) and (6) we get $\frac{dt_1}{d\alpha} = \frac{1}{2+(t_1-\alpha)A}$. Notice that $2 + (t_1 - \alpha) A > 1$ if and only if $t_1 + \left(\frac{1}{A} - \alpha\right) > 0$, which always holds, by assumption 5. It follows that when $t_1 > t_2$:

$$0 < \frac{dt_1}{d\alpha} < 1.$$

If we use lemma 3 this proves that the tax rate of a "recipient" country when the transfer mechanism is active ($\alpha > 0$) is higher than that of a "non-recipient" ($m_1 \geq M + 1$).

If $t_1 < t_2$, using (14), (8) and (7) we get $\frac{dt_1}{d\alpha} = \frac{1}{2-(t_1-\alpha)A}$. Notice that $2 - (t_1 - \alpha) A > 1$ if and only if $t_1 - \left(\frac{1}{A} + \alpha\right) < 0$. This is always satisfied because by lemma 2 and assumption 4 $t_1 \leq r < \frac{1}{A} < \frac{1}{A} + \alpha$. It follows that when $t_1 < t_2$:

$$0 < \frac{dt_1}{d\alpha} < 1.$$

If we use lemma 3 this proves that the tax rate of the "recipient" when the transfer mechanism is active ($\alpha > 0$) is higher than that of the "non-recipient".

3.2.3 The transfer and the fiscal externality

It is important to highlight the magnitude of the externality, for a given μ, when the equalization transfer holds and when it does not:

Proposition 4: *If assumptions 1-5 hold and there is a transfer T, then the fiscal externality of a recipient country decreases, for a given marginal cost of public funds and a given fixed tax rate of the other country.*
Proof: *see appendix.*

Notice that the transfer T, as in (10), works as a compensation transfer. The recipient country gets a lump-sum transfer, 1, restoring a quota of its tax-base αB_1. Notice that $\alpha B_1 = \alpha(1+n)$. Therefore, with the equalization transfer a country receives (or gives) the compensation transfer αn (recall that n is the mobile tax-base quota from country 1 to country 2) if a quota of its tax base shifts into (or out of) the other country.

Are the countries aware of this mechanism? Do they change their behaviour if there is a transfer with compensation properties?

3.2.4 The transfer and the best reply slope

If we totally differentiate (13) we derive the tax-rate reaction function slope of 1 for a given marginal cost of public funds:

$$\frac{dt_1}{dt_2} = -\frac{\frac{\partial^2 n}{\partial t_1 \partial t_2}(t_1 - \alpha) + \frac{\partial n}{\partial t_2}}{\frac{\partial^2 n}{\partial t_1^2}(t_1 - \alpha) + 2\frac{\partial n}{\partial t_1}}. \tag{15}$$

From (15) we can derive:

Proposition 5: *If assumptions 1-6 hold then, for a given marginal cost of public funds and a fixed t_2, $\frac{dt_1}{dt_2} > 0$.*
Proof: *See appendix.*

This is because an increase in t_2 decreases the migrating tax-base quota, for a given t_1, if $t_1 > t_2$, or increases it, for a given t_1, if $t_1 < t_2$. Therefore if t_2 increases, country 1 is induced to raise t_1, in the process of providing g by minimizing its deadweight loss, for a given marginal cost of public funds.

Proposition 6: *If assumption 2-3 and 6 hold and there is no federal transfer, then, for a given marginal cost of public funds, the slope of the tax-rate reaction function when* $t_1 > t_2$ *is steeper than the slope of the tax-rate reaction function when* $t_1 < t_2$.

Proof: *See appendix.*

This proposition comes from the assumption of the concavity of cross-border shopping cost as a function of distance from the border,[10] which implies that the further people are from the border, the less the cost increases as that distance increases. In fact if $t_1 > t_2$, for a given increase in t_2 (which means a decrease in the distance from the border of the consumer in 1, who is indifferent between buying in 1 and in 2), the increase in the number of people in 1 decreases with t_2, for a given t_1. If $t_1 < t_2$, for a given increase in t_2 (which means an increase of the distance from the border of the consumer in 2, who is indifferent between buying in 1 and in 2), the increase in the number of people shopping in 1 increases with t_2, for a given t_1 (see fig. 1 and 2). Therefore country 1, for a given increase in t_2, is induced to increase t_1 more in the former case than in the latter. In the former case an increase in t_1 causes a smaller loss in the benefit from the increase in t_2, than in the latter.

Proposition 7: *If assumptions 1-6 hold and there is a transfer T then, for a given marginal cost of public funds, (a) the slope of the tax-rate reaction function of a recipient country is lower than the slope of a non-recipient if* $t_1 > t_2$*; moreover (b) the slope of the tax-rate reaction function of a recipient country is higher than the slope of a non-recipient country if* $t_1 < t_2$. *Therefore, for a given marginal cost of public funds, (c) the difference in slopes of the tax-rate reaction functions of a recipient country between case* $t_1 > t_2$ *and the case* $t_1 < t_2$, *is lower than the corresponding difference for a non-recipient country.*

Proof: *See appendix.*

If $t_1 > t_2$, for a given increase in t_2, the increase in the number of people in 1 decreases with t_2, for a given t_1, but equalization affects the size of this latter

[10]These results hold in a model with uniform distribution of consumers. This last assumption is, in any case, less unplausible than it might seem. In fact, empirically what we need is just uniformity in the distribution of the consumers in the part of the country that is involved in cross border shopping.

decrease, because a quota of the increase in country 1's tax base, due to the increase in t_2 is returned to country 2 through the transfer. The reduction in the migrated tax base is lower than it would be without equalization. This explains why the reaction of 1 to an increase in t_2 is smoother when equalization holds: an increase in t_1 causes a greater loss of benefit, from the increase in t_2, when equalization holds (more tax base sticks in country 1, than it does in the no-equalization case).

If $t_1 < t_2$, for a given increase in t_2, the increase in the number of people in 1 increases with t_2, for a given t_1, but equalization affects the level of this latter increase for the same reason mentioned. The increase in the migrated tax-base is smaller than it would be without equalization. This explains why the reaction of 1 to an increase in t_2 is stronger with equalization: a rise in t_1 causes a loss in the benefit from the increase in t_2, that is smaller when equalization holds (less tax base sticks in country 1 than it does in the no-equalization case).

The intuition for part (c) of the proposition is that the increase (decrease) in the number of people and in the tax base, due to a change in tax-rate differentials has a smaller impact on the tax-rate decision when there is a transfer, because under the equalization system the other country receives (pays) a quota of the tax-base increase (decrease). Therefore the difference between the reaction-function slopes in the two tax regimes is smaller in the equalization case, since given the concavity of the cross-border shopping function, the difference between the slopes increases with the amount of the mobile tax-base.

4 The empirical test

Our main goal is to estimate the reaction function relating one country's tax to its neighbor's tax in two different situations: where a country is in a federation with a transfer mechanism like the one outlined in the previous section; and where no transfer mechanism exists. We find both situations in Canada, where there is an equalization system but not all the provinces are affected.

The Canadian equalization transfer is computed by using 33 tax bases. Equalization entitlements are computed for each of the 33 separate revenue categories. A jurisdisdiction's per-capita entitlement in a revenue category is equal to its per-capita tax-base deficiency in the category relative to a standard multiplied by the national average tax-rate for the category.[11] Equalization entitlements are summed over all revenue categories: jurisdictions with positive total entitlement receive a transfer of that amount from the federal government, whereas jurisdictions with negative total entitlement receive no transfer. Therefore the provinces that receive the transfer are the only ones that are affected by the equalization formula.

The transfer set out in our theoretical model is very similar to that used in Canada. In the Canadian system α is the federation average tax-rate and 1 is the per-capita standard tax base. We are simplifying things, by assuming that α and 1 are given for country 1 (Smart, 1998). This can be justified by thinking that the jurisdictions are small relative to the federation in terms of contribution to the total revenue and therefore have only negligible effects on national averages.[12] The stylized transfer in (10) differs from the Canadian one because it is linked to the endowment level of the country. The total entitlement of country 1 is a quota α of the sum of the mobile tax-base deficiency plus the income endowment deficiency. If this total entitlement is positive country 1 gets the transfer.

Notice that in our simple model the entitlement from the Canadian equalization formula would be just a quota α of the mobile tax-base deficiency, since the mobile good is the only one taxed locally.

However, even if we are interested in shedding light on the tax-choice behaviour on the mobile good, we think that the aggregate feature of the equalizing mechanism is important in determining whether a Canadian province receives the transfer. We capture the aggregate feature mantaining the simple structure of the model with one taxed mobile good by including an entitlement related to the income endowment; we set the relation between the standard income endowment and the income endowment in each country,

[11] The standard is the average per-capita tax base of five provinces: Quebec, Ontario, Manitoba, Saskatchewan and British Columbia.

[12] If each province is aware of the structure of the equalization rate, it can be induced to increase its tax rate, making its revenue rise because the national average tax rate will rise. "To the extent that this effect is significant, a province might be induced to exploit it by changing its tax-rate....This is the so called "tax back" problem....*For most provinces and most tax-bases this is not an issue. Only if the province makes up a significant proportion of the tax-base will it be important*....It is most likely to arise in the case of resources that are found in very few provinces. Examples where this might occur include potash in Saskatchewan, asbestos in Quebec, and offshore oil and natural gas in Newfoundland or Nova Scotia" (Boadway, 1998). The same argument can be used to argue that each province will not choose its tax rate to modify the standard tax base.

such that if the country is rich it will not get the transfer, while if it is poor it always gets the transfer, whatever its tax-rate on the mobile tax base. The rationale linking this theoretical property to the Canadian framework is that a poor Canadian province has presumably lower per-capita total tax-base, than a rich one does and so is entitled to the transfer, regardless of its specific mobile tax-revenue entitlement.

In our empirical case, the item we consider is the tax on cigarettes.

In Canada after 1982 an equalization ceiling was introduced. It is computed as percentage of GNP: when it applies, payments to the recipient provinces are scaled back to ceiling totals with the national reductions shared equally among the recipient provinces, according to population. In our model with discrete demand for the locally taxed good there can be a tax so high that no consumer is available to buy the good. The transfer mechanism, as designed in the model, punishes the unvirtuous province, denying any transfer. This transfer mechanism is very similar in terms of effects to the real one: if the taxation level in the recipient provinces is unbearably high, so as to depress the economy (people decide not to buy the good anymore), the ceiling (computed as percentage of GNP) will very likely be binding on equalization transfers, reducing them severely. In our model to make things simple when in the "recipient" country taxation is very high and so federal GNP very depressed, the recipient does not get any transfer.

We can split the Canadian provinces into those whose budget constraint is not affected by the equalization formula (Alberta, Ontario, British Columbia and Saskatchewan for the period 1984-85) and those that are affected (Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Manitoba and Saskatchewan for the period 1986-94).

In order to isolate the independent impact of the neighboring tax rates on the tax rate of a Canadian province, one must also take other variables factor into account, that might affect the provincial tax rate. First of all we control for the US neighboring tax rates.

Moreover the province's tax rate on commodities depends on several other types of variables. Provincial taxation can be influenced by economic and demographic environment. We controlled for it by using the following variables: population, density, per-capita income, per capita GDP, unemployment rate, proportion of population over 65, total expenditure over GDP. We take account of the federal fiscal instruments, which can differ from province to province, by using federal grants-in-aid in relation to total population and the federal income tax, collected in each province, normalized with GDP.

For the previous variables we computed the corresponding mean variables of the neighboring Canadian provinces and neighboring US states to each Canadian province.

The political colour of the provincial government can also affect the tax-rate level: we divided the Canadian party system in three main groups: the Progressive-Conservative, which is right wing, the Liberal, which is center, and a left wing group, composed by the New Democratic Party, the Parti Québecois and the Social Credit Party. We then built dummies for the the provincial premier's membership in each of the three groups and variables accounting for the percentage in the legislature of the three political groups.

There are certain unchanging characteristics of a province that are likely to affect its fiscal system, such as climate and geography. We take these characteristics into account by including a dichotomous variable for each province.

Changes in the macroeconomic situation can affect all provinces' fiscal policy. To account for this, we use a dichotomous variable for each year. In our context these effects are very important because in the years 1984-94 there was an increasingly severe federal no-smoking policy which led to massive increases in the tax-rate on cigarettes. This was followed by a very great increase in cigarettes exports year by year.

We estimate the following equation:

$$t_{st} = \alpha_s + \beta_t + \delta_1 h_{st} + \delta_2 v_{st} + \delta_3 EXPE_{st} + \vartheta x_{st} + \epsilon_{st} \tag{16}$$

t_{st} is the tax rate for province s and year t; α_s are province-fixed effects; β_t are dummies that pick up macro-shock and common changes in fiscal policy; x_{st} is a vector of province-specific time-varying shocks; h_{st} is the average tax rate of the neighboring provinces in year t; v_{st} is the average tax-rates of the neighboring US states in year t; $EXPE_{st}$ is the ratio of the total provincial public expenditure to GDP in year t; ϵ_{st} is the error term.

