Bother thy neighbour?
Intergovernmental Tax Interactions
in the Canadian Federation

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Abstract

The subject of tax interactions, such as tax competition, has become pervasive in government discussions and in the media in Canada over the past few years. These interactions may become more widespread as provinces gain greater flexibility in personal income taxes through a tax-on-income system and as many jurisdictions implement tax reduction packages. The goal of this paper is to determine the existence and extent of horizontal tax interactions (among provinces) and vertical tax interactions (between the federal and provincial governments) in Canada between 1963 and 1998. The framework adopted draws on recent work by Hayashi and Boadway (2000) which adapts Zodrow and Mieszkowski's (1986) static tax competition model to include all provinces and the federal government. Jurisdictions choose tax rates to maximise the government objective function that includes both revenues and the capital stock as arguments. All governments act as Nash competitors. Tax interactions in both corporate income taxes (CIT) and personal income taxes (PIT) are examined. Estimation results for the period covered find evidence of vertical and horizontal tax interactions in the field of CIT. However, there is no evidence of horizontal tax interactions in the field of PIT, and little for vertical interactions, during this time period.

Résumé

La question des interactions en matière fiscale, comme la concurrence en matière fiscale, occupe désormais une grande place dans les discussions tenues au sein du gouvernement et mobilise l'attention des médias au Canada depuis un certain temps. Ces interactions pourraient prendre de l'envergure car les provinces acquièrent une plus grande marge de manœuvre au chapitre de l'impôt des particuliers, grâce au régime de l'impôt calculé sur le revenu et que de nombreuses administrations publiques adoptent un plan de réduction des impôts. Le document a pour objectif de déterminer l'existence et l'ampleur des interactions fiscales horizontales (parmi les provinces) et les interactions fiscales verticales (entre les paliers fédéral et provincial au Canada) entre 1963 et 1998. Le cadre adopté s'appuie sur des travaux effectués récemment par Hayashi et Boadway (2000), qui adapte un modèle statique de concurrence fiscale de Zodrow et Mieszkowski's (1986) pour inclure toutes les provinces et le gouvernement fédéral. Les administrations publiques ont choisi des taux d'imposition qui maximise la fonction de décision du gouvernement dans laquelle s'insèrent les recettes et le capital social. Tous les gouvernements agissent en tant que concurrents du Nash. Les interactions fiscales au titre de l'impôt des sociétés et de l'impôt des particuliers sont examinées. Les résultats estimatifs obtenus pour la période couverte font ressortir l'existence d'interactions fiscales à la fois verticale et horizontale en ce qui touche l'impôt des sociétés. Toutefois, rien ne prouve qu'il existe des interactions fiscales horizontales dans le domaine de l'impôt des particuliers, et les interactions verticales semblent très minces, pendant cette période.

1 Introduction

Within the vast body of literature on fiscal federalism, a great deal of work concerns tax externalities. Since a decrease in province A's tax rate could lead to an outflow of the tax base in province B, there may be an incentive for provinces to choose tax rates that are inefficient. Work in this area has normally focussed on horizontal tax interactions between provincial governments, with limited involvement of the federal authority. However, there are also possible externalities between levels of government, arising from tax base overlap, which can have efficiency implications. Since Canada is currently in the process of de-linking federal and provincial taxes, and tax cuts are a subject of focus, there is increasing scope for externalities in vertical interactions (between federal and provincial governments). Thus it is important to understand the nature of both horizontal and vertical tax externalities. Few empirical studies so far have included vertical interactions in their analysis.

In this paper we estimate tax interactions among federal and provincial governments in Canada based on recent work by Hayashi and Boadway (2000). In their paper, Hayashi and Boadway (2000) adapt the standard static tax competition model of Zodrow and Mieszkowski (1986) to include all provinces as well as the federal government and allow for imperfect capital mobility through adjustment costs. The dynamic structure of the model is incorporated through partial adjustment functions and lags in decision making at both the federal and provincial level. Governments choose tax rates to maximise their objective function that includes both revenues and the capital stock as arguments. All governments act as Nash competitors and take the other players' tax rates as given. Due to statistical constraints each province cannot be analysed separately in the model. Therefore, we examine the following jurisdictions: Ontario, Quebec, Alberta and aggregates of the remaining Western provinces and the Atlantic provinces. We test the existence of tax externalities in the field of Personal Income Tax (PIT) and Corporate Income Tax (CIT).