4.1 Hypotheses

Equation (16) estimates the tax-rate reaction function coefficient without any distinction between tax regimes or between equalized and unequalized provinces. From proposition 4, we expect δ_1 to be positive and significant. We next estimate $\delta_1 = \gamma_1 + \gamma_2 \lambda\psi + \gamma_3 (1 - \lambda)(1 - \psi) + \gamma_4 \lambda (1 - \psi)$, where ψ is a dummy equal to 1 for the provinces where $t_{st} > h_{st}$ and λ is a dummy equal to 1 for the provinces where the equalizing system acts. In this case γ_1 is the slope of the tax-rate reaction function in the case $t_{st} > h_{st}$ and province s is not receiving the equalization transfer, and $\gamma_1 + \gamma_3$ is the slope of the tax-rate reaction function in the case $t_{st} < h_{st}$ and province s is not receiving the equalization transfer. We check proposition 5 by testing the inequality $\gamma_1 > \gamma_1 + \gamma_3$, which holds if γ_3 is negative. If this test is successful it makes sense to test the effect of the equalization system on the reaction function, assuming, as we do in the theory, that the cross-border shopping cost is concave in distance from the border.

We then estimate $\delta_1 = \zeta_1 + \zeta_2\lambda\psi + \zeta_3(1-\lambda)\psi$. In this case $\zeta_1 + \zeta_2$ is the slope of the tax-rate reaction function in the case $t_{st} > h_{st}$ and province s is receiving the equalization transfer; $\zeta_1 + \zeta_3$ is the slope of the tax-rate reaction function in the case $t_{st} > h_{st}$ and province s is not receiving the equalization transfer. From part a) of proposition 6 we expect $\zeta_2 < \zeta_3$.

To complete the test of proposition 6 we estimate $\delta_1 = \kappa_1 + \kappa_2\lambda(1-\psi) + \kappa_3(1-\lambda)(1-\psi)$, where $\kappa_1 + \kappa_2$ is the slope of the tax-rate reaction function in the case $t_{st} < h_{st}$ and province s is receiving the equalization transfer; $\kappa_1 + \kappa_3$ is the slope of the tax-rate reaction function in the case $t_{st} < h_{st}$ and province s is not receiving the transfer. From part b) of proposition 6 we expect that $\kappa_2 > \kappa_3$.

Finally we look again at $\delta_1 = \gamma_1 + \gamma_2\lambda\psi + \gamma_3(1-\lambda)(1-\psi) + \gamma_4\lambda(1-\psi)$. This decomposition allows to test part c) of proposition 6. We test in fact $(\gamma_1 + \gamma_2) - (\gamma_1 + \gamma_4) < \gamma_1 - (\gamma_1 + \gamma_3)$. The intuition for this inequality is that the equalization system offsets the role of the cost function in the reaction function slope. Notice that the previous two tests establish that the equalization transfer decreases the tax-rate reaction function slope when $t_{st} > h_{st}$, and increases it when $t_{st} < h_{st}$ therefore in this last test we ask whether these effects on the reaction function slope are confirmed by the fact that the difference between the two slopes when $t_{st} > h_{st}$ and $t_{st} < h_{st}$ decreases when the equalization transfer holds.

4.2 Tax rates

We used annual data on the provinces and US states for the years 1984 through 1994.[13] Cigarettes in Canada and United States are normally subject to *ad valorem* general sales taxes as well as unit taxes. We use a total real unit

[13] All the variables are defined in table 1 and described in detail in the data appendix.

tax rate, calculated by taking the unit-tax equivalent of the general sales tax (the general sales tax rate times price), adding this to the unit tax, and then dividing by the CPI to adjust for inflation. We divide the Canadian tax rates by the PPP index to express them in US dollars. We compute these total tax rates for the US using tax rates from ACIR annual reports.[14] We take total tax rates for Canada from the web site of the National Clearinghouse on Tobacco and Health for Canada.

We used total tax rates because in setting unit taxes on cigarettes, provinces also take into account the general sales taxes levied on them, which also influence the tax-inclusive prices.

Taxes on cigarettes vary among Canadian provinces. In 1991 PEI provincial taxes on a pack 20 cigarettes were \$1.80 (in Canadian dollars), New Brunswick \$2.50, Nova Scotia \$1.85, Québec \$1.52, Ontario \$1.66, Newfoundland \$1.97, Saskatchewan \$1.66, Manitoba \$1.94, Alberta \$1.40, British Columbia \$1.60.

As noted above, our main focus is on the different relationship between provincial cigarette tax rates and those in neighboring provinces. We estimate the neighboring tax rates by taking the mean of the neighboring Canadian provinces (h_{st}), dividing them by the CPI and PPP index. We do the same for the neighboring US states' tax rates (v_{st}).

4.3 Other variables

There is a set of time-varying variables economic and demographic variables: the province's population (POP_{st}), population density ($DENS_{st}$), unemployment rate ($UNEMP_{st}$), proportion of individuals over 65 ($AGED_{st}$) and per-capita income in 1989 US dollars (INC_{st}) , federal per-capita grant-in-aid in 1989 US dollars ($GRANT_{st}$), per-capita GDP in 1989 US dollars (GDP_{st}) and federal tax revenue on GDP ($INCTAX_{st}$). We computed the corresponding neighboring variables for Canada and the US by taking the mean of the variables of the Canadian provinces or US states that border the province s. Moreover we also have time varying political variables: two dichotomous variables (premier is democrat-conservative or liberal), the proportion of the Progressive-Conservative party in the provincial legislature ($PROG-CONS$), the proportion of the Liberal party in the provincial legislature ($LIBERAL$) and the proportion of the New Democratic, Quebec

[14]See the data appendix for web-site details.

and Social Credit parties ($LEFT$).

4.4 Estimation Strategy

We face a system of six simultaneous equations: three from the solution of the optimal tax problem of country 1, which determines t_1, g_1 and μ_1, for a given t_2; and three from the symmetric tax problem solved by country 2, which determines t_2, g_2 and μ_2, for a given t_1. In the empirical specification we can think of t_1 as the Canadian province tax-rate (t_{st}) and t_2 as the mean of the neighboring province tax rates (h_{st}). By using not all the neighboring variables but just the mean, we reduce the empirical situation to a two-country problem: each country competes with one fictitious (average) neighboring country.

Like all studies of social interactions, this economic framework suffers from an identification problem of the model's structural equations and a simultaneity bias of the standard errors of the equation estimated. The issues arise because tax-rate interactions are symmetric, in the sense that each country's behavior affects that of its neighbors in the same way, the neighboring countries behavior affects the country's own behavior, which feeds back again on the neighbors.

We tackle these two problems firstly by identifying one of these six equations, specifically equation (13); and secondly, by instrumenting the endogenous variables to cope with the endogeneity bias. In this equation we have two endogenous variables, the average neighboring tax rate, t_2, and the marginal cost of public funds, μ_1. If we want to correctly identify and estimate (13), we need variables which are correlated to t_2 and μ_1, but not to t_1.

If, for example, we want to estimate equation (16) when $\delta_1 = \gamma_1 + \gamma_2 \lambda\psi + \gamma_3 (1-\lambda)(1-\psi) + \gamma_4 \lambda (1-\psi)$, we face the following system:

$$h_{st} = \varepsilon_s + \vartheta_t + \sigma_1 x_{st} + \sigma_2 z_{st} + \epsilon_{1st} \tag{17}$$

$$\lambda\psi h_{st} = \eta_s + \iota_t + \eta_1 x_{st} + \eta_2 z_{st} + \epsilon_{2st} \tag{18}$$

$$(1-\lambda)(1-\psi) h_{st} = \tau_s + \xi_t + \varkappa_1 x_{st} + \varkappa_2 z_{st} + \epsilon_{3st} \tag{19}$$

$$\lambda (1-\psi) h_{st} = \pi_s + \varpi_t + \theta_1 x_{st} + \theta_2 z_{st} + \epsilon_{4st} \tag{20}$$

$$EXPE_{st} = \sigma_s + \varrho_t + \varsigma_1 x_{st} + \varsigma_2 z_{st} + \epsilon_{5st} \tag{21}$$

$$v_{st} = \upsilon_s + \varphi_t + \rho_1 x_{st} + \rho_2 z_{st} + \epsilon_{6st} \tag{22}$$

$$t_{st} = \alpha_s + \beta_t + \gamma_1 h_{st} + \gamma_2 \lambda\psi h_{st} + \gamma_3 (1-\lambda)(1-\psi) h_{st} + \gamma_4 \lambda (1-\psi) h_{st} \quad (23)$$

$$\gamma_5 EXPE_{st} + \gamma_6 v_{st} + \phi x_{st} + \epsilon_{7st}$$

Where x_{st} and z_{st} are all the covariates of the system. The $z_{st}s$ are those that affect h_{st}, $\lambda\psi h_{st}$, $(1-\lambda)(1-\psi) h_{st}$, $\lambda (1-\psi) h_{st}$, $EXPE_{st}$ and v_{st}, but are uncorrelated with t_{st}.

Equations (17), (18), (19), (20) are respectively the reduced-form equations of the mean Canadian neighboring tax rate, of its interactions with the case when $t_{st} > h_{st}$ and the equalization is acting, $t_{st} < h_{st}$ and the equalization is not acting, $t_{st} < h_{st}$ and the equalization is acting; equation (21) is the reduced form of the marginal cost of public funds, which we proxied with total government expenditure over GDP ($EXPE_{st}$), using the first order condition of the theoretical model relative to the optimal choice of the public good.[15]

Equation (22) is the reduced form of the mean neighboring US tax rate: we consider the possibility that the province's tax-rate may be influenced by the neighboring US rates: eight out of the ten provinces considered border the US. This variable could clearly be endogenous: the US rate mean can also be influenced by the Canadian province.

Finally, equation (23) is the structural equation of the province tax rate.

If this is the structural model it is clear that a simple OLS estimate of (23) would suffer from endogeneity and measurement error bias: the error term ϵ_{7st} would be correlated with ϵ_{1st}, ϵ_{2st}, ϵ_{3st}, ϵ_{4st}, ϵ_{5st} and ϵ_{6st}. The endogeneity bias comes from the fact that we are dealing with simultaneous equations; the measurement error bias comes from the fact that we have no exact measure of the marginal cost of public funds μ, which we have had to proxy. We use the two-stage least squares method: first we estimate the reduced forms (17), (18), (19), (20), (21), (22) and then we substitute their fitted value into (23). The same reasoning holds if we want to estimate δ_1 disaggregated differently, depending on which hypotheses we want to test (see section 4.1).

The residuals of this last equation are corrected by using the actual values

[15] The first order condition of (12) with respect to g is:

$$\frac{\partial L}{\partial g} = \frac{\gamma_1}{g} - \mu = 0$$

of the endogenous variables.[16]

4.4.1 Instrumentation

The vector z is composed of 11 variables, which allows us to identify equation (23), which has six endogenous variables. Moreover we argue that these $z_{st}s$ variables are uncorrelated with t_{st} and so good instruments for the endogenous variables.

We instrumented the mean Canadian neighboring tax rate h_{st}, $\lambda\psi h_{st}$, $(1-\lambda)(1-\psi)h_{st}$, $\lambda(1-\psi)h_{st}$, with the neighboring Canadian variables (see data appendix) for POP_{st}, $AGED_{st}$, $INCTAX_{st}$.

The level of taxation, and in a reduced form equation also the tax rate on cigarettes, is in fact normally linked to the size and density of population: these variables influence the available tax base and the cost of public goods. Moreover age structure influences taxation, according to the relative preference for policies for youth (education, say) or the elderly (health). It is reasonable to think that these variables do not affect the neighboring province' s tax-rate on cigarettes. The inclusion of $INCTAX_{st}$ is explained by the fact that the federal income tax can influence the provincial tax and therefore provincial taxes on cigarettes in a reduced form equation. (Besley, Rosen, 1998)

We instrumented the mean US neighboring state tax-rate with the same corresponding variables.

The Canadian and US neighboring variable for $INCTAX_{st}$ can also be a proxy for local time-varying shocks from neighboring provinces (business cycle) and could affect t_{st}. In this case it would be a missing variable in the second stage equation, which would bias all the coefficients. To avoid this, we control for some other neighboring variables that could pick up the same business cycle effect as $INCTAX$: the neighboring Canadian variables for INC_{st} and its square, $GRANT_{st}$,$UNEMP_{st}$, GDP_{st}; and symmetric variables for the neighboring US states.

Finally, we instrumented $EXPE_{st}$ with $GRANT_{st}$, $INCTAX_{st}$. These variables are all important in determining the tax rate on cigarettes, not

[16] The two-stage least square strategy would deliver residuals using the fitted values of the endogenous variables. Since we are estimating the structural model, we are interested in the residuals using the actual values of the endogenous variables.

We execute the procedure, by using the *ivreg* command of STATA, which already gives the corrected residuals with the actual values of the endogenous variables.

directly, but indirectly through the level of public expenditure. The level of total revenue and of total expenditure is higher, the higher $GRANT_{st}$ is[17]: the more grant a province receives, the higher its public expenditure is for a given level of taxation. The inclusion of $INCTAX_{st}$ is because the federal income tax can influence the provincial income tax and therefore total provincial revenue, which of course is closely correlated with total expenditure. We also included the political variables for the relative strenght of the various groups: $(PROG-CONS)$, $(LIBERALS)$ and $(LEFT)$. It is reasonable to expect public expenditure policies to differ with the political majority.

It is important to notice that $GRANT_{st}$ and $INCTAX_{st}$ can also proxy time-varying provincial shocks (business cycle) and so result in missing variables in the second stage equation. We control for this in the second stage equation, using $UNEMP_{st}$, INC_{st} and its square, and GDP_{st}. The political variables could also influence the choice of the cigarette tax rate, so in the second stage equation we control for dummies for the political colour of the premier, which are closely related with the political instruments and so pick up the same political effect.

Moreover, in the second stage equation we also control for POP_{st} and its square, $AGED_{st}$ and $DENS_{st}$. We control finally for year and province effects.

After performing the two stage least square regressions we test the validity of the instrument, regressing the residuals from the second stage equation on the instruments and all the exogenous variables and running an F-test on the joint significance of the instruments.

An identical procedure is adopted to instrument the endogenous variables when δ_1 is aggregated, $\delta_1 = \chi_1\psi + \chi_2(1-\psi)$, $\delta_1 = \zeta_1 + \zeta_2\lambda\psi + \zeta_3(1-\lambda)\psi$ and $\delta_1 = \kappa_1 + \kappa_2\lambda(1-\psi) + \kappa_3(1-\lambda)(1-\psi)$. In all these cases the endogenous variables are fewer than six, and as the instruments are 11, the coefficients are all identified.

4.5 Results

We start by regressing the own tax rate in each province on the mean of the neighboring Canadian tax-rates. The own tax rate is strongly correlated

[17] In Besley Rosen (1998) these variables appear on the right hand side of their regression because they estimate an equation, that in our framework corresponds to a reduced form of the simultaneous equation system. They do not include any proxy for the marginal cost of public funds.

with the mean of the neighboring Canadian province rates. The coefficient is 0.69 and very significant (t-student=7.37).

In table 2 we regress the tax rate on the control variables, with and without year and province effects. In column 1 (without year and province effects), population is significant and has a negative sign: the larger it is, the tax base liability and the lower the rate necessary to satisfy the budget constraint for a given marginal cost of public funds. Per-capita income, although not significant in this regression, is negatively related to the tax rate: the higher it is, the lower the necessity to raise the tax rate to cope with the budget constraint. If we control for the year and province effects (column 3, tab. 2), the sign of this relation (tax rate with per-capita income) is the same for the corresponding neighboring Canadian variables. But it is instead interesting to notice that it is the opposite for the corresponding neighboring US variables: the higher the neighboring per-capita income, the higher the Canadian tax rate. It seems that the larger the tax base of a US neighboring state, the smaller is that of the Canadian province. This could suggest that growth in the economy of a bordering US state does not induce growth spill-over in the neighboring Canadian province, but might drain labour and capital resources.

Notice that all the year effects are positive and significant (column 2, tab 2). They reflect a strong federal antismoking policy, which led the Canadian government to raise each year the federal tax on cigarettes year after year (this positive sign is consistent with a recent result on vertical fiscal externalities in Besley, Rosen (1998)).

In table 3 we first run (col.1) the OLS regression on the aggregated mean of the neighboring Canadian tax-rates: we get a positive but not significant coefficient. When we instrument and use the two stage least square method (col.2, table 3), the previous coefficient becomes significant (t=2.35) and continues to be positive: if the average neighboring province increases its tax-rate by 1, each Canadian province will increase its own tax rate by 0.8. The overidentification test is passed ($Prob > F = 0.86$). This first test confirms first that in Canada there is cigarette tax competition and second that the slope of the reaction function is positive (proposition 5).

If we split the reaction function coefficient (col.4 of tab.3), we find that a province with a higher tax rate than its neighbor seems not to have a different reaction to a neighboring change in tax than if it had a lower rate: the coefficient $\chi_2 = 0.002$ is not significant. This means that apparently there is no difference in the reaction function slopes between the two tax regimes $t_{st} > h_{st}$ and $t_{st} < h_{st}$. However, to test proposition 5 correctly we need to look at the reaction function slopes in the case when no-equalization holds, which is exactly one of the assumptions of proposition 5.

Therefore we further split the reaction function coefficient (col. 1 of tab.4) in the neighboring Canadian tax rate mean (γ_1), its interactions with the case when $t_{st} > h_{st}$ and equalization is acting ($\gamma_1+\gamma_2$), $t_{st} < h_{st}$ and equalization not acting ($\gamma_1 + \gamma_3$), $t_{st} < h_{st}$ and equalization is acting ($\gamma_1 + \gamma_4$). We are interested in comparing γ_1, which alone accounts for the case when $t_{st} > h_{st}$ and equalization is not acting, with ($\gamma_1 + \gamma_3$). Interestingly $\gamma_1 > \gamma_1 + \gamma_3$. In fact both coefficients are significant at more than 5% with $\gamma_1 = 1.911$ and $\gamma_3 = -1.45$.

The particular business cycle relation between a Canadian province and its US neighbor is also confirmed. The overidentification test is passed ($Prob > F = 0.99$).

In column 2 of table 4 we run a regression of the tax-rate on the mean of the neighboring Canadian tax rates plus two interactions: one with a dummy for a tax rate that is higher than the mean of the neighboring Canadian tax rates and the equalization system is acting, and the other with a dummy for a tax rate that is higher than the mean of the neighboring Canadian tax rates and no equalization holds. It is very interesting to see that the cross-border technology effect is significant at more than 5% when the equalization transfer does not affect the province ($\zeta_3 = 1.431$); when the equalization transfer affects the province, the effect is not significant: ζ_2 is not significant. Notice that in the $t_{st} > h_{st}$ regime the tax-rate reaction function coefficient ($\zeta_1+\zeta_3$) is significantly higher since (ζ_2 is not significant) than the reaction function coefficient in the tax-regime $t_{st} < h_{st}$ (in this case the relevant coefficient is ζ_1). This result is entirely due to the provinces that are not affected by the equalization transfer; in fact in the tax regime $t_{st} > h_{st}$ the coefficient of the provinces affected by the equalization transfer ($\zeta_1 + \zeta_2$) is not significantly different (since ζ_2 is not significant) from the aggregated coefficient relative to the tax regime $t_{st} < h_{st}$ (ζ_1). This goes exactly in the same direction of our theory: in the tax regime $t_{st} > h_{st}$ when the equalization transfer acts, the slope of the reaction function is lower than in the case when there is no-equalization (part (a) of proposition 6). The overidentification test is passed (Prob>F=0.98).

In column 3 of table 4 we run a regression of the tax rate on the mean of the neighboring Canadian rates plus two interactions: one with a dummy for a tax rate lower than the mean of the neighboring Canadian rates and the equalization system is acting, and the other with a dummy for a tax rate lower than the mean of the neighboring Canadian rates and no equalization. Also in this case, the cross-border shopping technology effect is significant at more than 5% when there is no equalization transfer ($\kappa_3 = -1.199$); when the transfer does affect the province, the effect is not significant: κ_2 is not significant. Also in this second case, the fact that the tax-rate reaction function coefficient ($\kappa_1 + \kappa_3$) in the $t_{st} < h_{st}$ regime is lower than when the tax-regime is $t_{st} > h_{st}$ (κ_1) is caused by the provinces that are not affected by the equalization transfer. Therefore in the tax-regime $t_{st} < h_{st}$ where the equalization transfer acts, the slope of the tax-rate reaction function is higher than when there is no equalization (part (b) of proposition 6). The overidentification test is passed in this regression (Prob>F=0.99).

We finally come back to column 2 of table 4 and test part (c) of proposition 6. It interesting to notice that, as γ_2 and γ_4 are not significant, there is no difference in the reaction function slopes between the case $t_{st} > h_{st}$ and $t_{st} < h_{st}$, when equalization holds. Moreover $\gamma_3 = -1.45$ is significant more than 5%. Notice that -γ_3 is the difference in the reaction function slopes ($\gamma_1 - (\gamma_1 + \gamma_3)$) between the case $t_{st} > h_{st}$ and $t_{st} < h_{st}$, when equalization does not hold. This confirms that the result of part (c) of proposition 6 is due to the equalization system, which offsets the technological consumption factor in the difference in the coefficient reaction functions: when the equalization system acts, the difference between the coefficients in the two regimes ($t_{st} > h_{st}$ and $t_{st} < h_{st}$) disappears.

5 Conclusions

First we theoretically assess the effect of an equalization transfer in a model with tax-competition on a mobile good. We show that in this context an equalization transfer has welfare properties similar to a compensation transfer. The introduction of an equalization transfer, based on fiscal capacity, can affect the first order conditions, by changing the magnitude of the fiscal externality. For a given marginal cost of public funds each country, given the tax rate of the other, chooses a higher rate if an equalization transfer holds.

We test whether the provincial governments are aware of this property of the transfer by looking at how each province changes its tax rate if the neighboring provinces change theirs. We derive the reaction function slopes according to four different complementary tax-rate and transfer regimes, assuming a concave cross-border shopping cost in the distance from the border.

Analysing the changes in the reaction function slopes, we can test what the theory predicts, if the equalization transfer is introduced.

The paper develops a test of the theoretical result by using a data-set for Canada and US running from 1984 to 1994 with sales taxes and specific cigarettes taxes. The test confirms the concavity of the cross-border shopping cost function and shows that the introduction of an equalization transfer decreases the fiscal externality due to tax-base mobility.

Several extensions of this work are possible. On theoretical grounds it would be important to model a stage where the federal government decides how to allocate the transfers to the local governments. The equilibrium transfers could be very different depending on whether the central government is maximizing a representative federal welfare function or is maximizing its re-election chances. In this last case the federal government would use the transfers to discriminate between political allies and adversary administrations.

On the empirical side, it would be useful to collect data on border densities and border lengths. It is reasonable to think that each state fixes its tax rate, being aware of the neighboring rates, where population density near the border and the length of the border are greater. Finally an interesting empirical application to the Canada-US border could be a robustness check for yardstick competition in the US: when a governor runs for election, fiscal externality due to yardstick competition should hold between neighboring states in the US but not between a US state and a Canadian province. It is hard to relate a political party in another nation to one's own state incumbent.

References

[1] Baltagi, B. H. and Levin D. (1992), Cigarettes Taxation: Raising Revenues and Reducing Consumption, Structural Change and Economic Dynamics 2, 321-336.

[2] Besley, T. and H. S. Rosen (1998), Vertical externalities in tax setting: evidence from gasoline and cigarettes, Journal of Public Economics 70, 383-398.

[3] Besley, T. and A. Case (1995), Incumbent Behavior: Vote Seeking, Tax Setting and Yardstick Competition, American Economic Review 85, 25-45.

[4] Besley, T. and Coate S. (2000), Elected versus Appointed Regulators: Theory and Evidence, mimeo, STICERD-LSE, London.

[5] Besley T., Griffith R., Klemm A. (2001), Empirical Evidence on Fiscal Interdependence in OECD Countries, presented at the IFS conference "World Tax Competition", May 24-25, 2001.

[6] Bird, R. M. and E. Slack (1990), Equalization: the Representative Tax System Revisited, Canadian Tax Journal 38, 913-927.

[7] Boadway, R. and M. Keen (1996), Efficiency and The Optimal Direction of Federal-State Transfers, International Tax and Public Finance 3, 137-155

[8] Boadway, R. (1998), The Economics of Equalization: an Overview, in R. Boadway and P. Hobson (ed.), Equalization: its Contribution to Canada's Economic and Fiscal Progress (John Deutsch Institute for the Study of Economic Policy Queen's University).

[9] Boadway, R. and M. Hayashi (2002), An Empirical Analysis of Intergovernmental Tax Interaction: the Case of Business Income Taxes in Canada, Canadian Journal of Economics, 34, 481-503.

[10] Bordignon M., Manasse P., Tabellini G. (2001), Optimal Regional Redistribution under Asymmetric Information, American Economic Review 91, 709-723.

[11] Bucovetsky, S. and M. Smart (2002), The Efficiency Consequences of Local Revenue Equalization: Tax Competition and Tax Distortions, mimeo, University of Toronto, Toronto.

[12] Commission of the European Communities (1985), Completing the Internal Market, COM(85) 310, Brussels.

[13] Commission of the European Communities (1996), A Common System of VAT: A Program for the Single Market, COM(96) 328 Final, Brussels.

[14] Dahlby, B. and S. Wilson (1994), Fiscal Capacity, Tax Effort and Optimal Equalization Grants, Canadian Journal of Economics 27, 657-672.

[15] Dalbhy, B. (1996), Fiscal Externalities and the Design of Intergovernmental Grants, International Tax and Public Finance 3, 397-412.

[16] Devereux M., Griffith R., Klemm A. (2001), Have Taxes on Mobile Capital Declined?, presented at the IFS conference "World Tax Competition", May 24-25, 2001.

[17] Devereux M., Lockwood B., Redoano M. (2001), Do Countries Compete over Corporate Tax Rates?, presented at the IFS conference "World Tax Competition", May 24-25, 2001.

[18] Dhillon A., Perroni C., Scharf K. A. (1999) Implementing Tax Coordination, Journal Public Economics 72, 243-268.

[19] Esteller-Moré A. and A. Solé-Ollé (2002), Tax Setting in a Federal System: The Case of Personal Income Taxation in Canada, International Tax and Public Finance, 9, 235-257.

[20] Fitz Gerald J., Johnston J., Williams J. (1995), Indirect Tax Distortion in a Europe of Shopkeepers, ESRI working paper n.56, Dublin.

[21] Kanbur, R. and M. Keen, (1993), Jeux sans Frontiers: Tax Competition and Tax Coordination when Countries Differ in Size, American Economic Review, 83, 887-892.

[22] Keen, M. (1989), Pareto Improving Indirect Tax Harmonization, European Economic Review 33, 1-12.

[23] Keen, M. and S. Smith (1996), The Future of VAT in the European Union, Economic Policy 23, 373-411

[24] Köthenbürger, M (2002), Tax Competition and Fiscal Equalization, International Tax and Public Finance, 9, 391-408.

[25] Lee, C., M. Pearson and S. Smith (1988) Fiscal Harmonization: an Analysis of the European Commission's Proposals, Institute for Fiscal Studies Report series n.28, Institute for Fiscal Studies, London

[26] Lockwood, B. (1993), Commodity Tax Competition under Destination and Origin Principles, Journal of Public Economics 32, 141-162.

[27] Lockwood, B. (2001), Tax Competition and Tax Co-ordination under Destiantion and Origin Principle: a Synthesis, Journal of Public Economics, August 2001.

[28] Manski, C. (1993), Identification of Endogenous Social Effects: The Reflection Problem, Review of Economics Studies 60, 531-542.

[29] Mintz, J. and Tulkens, H. (1986), Commodity Tax Competition between Member States of a Federation: Equilibrium and Efficiency, Journal of Public Economics 29, 133-172.

[30] Rizzo, L. (2002), "Equalization and Tax Competition: Theory and Evidence", in Proceedings of the 2002 North American Summer Meetings of the Econometric Society: Urban and Public Economics, edited by D. K. Levine, W. Zame, R. Gordon, T. McGuire, J. Rust, http://www.dklevine.com/proceedings/urban-and-public.html.

[31] Smart, M. (1998) Taxation and deadweight loss in a system of intergovernmental transfers, Canadian, Journal of Economics, XXXI, n.1.

[32] Scharf, K. A. (1999) Scale Economies in Cross-Border Shopping and Commodity Taxation, International Tax and Public Finance 6, 89-99

[33] Wellish, D. (2000) Theory of Public Finance in a Federal State, Cambridge University Press, Cambridge.

[34] Wildasin, D. E. (1988), Nash Equilibria in Models of Fiscal Competition, Journal of Public Economics 35, 229-240.

[35] Wildasin, D. E. (1991), Income Redistribution in a Common Market, American Economic Review 81, 757-774.

[36] Wilson, J. D. (1991), Tax Competition with Interregional Differences in Factor Endowments, Journal of Urban Economics 21, 423-451.

[37] Wilson, J.D. (1999), Theories of tax competition, National Tax Journal, vol. 52, pp. 269-304.

[38] Wooders, M.H., Zissimos B., Dhillon A. (2002), Tax Competition Reconsidered, Warwick Economic Research Papers, Warwick.

6 Data Appendix

t_{st} is the Canadian cigarette tax rate, inclusive of general sales tax, for province s in year t, divided by the CPI and PPP index. These rates are downloaded from www.cctc.ca, which is the web site of the National Clearinghouse on Tobacco and Health for Canada: the tax rates are already provided as the sum of the unit tax-equivalent of the general sales tax plus the unit tax-rate. They are expressed in Canadian dollars per pack of 20.

6.1 Endogenous variables

h_{st} is the mean of the tax rates in year t of the Canadian provinces neighboring on province s, divided by the CPI and PPP index.

The tax rates on cigarettes for the United States are taken from www.library.unt.edu/gpo/acir/acir.html: they are expressed in US dollars per pack of 20 cigarettes. Tax rates on sales are also taken from www.library.unt.edu/gpo/acir/acir.html: they are expressed in percentage of the price. The final tax rate is calculated by taking the unit-tax equivalent of the general sales tax (which is obtained multiplying the general sales tax-rate by the price), adding this to the unit tax-rate. The variable v_{st} is the mean of the tax rates of the US states neighboring province s in year t.

$EXPE_{st}$ is the total province expenditure divided by the GDP for province s in year t. Total province expenditure comes from www.statcan.ca for Canada.

6.2 Demographic and economic variables

POP_{st} is the number of persons in province s in year t. It comes from www.statcan.ca for Canada and www.census.gov for the United States.

$DENS_{st}$ is calculated as the total population (POP_{st}) divided by the area for province s in year t. Areas are expressed in square miles: for Canada from www.statcan.ca/english/Pgdb/Land/Geography/phys01.htm and for the US from http://quickfacts.census.gov/qfd/index.html.

$AGED_{st}$ is the ratio of individuals who are over 65 to the total population of province s in year t. The number of individuals who are over 65 comes from www.statcan.ca for Canada and www.census.gov for the United States.

$UNEMP_{st}$ unemployment rate for province s in year t. From www.statcan.ca for Canada and from www.stats.bls.gov for the US.

INC_{st} per-capita income for province s in year t divided by the CPI and PPP index. Income comes from www.statcan.ca for Canada and from www.bea.doc.gov for the US.

$GRANT_{st}$ federal grant-in-aid over GDP for province s in year t. Federal grant-in-aid comes for the US from "Federal Expenditures by State" which is part of the Consolidated Federal Funds Reports program from US Census Bureau and for Canada from www.statcan.ca.

GDP_{st} per-capita GDP for province s in year t. GDP comes from www.statcan.ca for Canada and www.bea.doc.gov for the US.

$INCTAX_{st}$ federal tax revenue over GDP for province s in year t. Federal tax-revenue comes from www.statcan.ca for Canada and from www.bea.doc.gov for the US.

$PROG - CONS_{st}$ percentage of the Progressive Conservative in the provincial legislature. From http://www.swishweb.com/Politics/Canada.

$LIBERAL_{st}$ percentage of the Liberal Party in the provincial legislature. From http://www.swishweb.com/Politics/Canada.

$LEFT_{st}$ percentage of New Democratic, Quebec and Social Credit parties in the provincial legislature. From http://www.swishweb.com/Politics/Canada.

Moreover we computed two dichotomous variables to account for the party of the premier (Progressive Conservative and Liberal).

From http://www.swishweb.com/Politics/Canada.

The PPP (Parity Purchasing Power) index for Canada-US was downloaded by the OECD web site.

US cigarettes price per pack comes from The Federal Tax Burden on Cigarettes, Vol. 27, 1996.

The CPI comes from the Statistical Abstracts of the United States (2000).

6.3 The neighboring variables

For all the demographic and economic variables we compute the neighboring Canadian and United States variables. A neighboring Canadian variable for province s in year t is computed as the mean of the variable in all the Canadian provinces neighboring province s in year t. The neighboring Canadian x variable is defined as: $C\ NEIGH\ x$.

A neighboring United States variable for province s in year t is computed as the mean of the variable in all the US states neighboring province s in year t. The neighboring United States x variable is defined as: $US\ NEIGH$ x.

An example: suppose there are four neighboring provinces (we define them as $n = 2, 3, 4, 5$), then the neighboring Canadian x_{st} variable for province 1 in year t would be:

$$C\ NEIGH\ x_{1t} = \frac{\sum_{s \in n} x_{st}}{4}.$$

7 Appendix

Proof of the second part of lemma 1: We now prove the lemma for the rich type country.

Assume that if country 1 is rich, it gets the transfer. If country 1 is rich: $m_1 \geq M + 1$. Moreover when it gets the transfer: $-n(t_1, t_2) + (M - m_1) > 0$, which implies $m_1 < M - n(t_1, t_2)$. This is a contradiction because this last inequality cannot hold in the rich type case, as defined in assumption 1, since $k < 1$ and $l < 1$, $\forall t_1 \in [0, r]$, given any $t_2 \in [0, r]$.

We now show that being poor is also a necessary condition to be recipient. Assume that if country 1 gets the transfer, it is poor. If country 1 gets the transfer, this means that: $-n(t_1, t_2) + (M - m_1) > 0$, which implies $m_1 < M - n(t_1, t_2)$, moreover since the country is also rich: $m_1 \geq M + 1$, but being $k < 1$ and $l < 1$, $\forall t_1 \in [0, r]$, given any $t_2 \in [0, r]$, this is a contradiction with the initial assumption that country 1 gets the transfer.

Proof of proposition 1

Since assumption 2 holds, we can apply lemma 2 and define the following strategy sets for each country of the federation:

$$0 \leq t_1 \leq r$$

$$0 \leq t_2 \leq r$$

These two sets are compact, non-empty and convex.

The pay-off function of country 1 is:

$$W(t_1, t_2) = u(1) + m_1 - (p + t_1) - f + \tag{24}$$

$$\gamma_1 \ln \{(1 + n)\, t_1 + \max [0, \alpha (-n + (M - m_1))]\}$$

(24) is just the welfare function of country 1 with the budget constaint fitted in.[18] This function is continuous in $\forall t_1 \in [0, r]$. It is easy to verify the continuity in $t_1 > t_2$ and $t_1 < t_2$. Moreover the limit of the function when $t_1 \to t_2$ coincides in the two regimes ($t_1 > t_2$ and $t_1 \leq t_2$): $\lim_{t_1 \to t_2^+} W(t_1, t_2) = \lim_{t_1 \to t_2^-} W(t_1, t_2) = u(1) + m - (p + t_1) - f + \gamma_1 \ln \{t_1 + \max [0, \alpha (M - m_1)]\}$. This proves the continuity also in the case $t_1 = t_2$.

Taking the derivative of (24):

$$\frac{\partial W}{\partial t_1} = -1 + \frac{\gamma_1}{g} \left[\frac{\partial n}{\partial t_1} t_1 + (1 + n) - \alpha \frac{\partial n}{\partial t_1} \right]. \tag{25}$$

where: $g = (1 + n) t_1 + \max [0, \alpha (-n + (M - m_1))]$.

If we use (8) and (6), when $t_1 > t_2$:

$$\frac{\partial W}{\partial t_1} = -1 + \gamma_1 \frac{-Ae^{(t_1 - t_2)} t_1 + (2 - e^{A(t_1 - t_2)}) + \alpha A e^{A(t_1 - t_2)}}{(2 - e^{A(t_1 - t_2)}) t_1 + \alpha (e^{(t_1 - t_2)} - 1 + M - m_1)}.$$

If we use (8) and (7), when $t_1 \leq t_2$:

$$\frac{\partial W}{\partial t_1} = -1 + \gamma_1 \frac{-Ae^{(t_2 - t_1)} t_1 + e^{A(t_2 - t_1)} + \alpha A e^{A(t_2 - t_1)}}{e^{A(t_2 - t_1)} t_1 + \alpha (1 - e^{(t_2 - t_1)} + M - m_1)}.$$

Notice that the first order derivative of the pay-off function is a continuous function in $t_1 = t_2$. In fact its limit when $t_1 \to t_2$ coincides in the two regimes: $\lim_{t_1 \to t_2^+} \frac{\partial W}{\partial t_1} = \lim_{t_1 \to t_2^-} \frac{\partial W}{\partial t_1} = -1 + \gamma_1 \frac{-At_1 + 1 + \alpha A}{t_1 + \alpha (M - m_1)}$.

Taking the derivative of (25):

$$\frac{\partial^2 W(t_1, t_2)}{\partial t_1^2} = \frac{\gamma_1}{g^2} \left[\left((t_1 - \alpha) \frac{\partial^2 n}{\partial t_1^2} + 2 \frac{\partial n}{\partial t_1} \right) g - \left(\frac{\partial g}{\partial t_1} \right)^2 \right] \tag{26}$$

if we use (8) and (6), when $t_1 > t_2$:

$$\frac{\partial^2 W(t_1, t_2)}{\partial t_1^2} = \frac{\gamma_1}{g^2} \left[Ae^{A(t_1 - t_2)} [-2 + (\alpha - t_1) A] g - \left(\frac{\partial g}{\partial t_1} \right)^2 \right]. \tag{27}$$

[18] This is justified by the fact that when this problem is solved the budget constraint is always binding ($\mu > 0$), otherwise ($\mu = 0$) the FOC with respect to t_1 could not be satisfied:

$$\frac{\partial L}{\partial t_1} = -1 - \mu \left[-\frac{\partial n}{\partial t_1} (t_1 - \alpha) - (1 + n) \right] = 0$$

Notice that assumption 5 implies:

$$\alpha - \frac{2}{A} < \alpha - \frac{1}{A} < 0 \leq t_1 \leq r$$

which means that:

$$\frac{\partial^2 W(t_1, t_2)}{\partial t_1^2} < 0.$$

Note that (27) is true without need of assumption 5, if country 1 is non-recipient or there is no transfer mechanism in the federation.

If we use (8) and (7), when $t_1 < t_2$:

$$\frac{\partial^2 W(t_1, t_2)}{\partial t_1^2} = \frac{\gamma}{g^2} \left[A e^{A(t_2 - t_1)} \left[-2 - (\alpha - t_1) A \right] g - \left(\frac{\partial g}{\partial t_1} \right)^2 \right]. \qquad (28)$$

Assumption 4 and lemma 2 imply:

$$t_1 \leq r < \frac{1}{A} < \alpha + \frac{2}{A}$$

which means that:

$$\frac{\partial^2 W(t_1, t_2)}{\partial t_1^2} < 0.$$

Again, (28) is true without need for assumption 4, if country 1 is non-recipient or there is no transfer mechanism.

Notice that the first-order derivative of the pay-off function has a kink in $t_1 = t_2$. In fact if we take the limit of the second-order derivative when $t_1 \to t_2$ in the two regimes: $\lim\limits_{t_1 \to t_2^+} \frac{\partial^2 W}{\partial t_1^2} = -A\left(At_1 + 2 - \alpha A\right) - \frac{(1 - At_1 + \alpha A)^2}{t_1 + \alpha(M - m_1)} \neq \lim\limits_{t_1 \to t_2^-} \frac{\partial^2 W}{\partial t_1^2} = A\left(At_1 - 2 - \alpha A\right) - \frac{(1 - At_1 + \alpha A)^2}{t_1 + \alpha(M - m_1)}$.

But since the pay-off function is continuous and differentiable in $t_1 = t_2$ and concave in $t_1 < t_2$ and $t_1 > t_2$, it must be concave $\forall t_1 \in [0, r]$, whatever $t_2 \in [0, r]$.

Notice that the set of maximizers $t_1(t_2)$ is non-empty and compact since the pay-off function is continuous and the strategy set, where t_1 is chosen, $(0 \leq t_1 \leq r)$ is non-empty and compact. The set of maximizers $t_1(t_2)$ is also convex since the pay-off function is concave in t_1 and the strategy set is convex. The above properties ensures that the reaction function $t_1(t_2)$ is continuous and convex-valued. The same reasoning applies to country 2. We can therefore apply Kakutani fixed point theorem and say that the game, where the two countries choose their own tax-rate and local public good by maximizing their welfare function, has a Nash equilibrium.

Proof of proposition 2

If a symmetric equilibrium exists, the FOC for the recipient is $\frac{\partial W}{\partial t_1} = -1 + \gamma_1 \frac{-At_1+1+\alpha A}{t_1+\alpha(M-m_1)}$ and for the non-recipient $\frac{\partial W}{\partial t_2} = -1 + \gamma_1 \frac{-At_2+1}{t_1}$. We can get t_1 and t_2 and equate them, obtaining:

$$\gamma_1 = \frac{\gamma_2 + \alpha (M - m_1)(1 + A\gamma_2)}{1 + \alpha A (1 + A\gamma_2)} \tag{29}$$

This is the locus (γ_1, γ_2), which, for a given α, $M - m_1$ and A, guarantees the existence of a symmetric equilibrium. Therefore if $\gamma_1 \neq \frac{\gamma_2+\alpha(M-m_1)(1+A\gamma_2)}{1+\alpha A(1+A\gamma_2)}$, then $t_1 \neq t_2$.

Notice that if $\alpha = 0$,the symmetric equilibrium holds if and only if $\gamma_1 = \gamma_2$. Moreover taking the derivative of (29):

$$\frac{\partial \gamma_1}{\partial \alpha} = \frac{(M - m_1 - A\gamma_2)(1 + A\gamma_2)}{[1 + \alpha A (1 + A\gamma_2)]^2}$$

from which $\frac{\partial \gamma_1}{\partial \alpha} \leq 0$, if and only if $\gamma_2 \geq \frac{M-m_1}{A}$ and $\frac{\partial \gamma_1}{\partial \alpha} > 0$, if and only if $\gamma_2 < \frac{M-m_1}{A}$. This derivative says how γ_1 should vary, for a given γ_2, when an equalization system is introduced to let a symmetric equilibrium hold. If we recall that when $\alpha = 0$,the symmetric equilibrium holds if and only if $\gamma_1 = \gamma_2$, it follows that when $\alpha > 0$, a symmetric equilibrium exists for some $\gamma_1 \leq \gamma_2$ if and only if $\gamma_2 \geq \frac{M-m_1}{A}$ and for some $\gamma_1 > \gamma_2$ if and only if $\gamma_2 < \frac{M-m_1}{A}$. This let us prove that when $\alpha > 0$, if $\gamma_2 \geq \frac{M-m_1}{A}$ and $\gamma_1 > \gamma_2$, or if $\gamma_2 < \frac{M-m_1}{A}$ and $\gamma_1 \leq \gamma_2$, a symmetric equilibrium does not exist. Moreover, since when $\alpha = 0$ $\gamma_1 \neq \gamma_2$ guarantees the non-existence of the symmetric equilibrium, we can establish that a symmetric equilibrium does not exists if $\gamma_2 \geq \frac{M-m_1}{A}$ and $\gamma_1 > \gamma_2$, or if $\gamma_2 < \frac{M-m_1}{A}$ and $\gamma_1 < \gamma_2$, $\forall \alpha \in \left[0, \frac{1}{A}\right[$.

Proof of proposition 4

As assumption 2 holds, by lemma 2 $t_1 \in [0, r]$ and $t_2 \in [0, r]$. Therefore it makes sense to differentiate the Lagrangian (12) with respect to t_2. Assume that $m_1 < M - 1$ and so, by lemma 1, country 1 is a recipient country. If we differentiate the Lagrangian (12) with respect to t_2, for a given t_1, we get the analytical expression of the fiscal externality:

$$\frac{\partial L}{\partial t_2} = \mu(t_1 - \alpha)\frac{\partial n}{\partial t_2} \tag{30}$$

Evaluate (30) in $t_2(t_1, \alpha)$, which is the tax rate chosen by country 2, given t_1 and α. Differentiating (30), with respect to α, for a given t_1:

$$\frac{\partial L}{\partial t_2 \partial \alpha} = -\mu\frac{\partial n}{\partial t_2} + \mu(t_1 - \alpha)\frac{\partial^2 n}{\partial t_2^2}\frac{\partial t_2}{\partial \alpha}. \tag{31}$$

Using (8) and (6), we can rewrite (31) when $t_1 > t_2$ as:

$$\frac{\partial L}{\partial t_2 \partial \alpha} = -\mu A e^{A(t_1 - t_2)}\left[1 + A(t_1 - \alpha)\frac{\partial t_2}{\partial \alpha}\right].$$

Assumption 5 and proposition 2 ($0 < \frac{\partial t_2}{\partial \alpha} < 1$) imply that the expression in square brackets is always positive; in fact $t_1 + \left[\frac{1}{A}\left(\frac{\partial t_2}{\partial \alpha}\right)^{-1} - \alpha\right] > 0$, from which:

$$\frac{\partial L}{\partial t_2 \partial \alpha} < 0 \quad \forall \alpha \in \left[0, \frac{1}{A}\right(.$$

If we use lemma 3, this proves that in a federation with a transfer T, a recipient country faces a lower fiscal externality (30) than a non-recipient.

To complete the proof we tackle the case $t_1 < t_2$. If we use (8) and (7), we can rewrite (31) when $t_1 < t_2$ as:

$$\frac{\partial L}{\partial t_2 \partial \alpha} = -\mu A e^{A(t_2 - t_1)}\left[1 - A(t_1 - \alpha)\frac{\partial t_2}{\partial \alpha}\right].$$

Assumption 4 with lemma 2 and proposition 2 ($0 < \frac{\partial t_2}{\partial \alpha} < 1$) implies that the expression in square brackets is always positive in fact $t_1 \leq r < \frac{1}{A} < \alpha + \frac{1}{A}\left(\frac{\partial t_2}{\partial \alpha}\right)^{-1}$, which also implies: ,

$$\frac{\partial L}{\partial t_2 \partial \alpha} < 0 \quad \forall \alpha \in \left[0, \frac{1}{A}\right(.$$

Also in this second case, if we use lemma 3, this proves that in a federation with a transfer T, a recipient country faces a lower fiscal externality (30) than non-recipient.

Proof of proposition 5

Recall that:

$$\frac{dt_1}{dt_2} = -\frac{\frac{\partial^2 n}{\partial t_1 \partial t_2}(t_1-\alpha)+\frac{\partial n}{\partial t_2}}{\frac{\partial^2 n}{\partial t_1^2}(t_1-\alpha)+2\frac{\partial n}{\partial t_1}}. \tag{32}$$

If $t_1 > t_2$, using (8) and (6) in (32) we get

$$\frac{dt_1}{dt_2} = \frac{1+A(t_1-\alpha)}{2+A(t_1-\alpha)}. \tag{33}$$

Assumption 5 implies that the numerator and denominator of (33) are positive, in fact $t_1 + \left(\frac{1}{A}-\alpha\right) > 0$ and $t_1 + \left(\frac{2}{A}-\alpha\right) > 0$. It follows that when $t_1 > t_2$:

$$\frac{dt_1}{dt_2} > 0.$$

If $t_1 < t_2$, using (8) and (7), we get

$$\frac{dt_1}{dt_2} = \frac{1-A(t_1-\alpha)}{2-A(t_1-\alpha)}. \tag{34}$$

Assumption 4 and lemma 2 imply that the numerator and the denominator of (34) are positive; in fact $t_1 - \left(\frac{1}{A}+\alpha\right) < 0$ and $t_1 - \left(\frac{2}{A}+\alpha\right) < 0$, being $t_1 \leq r < \frac{1}{A} < \alpha + \frac{2}{A}$. It follows that when $t_1 < t_2$:

$$\frac{dt_1}{dt_2} > 0.$$

Proof of proposition 6

Notice that if there is no federal transfer (12) becomes:

$$\underset{t_1,g,\mu}{Max}\; u(1) + m_1 - (p+t_1) - f + \gamma_1 \ln g - \mu\left[g-(1+n)\,t_1\right] \tag{35}$$

When $t_1 > t_2$, if we totally differentiate with respect to t_1 and t_2 the FOC of (35) with respect to t_1 and use lemma 2 ($t_1 \in [0,r]$) we get:

$$\frac{dt_1}{dt_2} = \frac{1+At_1}{2+At_1} > \frac{1}{2}$$

This is because $t_1 > 0$, in fact $t_1 = 0$ would imply $t_2 < 0$. When $t_1 < t_2$:

$$\frac{dt_1}{dt_2} = \frac{1-At_1}{2-At_1} \leq \frac{1}{2}$$

which implies:

$$\left.\frac{dt_1}{dt_2}\right|_{t_1>t_2} - \left.\frac{dt_1}{dt_2}\right|_{t_1<t_2} > 0,\ \forall t_1 \in [0, r] \,.$$

This means that the difference in slope in a point (t_1, t_2) belonging to the reaction function in the tax regime $t_1 > t_2$ and any other point (t_1, t_2) belonging to the reaction function in the tax regime $t_1 < t_2$ is positive: the reaction function slope in the regime $t_1 > t_2$ is higher than in the tax-regime $t_1 < t_2$.

Proof of Proposition 7

Assume $m_1 < M - 1$ and so country 1 is the recipient. If $t_1 > t_2$, $\frac{dt_1}{dt_2} = \frac{1+A(t_1-\alpha)}{2+A(t_1-\alpha)}$. Taking the following:

$$\frac{\partial^2 t_1}{\partial t_2 \partial \alpha} = \frac{A\left(\frac{\partial t_1}{\partial \alpha} - 1\right)}{\left[2 + A\left(t_1 - \alpha\right)\right]^2}$$

and using proposition 2, implies:

$$\frac{\partial^2 t_1}{\partial t_2 \partial \alpha} < 0 \quad \forall \alpha \in \left[0, \frac{1}{A}\right(. \tag{36}$$

Notice that, by applying lemma 3, (36) proves that the reaction function slope of a recipient country, when the transfer mechanism is active ($\alpha > 0$) is lower than the tax-rate reaction function of a non-recipient.

If $t_1 < t_2$, $\frac{dt_1}{dt_2} = \frac{1-A(t_1-\alpha)}{2-A(t_1-\alpha)}$ taking the following:

$$\frac{\partial^2 t_1}{\partial t_2 \partial \alpha} = \frac{-A\left(\frac{\partial t_1}{\partial \alpha} - 1\right)}{\left[2 - A\left(t_1 - \alpha\right)\right]^2}$$

and by using proposition 2, implies:

$$\frac{\partial^2 t_1}{\partial t_2 \partial \alpha} > 0 \quad \forall \alpha \in \left[0, \frac{1}{A}\right(. \tag{37}$$

Again, by applying lemma 3, (37) proves that the reaction function slope of a recipient country, when the transfer mechanism is active ($\alpha > 0$) is higher than the tax-rate reaction function of a non recipient.

Part (c) of the proposition is a direct consequence of part (a) and (b). Let us define:

$$\Delta = \left.\frac{dt_1}{dt_2}\right|_{t_1 > t_2} - \left.\frac{dt_1}{dt_2}\right|_{t_1 < t_2}$$

then using (36) and (37):

$$\frac{\partial \Delta}{\partial \alpha} = \left.\frac{\partial t_1}{\partial t_2 \partial \alpha}\right|_{t_1 > t_2} - \left.\frac{\partial t_1}{\partial t_2 \partial \alpha}\right|_{t_1 < t_2} < 0 \quad \forall \alpha \in \left[0, \frac{1}{A}\right(.$$

This means that the difference in slope in a point (t_1, t_2) belonging to the reaction function in the tax-regime $t_1 < t_2$ and any other point (t_1, t_2) belonging to the reaction function in the tax-regime $t_1 > t_2$ decreases if the country is recipient.

The reaction function form

It is interesting to see how our simple model can give us enough information to draw the reaction functions (figure 4), for a given marginal cost of public funds μ, if assumption 1-5 hold. The reaction function, for a given μ, is continuous $\forall t_1 \in [0, t_2[\,]t_2, r]$, since it is differentiable either in $t_1 > t_2$, $\frac{dt_1}{dt_2} = \frac{1+A(t_1-\alpha)}{2+A(t_1-\alpha)}$, or in $t_1 < t_2$, $\frac{dt_1}{dt_2} = \frac{1-A(t_1-\alpha)}{2-A(t_1-\alpha)}$. If we use (6) and (8) and substitute in (13), we can write (13) when $t_1 > t_2$ in the following way:

$$2 - e^{A(t_1-t_2)} + (t_1 - \alpha)\left(-Ae^{A(t_1-t_2)}\right) - \frac{1}{\mu} = 0 \tag{38}$$

If we solve (38) for t_1, we get the reaction function of country 1 for any $t_1 > t_2$. Taking the limit when $t_1 \to t_2$, (38) reduces to $1 - A(t_1 - \alpha) - \frac{1}{\mu} = 0$, from which:

$$t_1 = \left(1 - \frac{1}{\mu}\right)\frac{1}{A} + \alpha.$$

If we use (7) and (8) and substitute in (13), we can write (13) when $t_1 \leq t_2$ in the following way:

$$e^{A(t_1-t_2)} + (t_1 - \alpha)\left(-Ae^{A(t_1-t_2)}\right) - \frac{1}{\mu} = 0 \tag{39}$$

Solving (38) for t_1, we get the reaction function of country 1 for any $t_1 \leq t_2$. If we take the limit when $t_1 \to t_2$, (39) becomes $1 - A(t_1 - \alpha) - \frac{1}{\mu} = 0$, that is:

$$t_1 = \left(1 - \frac{1}{\mu}\right)\frac{1}{A} + \alpha.$$

This means that the reaction function, for a given μ, is continuous also in $t_1 = t_2$. Note that the function has a kink in $t_1 = t_2$ because $\lim\limits_{t_1 \to t_2^+} \frac{\partial t_1}{\partial t_2} = \frac{1+A(t_1-\alpha)}{2+A(t_1-\alpha)} \neq \lim\limits_{t_1 \to t_2^-} \frac{\partial t_1}{\partial t_2} = \frac{1-A(t_1-\alpha)}{2-A(t_1-\alpha)}$.

Moreover if we take the derivative of (33) with respect to t_2:

$$\frac{\partial^2 t_1}{\partial t_2^2} = \frac{A}{\left[2 + A\left(t_1 - \alpha\right)\right]^2}\frac{\partial t_1}{\partial t_2}$$

which, by using proposition 4, implies that if $t_1 > t_2$ then $\frac{\partial^2 t_1}{\partial t_2^2} > 0$, for a given μ.

If we take the derivative of (34) with respect t_2:

$$\frac{\partial^2 t_1}{\partial t_2^2} = -\frac{A}{\left[2 - A\left(t_1 - \alpha\right)\right]^2} \frac{\partial t_1}{\partial t_2}$$

again, by using proposition 4 we can state that if $t_1 < t_2$ then $\frac{\partial^2 t_1}{\partial t_2^2} < 0$ for a given μ.

Therefore we know that, for a given marginal cost of public funds μ, the reaction function is continuous and convex if $t_1 > t_2$ and concave if $t_1 < t_2$. When an equalization transfer is introduced the reaction function crosses the 45° line at the point $(t = s + \alpha,\ t = s + \alpha)$. $(s,\ s)$ is the point where the reaction function crosses the 45° line before the introduction of the transfer. These informations toghether with the ones from propositions 5 and 6 allow us to draw the reaction function for a given marginal cost of public funds.

Table 1: Summary Statistics

Variable		
TAX (province unit cigarette tax, inclusive of general sales tax, 1989 US$)	0.92573	(0.3696)
C NEIGH TAX (neighboring Canadian province average unit cigarette tax, inclusive of general sales tax, 1989 US$)	0.88376	(0.3096)
US NEIGH TAX (neighboring US state unit cigarette tax, inclusive of general sales tax, 1989 US$)	0.24846	(0.1452)
EXPE (total province public expenditure divided by provincial gdp)	0.61838	(0.1510)
PROG-CONS (% of progressive-conservative in the provincial legislature)	0.34292	(0.2970)
LIBERALS (% of liberals in the provincial legislature)	0.37583	(0.3316)
NDP (%of national democrats, quebec party and socialist party in the provincial legislature)	0.26808	(0.3137)
POP (province population)	0.27181	(0.3110)
DENS (population density: population divided by area)	12.7921	(11.2883)
UNEMP (unemployment rate)	11.4873	(3.7241)
AGED (proportion of population over 65)	0.11474	(0.0163)
INC (province income per capita in 1989 US$)	13.2187	(1.9920)
GRANT (federal grants divided by provincial population)	0.00107	(0.0004)
INCTAX (federal income tax divided by provincial gdp)	0.08251	(0.0132)
GDP (provincial gross domestic product per-capita in 1989 US million $)	0.01385	(0.0031)
C NEIGH DENS (neighboring Canadian province average population density)	12.5121	(8.2137)
US NEIGH DENS (neighboring US state average population density)	52.9159	(71.4225)
C NEIGH UNEMP (neighboring Canadian province average unemployment rate)	10.93076	(2.4546)
US NEIGH UNEMP (neighboring US state average unemployment rate)	4.81776	(2.6718)
C NEIGH INC (neighboring Canadian province average population per-capita income in 1989 US$)	13.4088	(1.3908)
US NEIGH INC (neighboring US state average per-capita income in 1989 US$)	12.7175	(6.5527)
C NEIGH GRANT (neighboring Canadian province average federal grant on provincial gdp)	0.00101	(0.00032)
US NEIGH GRANT (neighboring US state average federal grant over state gdp)	0.00054	(0.00029)
C NEIGH INCTAX (neighboring Canadian province average federal income tax over provincial gdp)	0.0797	(0.0361)
US NEIGH INCTAX (neighboring US state average federal income tax over state gdp)	0.08064	(0.0104)
C NEIGH GDP (neighboring Canadian province average gdp per-capita in 1989 US million $)	0.01428	(0.0028)
US NEIGH GDP (neighboring US state average gdp per-capita in 1989 US million $)	0.01456	(0.0075)
C NEIGH POP (neighboring Canadian province average population)	2474501	(3165001)
US NEIGH POP (neighboring US state average population)	3060374	(1942044)
C NEIGH AGED (neighboring US state average proportion of population over 65)	0.10338	(0.0522)
US NEIGH AGED (neighboring Canadian province average proportion of population over 65)	0.11331	0.013135

Notes: Figures are meansin the first column, with standard deviations in second column, based on annual data for the years 1984-1994, inclusive, for the following ten Canadian provinces: Alberta, Ontario, British Columbia Saskatchewan, Newfoundland, Prince Edward Island, Nova Scotia, New Brunsweek, Quebec, Manitoba.

Table 2: Controls and year fixed effects regressions

Dependent Variable	TAX: province cig. tax rate (sales tax + specific unit tax)	TAX: province cig. tax rate (sales tax + specific unit tax)	TAX: province cig. tax rate (sales tax + specific unit tax)
dummy when TAX higher or equal than C NEIGH TAX	0.067 (0.72)		0.094 (1.38)
dummy when equalization holds	-0.420 (1.81)		0.023 (0.11)
POP $*10^7$	-2.888 (2.32)*		-9.257 (1.56)
DENS	-0.017 (0.61)		-0.015 (0.04)
UNEMP	0.045 (1.51)		0.054 (1.02)
GDP	33.114 (0.71)		49.789 (4.39)**
AGED	18.354 (1.77)		-34.885 (1.49)
INC$*10^3$	-0.092 (0.28)		-1.337 (2.47)*
INC^2 $*10^8$	0.570 (0.41)		5.261 (2.39)*
Dummy=1 if the premier of the Government belongs to the Liberals	0.124 (1.63)		-0.093 (1.17)
Dummy=1 if the premier of the Government belongs to the Progressive Conserv.	0.003 (0.07)		-0.080 (1.15)
CC NEIGH UNEMP	0.070 (1.20)		0.049 (2.59)*
US NEIGH UNEMP	-0.045 (1.36)		0.075 (1.21)
C NEIGH INC$*10^3$	0.005 (0.01)		-1.241 (1.79)
C NEIGH INC^2 $*10^8$	0.254 (0.11)		4.112 (1.47)
US NEIGH INC$*10^3$	0.405 (3.11)*		1.692 (3.90)**
US NEIGH INC^2 $*10^8$	0.248 (0.75)		-5.738 (4.44)**

C NEIGH DENS*10^3	-0.056 (1.70)		-0.470 (1.27)
US NEIGH DENS*10^3	0.006 (1.61)		0.109 (2.30)*
C NEIGH GRANT	170.951 (0.66)		423.158 (0.64)
US NEIGH GRANT	-1,475.955 (1.73)		-2,047.609 (2.53)*
C NEIGH GDP	-97.460 (3.53)**		56.584 (2.36)*
US NEIGH GDP	-315.937 (2.61)*		112.752 (0.68)
year==1985		0.067 (2.31)*	0.290 (3.12)*
year==1986		0.141 (3.00)*	0.723 (3.25)*
year==1987		0.229 (4.03)**	0.980 (2.89)*
year==1988		0.308 (5.07)**	1.313 (2.78)*
year==1989		0.394 (4.22)**	1.553 (2.95)*
year==1990		0.507 (5.50)**	1.728 (3.00)*
year==1991		0.733 (8.43)**	2.047 (3.50)**
year==1992		0.812 (17.59)**	2.286 (3.99)**
year==1993		0.769 (10.10)**	2.378 (3.59)**
year==1994		0.467 (2.97)*	2.256 (3.50)**
Constant	-0.481 (0.09)	0.287 (6.53)**	7.262 (1.36)
year effects	no	yes	yes
province effects	no	yes	yes
Observations	110	110	110
R-squared	0.72	0.77	0.91

Robust t-statistics in parentheses

* significant at 5%; ** significant at 1%

Notes: These are OLS estimates of the controls parameters of the estimated equation (16) (column 1 and 3). Column 2 is the regression with only the fixed effects. Variables are defined in table 1 and decribed in detail in the data appendix. Number in parentheses are t-statistics (with robust standard errors adjusted for clustering by province). Variables are defined in table 1 and described in detail in the data appendix.

Table 3: Tax-competition on cigarette tax-rate

Dependent Variable	TAX: province cig. tax rate (sales tax + specific unit tax)	TAX: province cig. tax rate (sales tax + specific unit tax)	TAX: province cig. tax rate (sales tax + specific unit tax)	TAX: province cig. tax rate (sales tax + specific unit tax)
C NEIGH TAX	0.277 (1.24)	0.803 (2.35)*	0.844 (2.56)*	0.802 (2.41)*
interaction with C NEIGH TAX of a dummy =1 when TAX higher than C NEIGH TAX				0.002 (0.01)
one year lag of TAX			-0.075 (0.28)	
dummy when TAX higher than C NEIGH TAX	0.121 (1.64)	0.189 (2.05)	0.204 (3.24)*	0.187 (0.48)
dummy when equalization holds	-0.138 (0.71)	-0.349 (1.32)	-0.441 (1.08)	-0.350 (1.43)
EXPE	3.424 (1.71)	10.484 (2.95)*	14.067 (2.49)*	10.481 (3.01)*
US NEIGH TAX	-1.394 (1.87)	-1.862 (1.36)	-1.382 (0.69)	-1.862 (1.35)
POP $*10^7$	-11.321 (1.48)	-12.594 (1.41)	-15.151 (1.44)	-12.580 (1.35)
DENS	-0.047 (0.13)	-0.075 (0.25)	-0.107 (0.26)	-0.075 (0.26)
UNEMP	0.076 (1.60)	0.099 (1.86)	0.099 (1.81)	0.099 (1.60)
GDP	103.119 (3.67)**	189.987 (4.07)**	268.350 (2.88)*	189.964 (3.96)**
PAGED	-39.809 (1.72)	-36.252 (1.60)	-33.570 (1.14)	-36.255 (1.61)
INC	-1.483 (2.41)*	-1.684 (2.56)*	-1.588 (2.65)*	-1.685 (2.55)*
$INC^2 *10^8$	5.955 (2.46)*	7.033 (2.71)*	6.740 (2.79)*	7.036 (2.69)*
Dummy=1 if the premier of the Government belongs to the Liberals	-0.116 (1.81)	-0.111 (1.47)	-0.195 (2.06)*	-0111 (1.58)
Dummy=1 if the premier of the Government belongs to the Progressive Conserv.	-0.056 (0.65)	0.004 (0.03)	0.076 (0.33)	0.004 (0.02)

CC NEIGH UNEMP	0.053 (1.62)	-0.0001 (0.00)	-0.073 (0.81)	-0.0001 (0.00)
US NEIGH UNEMP	0.080 (1.36)	0.112 (1.32)	0.180 (1.76)	0.113 (1.09)
C NEIGH INC	-1.511 (2.14)	-1.678 (2.36)*	-2.523 (2.88)*	-1.678 (2.33)*
C NEIGH INC^2 $*10^8$	5.589 (1.97)	6.976 (2.27)*	10.582 (2.60)*	6.977 (2.23)
US NEIGH INC	2.213 (3.40)**	2.850 (3.21)*	2.869 (2.51)*	2.851 (3.27)**
US NEIGH INC^2 $*10^8$	-7.109 (3.45)**	-8.896 (3.04)*	-8.830 (2.28)*	-8.897 (3.03)*
C NEIGH DENS	-0.763 (2.17)	-1.229 (2.43)*	-1.580 (2.20)	-1.229 (2.41)*
US NEIGH DENS	0.146 (2.65)*	0.148 (1.49)	0.141 (1.10)	0.148 (1.33)
C NEIGH GRANT	582.294 (0.96)	1,073.989 (1.54)	1,357.227 (1.45)	1,074.334 (1.55)
CUS NEIGH GRANT	-1,746.106 (2.70)*	-1,692.796 (1.79)	-2,394.972 (1.91)	-1,692.861 (1.78)
C NEIGH GDP	43.870 (1.35)	21.749 (0.59)	3.571 (0.06)	21.806 (0.60)
US NEIGH GDP	101.076 (0.61)	168.748 (0.61)	187.913 (0.44)	168.872 (0.58)
Constant	3.719 (0.62)	-4.920 (0.86)	-1.963 (0.22)	-4.922 (0.85)
year effects	yes	yes	yes	yes
province effects	yes	yes	yes	yes
overidentification test		0.86	0.9	0.86
Observations	110	110	100	110
R-squared	0.92	0.88	0.85	0.88

Robust t-statistics in parentheses

* significant at 5%; ** significant at 1%

Notes: Column (1) presents OLS estimates of the parameters of equation (16) with an aggregated tax-competition coefficient. Column (2), (3) presents two stages least squares estimates of the parameters of equation (16) with an aggregated tax-competition coefficient. Column (4) presents two stages least squares estimates, according to the tax regime the province belongs to. Numbers in parenthesis are t-statistics (with robust standard errors adjusted for clustering by province). Variables are defined in table 1 and described in detail in the data appendix.

Table 4: The effect of the equalizing transfer on tax-competition

Dependent Variable	TAX: province cig. tax rate (sales tax + specific unit tax)	TAX: province cig. tax rate (sales tax + specific unit tax)	TAX: province cig. tax rate (sales tax + specific unit tax)
C NEIGH TAX	1.911 (2.11)*	0.923 (2.47)*	1.137 (2.27)*
interaction with C NEIGH TAX of a dummy =1 when TAX lower than C NEIGH TAX & equalization	-0.854 (0.72)		0.047 (0.09)
interaction with C NEIGH TAX of a dummy =1 when TAX lower than C NEIGH TAX & no-equalization	-1.450 (2.28)*		-1.199 (2.02)*
interaction with C NEIGH TAX of a dummy =1 when TAX higher than C NEIGH TAX & equalization	-0.889 (0.66)	-0.021 (0.04)	
interaction with C NEIGH TAX of a dummy =1 when TAX higher than C NEIGH TAX & no-equalization		1.431 (2.15)*	
dummy when TAX higher than C NEIGH TAX	0.198 (0.43)	0.174 (0.39)	0.231 (0.46)
dummy when equalization holds	0.169 (0.20)	0.556 (1.16)	-0.397 (1.70)
EXPE	8.538 (2.41)*	8.570 (2.53)*	9.074 (2.55)*
US NEIGH TAX	-0.910 (0.38)	-0.043 (0.03)	-1.953 (1.30)
POP $*10^7$	0.077 (0.01)	-3.972 (0.61)	2.782 (0.21)
DENS	0.020 (0.10)	-0.013 (0.07)	0.092 (0.49)
UNEMP	0.073 (1.02)	0.084 (1.37)	0.059 (0.70)
GDP	122.348 (2.67)*	129.022 (2.54)*	126.656 (2.84)*
INC	-1.347 (1.82)	-1.280 (1.86)	-1.493 (1.84)
$INC^2 *10^8$	5.590 (1.92)	5.305 (1.95)	6.228 (1.95)
Dummy=1 if the premier of the Government belongs to the Liberals	0.032 (0.22)	-0.031 (0.55)	0.091 (0.44)
Dummy=1 if the premier of the Government belongs to the Progressive Conserv.	0.039 (0.16)	-0.024 (0.14)	0.114 (0.52)

CC NEIGH UNEMP	-0.002 (0.03)	0.017 (0.28)	-0.037 (0.66)
US NEIGH UNEMP	0.151 (2.13)*	0.150 (2.24)*	0.146 (1.70)
C NEIGH INC	-1.355 (1.54)	-1.331 (1.43)	-1.438 (1.79)
C NEIGH INC^2 $*10^8$	5.671 (1.59)	5.677 (1.46)	5.851 (1.78)
US NEIGH INC	1.575 (1.33)	1.165 (1.27)	2.302 (2.37)*
US NEIGH INC^2 $*10^8$	-4.502 (1.13)	-3.541 (1.04)	-6.527 (1.95)
C NEIGH DENS	-0.706 (1.36)	-0.740 (1.55)	-0.705 (1.20)
US NEIGH DENS	-0.094 (0.73)	-0.069 (0.82)	-0.087 (0.56)
C NEIGH GRANT	1,126.202 (1.74)	1,322.456 (1.82)	891.668 (1.35)
CUS NEIGH GRANT	-2,411.770 (2.25)*	-2,280.629 (2.25)*	-2,584.313 (2.37)*
C NEIGH GDP	81.387 (1.10)	95.152 (1.52)	54.938 (1.44)
US NEIGH GDP	160.236 (0.60)	232.733 (0.79)	86.309 (0.28)
Constant	-4.519 (0.65)	-2.713 (0.51)	-7.640 (1.24)
year effects	yes	yes	yes
province effects	yes	yes	yes
Overidentification test	0.99	0.98	0.99
Observations	110	110	110
R-squared	0.83	0.84	0.82

Robust t-statistics in parentheses

* significant at 5%; ** significant at 1%

Notes: Column (1) presents two stages least square estimates of the tax-competition coefficient splitted in four cases: TAX is higher than C NEIGH TAX and equalization holds or not; TAX is lower than C NEIGH TAX and equalization holds or not. Column (2) presents two stages least square estimates of the tax-competition coefficient plus its interaction with a dummy =1 when TAX is higher than C NEIGH TAX and equalization holds and with a dummy =1 when TAX is higher than C NEIGH TAX & no-equalization holds. Column (3) presents two stages least square estimates of the tax-competition coefficient plus its interaction with a dummy =1 when TAX is lower than C NEIGH TAX and equalization holds and with a dummy =1 when TAX is lower than C NEIGH TAX & no-equalization holds. Numbers in parentheses are t-statistics (with the robust standard error adjusted for clustering by province). Variables are defined in table 1 and described in detail in the data appendix.

Case $t_1 > t_2$

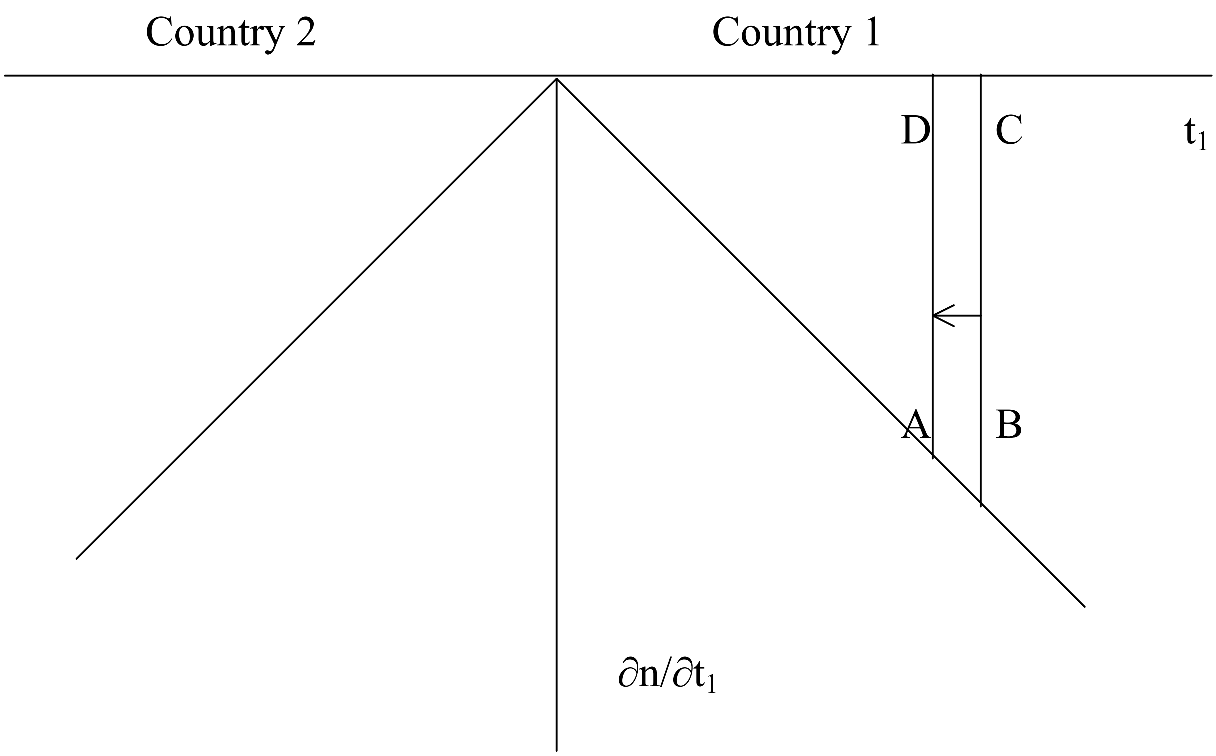

FIG. 1 When t_1 increases, the higher t_1 for a given t_2 is, the higher the increase in the number of people going in 2 is. The area on the right of the line AD represents people shopping in country 1, before the increase in t_1. The area ABDC describes people moving to country 2 after the increase in t_1.

Case $t_1 \leq t_2$

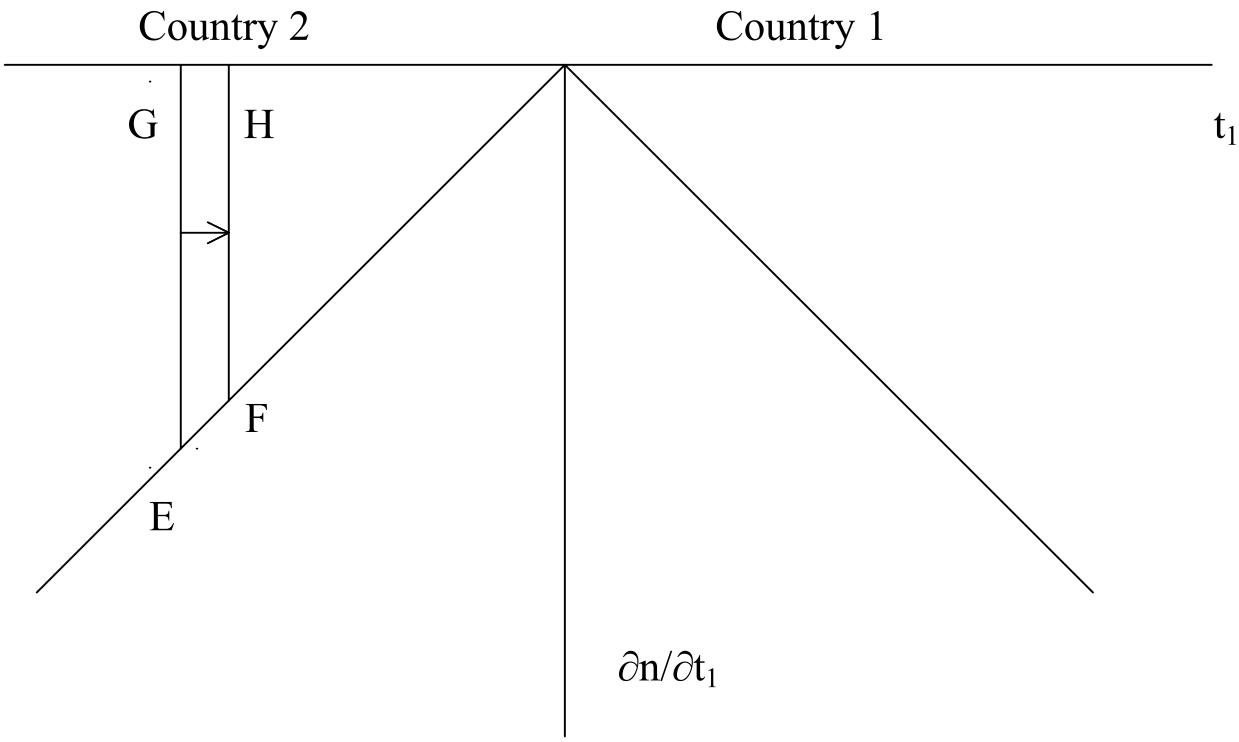

FIG.2 When t_1 increases, the higher t_1 for a given t_2 is, the higher the increase in the number of people going in 2 is. The area on the left of the line EG represents people shopping in country 1before the increase in t_1 . The area EFHG describes people moving to country 2 after the increase in t_1.

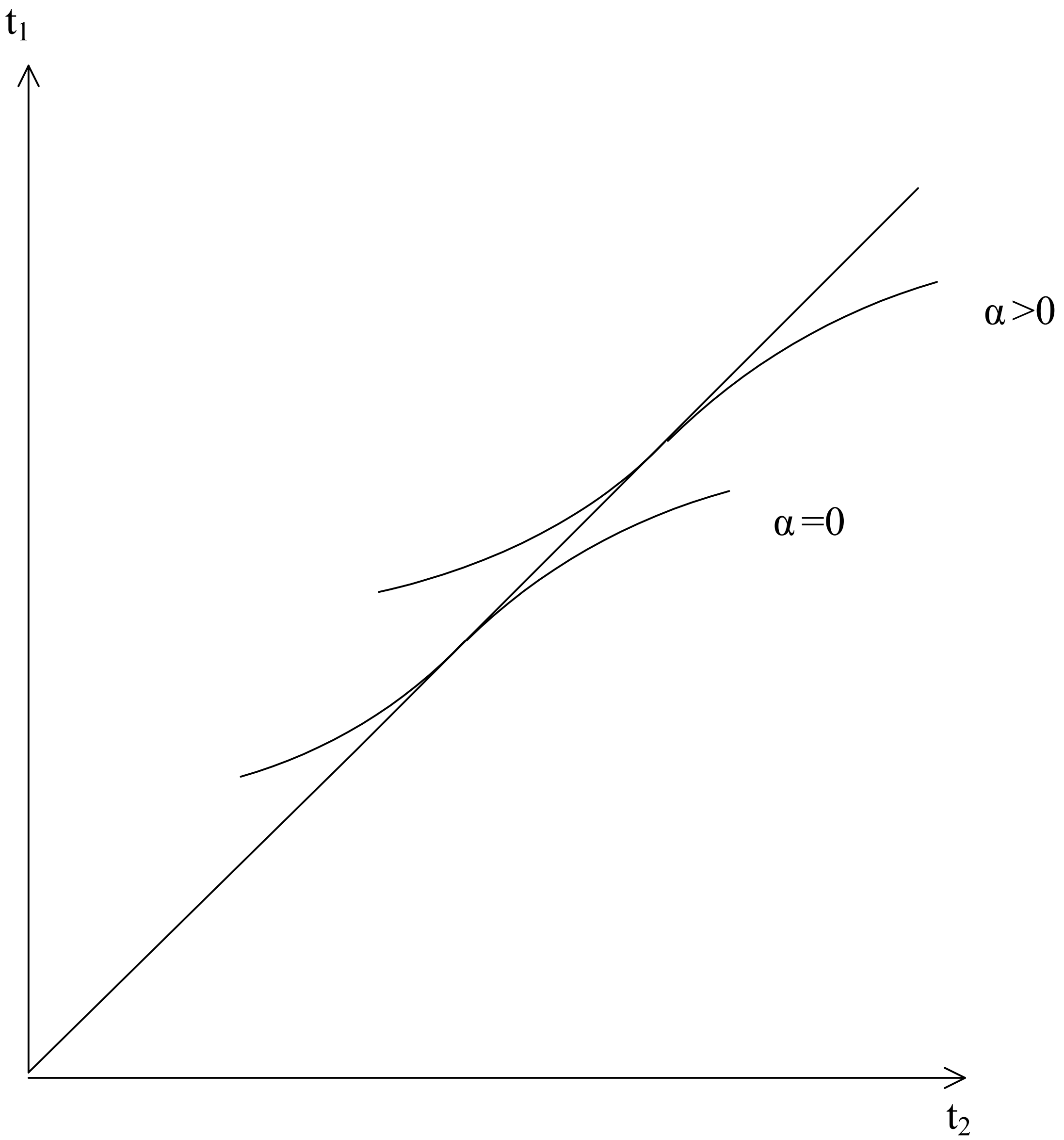

FIG.4 The reaction function, for a given marginal cost of public funds, is continuous and convex when $t_1 > t_2$ and concave when $t_1 < t_2$. The slope is always positive (proposition 4). When an equalization transfer is introduced the reaction function crosses the 45° line at the point ($t = s + \alpha$, $t = s + \alpha$). (s, s) is the point where the reaction function crosses the 45° line before the introduction of the transfer. Moreover proposition 5 we know that the slope of the reaction function, for a given marginal cost of public funds, when $t_1 > t_2$ is always higher than when $t_1 < t_2$; finally from proposition 6 when the equalization transfer is introduced ($\alpha > 0$) the slope of the reaction function, for a given marginal cost of public funds, decreases when $t_1 > t_2$ and decreases when $t_1 < t_2$.

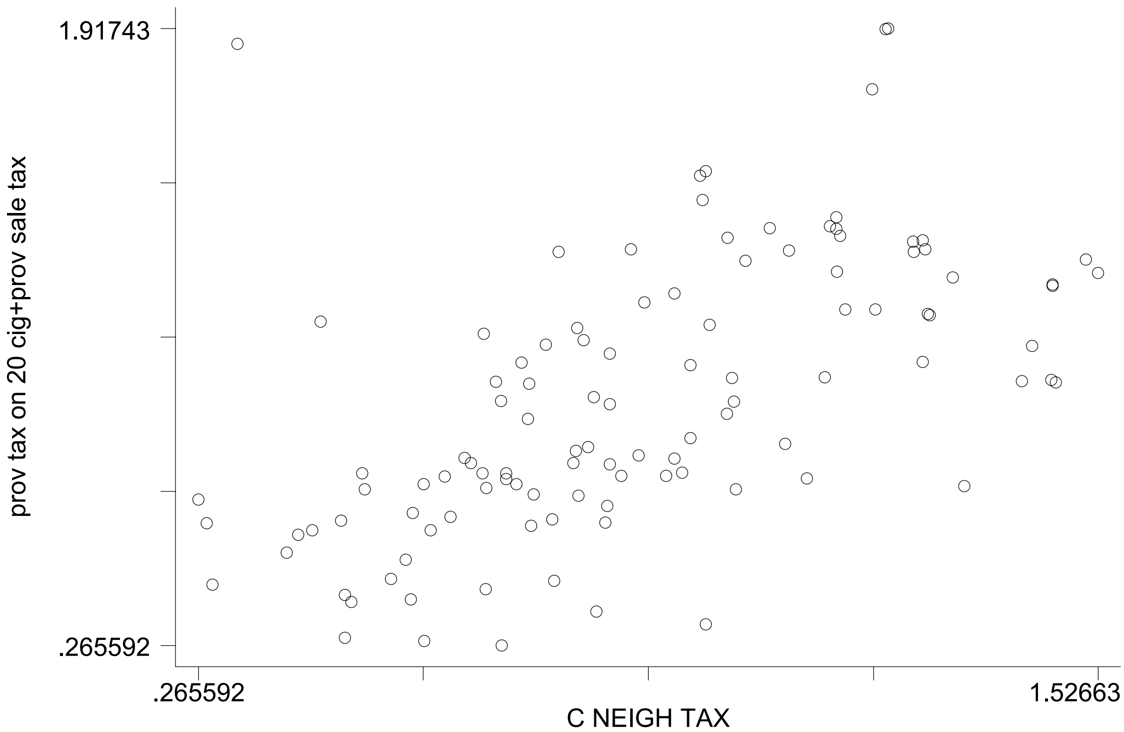

Fig. 3A The graph relates the province unit cigarette tax, inclusive of general sales tax in 1989 US $ and the neighbouring canadian province average unit cigarette tax, inclusive of general sales tax, in 1989 US $.

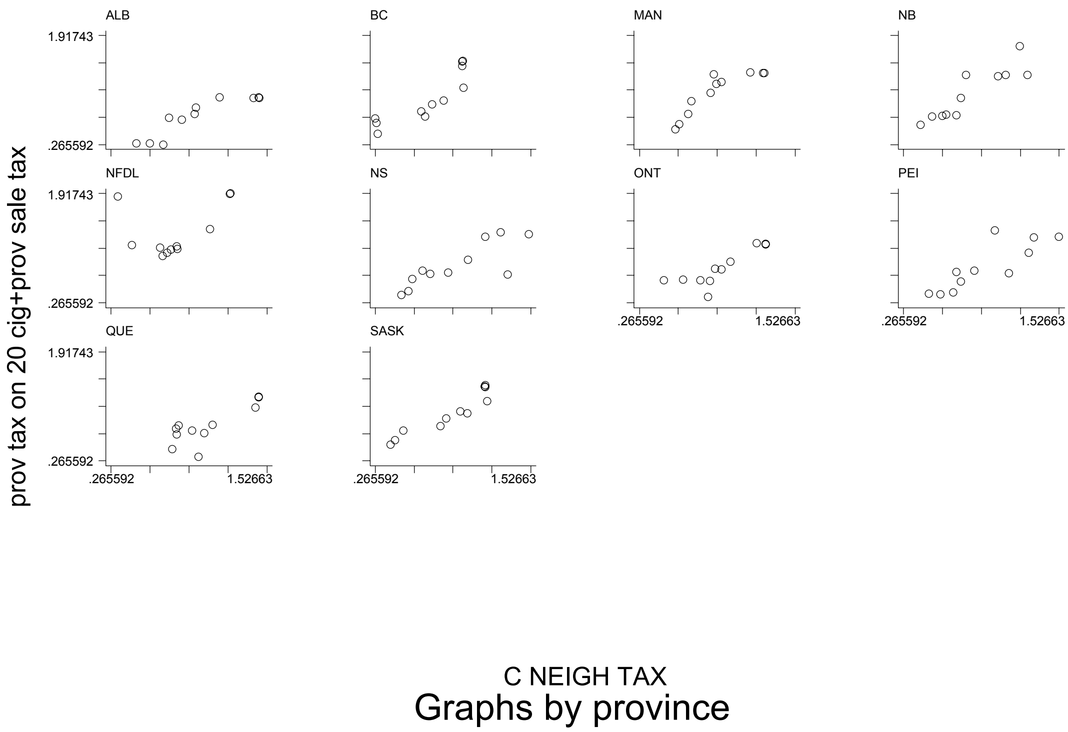

Fig. 3B The graph relates the province unit cigarette tax, inclusive of general sales tax in 1989 US and the neighbouring canadian province average unit cigarette tax, inclusive of general sales tax, in 1989 US $ for the ten different considered provinces: Alberta (ALB), Ontario (ONT), British Columbia (BC), Saskatchewan (SASK), Newfoundland (NFDL), Prince Edward Island (PEI), Nova Scotia (NS), New Brunsweek (NB), Quebec (QUE), Manitoba (MAN).