The paper proceeds as follows. Section 2 gives some background on vertical and horizontal tax externalities and summarises the relevant literature. Section 3 presents the empirical model and data. Section 4 discusses the results from the model. We find evidence of horizontal and vertical externalities for CIT but almost none for PIT. In Section 5 we draw some conclusions.

2 Background and Literature Review

2.1 Background

It is useful to begin with an explanation of the types of tax externalities. A good summary and explanation of what constitutes a horizontal or vertical externality can be found in Dahlby (1996). An inter-jurisdictional fiscal externality occurs when a government's tax policy affects individuals in another jurisdiction, either positively or negatively. This can be a direct effect (i.e. affects the utility of non-residents of a province) or an indirect effect (i.e. affects the budget constraint of other governments). Table 1 provides a simple explanation and example of each type of externality.

Table 1: Tax externalities

Types of Externality	Examples	Fiscal Implications
Direct Horizontal	Tax exporting: A hotel tax which is borne by visitors from another province.	Increased reliance on taxes where at least part of the burden is borne by residents of other jurisdictions.
Indirect Horizontal	Tax competition: A CIT tax credit or deduction designed to attract firms from other provinces.	The potential mobility of the tax base leads to downward pressure on tax rates.
Indirect Vertical	Tax base overlap: Federal and provincial excise taxes on cigarettes.	Ambiguous reaction by each level of government (see Table 2).

Source: adapted from Dahlby (1996)

A horizontal tax externality[1] results from the competition for mobile tax bases between governments at the same level. Thus, if province A increases its tax rate and this leads to an outflow of the tax base to province B, province A will perceive the marginal cost of public funds (MCPF) to be *higher* than the true MCPF. In this way provinces have an incentive to set taxes that are too low and therefore inefficient. In the presence of this externality, the interaction we expect to see is one where provinces reduce tax rates in an attempt to attract a larger tax base. The potential consequence, and a reason for concern over tax competition, is that as tax rates are reduced, the provision of local public goods may suffer as a result. As well, if all players engage in this behaviour, then no winners emerge. However, Boadway and Hobson (1993) point out that even if tax competition is a zero-sum game, it is still inefficient to the extent that governments perceive their options over choices of tax instruments to be too limited[2].

In contrast, vertical interactions have an ambiguous effect theoretically. Vertical tax externalities result from tax base overlap, rather than from competition per se, since each province shares its base, for the most part, with the federal government[3]. Following Hayashi and Boadway (2000) when we assume that governments are Nash competitors, vertical interactions can work in two opposing ways.

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1 Indirect horizontal externalities are more relevant for our purposes than direct ones, since we are concerned about the tax-induced movement of the tax base between provinces. When discussing horizontal externalities we will be referring only to indirect ones.

2 Despite the fact that it is generally accepted that horizontal tax competition involves a tax rate increase from one province positively affecting the revenues of another province, there are other possibilities. For example, Dahlby (1996) notes that increases in one state's tax can reduce real incomes, causing a decline in imports from another state, and thus a *decline* in that state's revenues. As well, Esteller-Moré and Solé-Ollé (2001) note that if one province increases its rate, the other province might receive a surge in revenue due to the tax base that moves to its province, enabling it to provide the same level of public goods at a lower rate. Mintz and Smart (2001) have an interpretation of tax competition that could apply here as well, as will be discussed later.

3 For this reason, it is more accurate to call it a vertical *interaction*, since it is not really *competition* over a mobile base. However, the notions are similar.

a) First, there is an "incentive effect". One level of government may increase their tax rates in such a way that ignores the fact that the other level of government will also be affected by any resulting decrease in the shared tax base. In this case, each government perceives the MCPF to be less than its true value[4]. Thus both levels have an incentive to increase taxes beyond what is efficient, since some of the cost is passed onto another level of government.

b) A less commonly talked about vertical effect is "crowding-out", which works in the opposite direction from that mentioned above. An increase in the tax rate at one level of government can make it more difficult for the other level to raise revenues from the same base. Thus we would see a negative relationship between revenues of different levels. However, Courchene (1999) points out that this can also work in the opposite direction: a decrease in taxes at one level can allow the other level to increase taxes, thereby taking up the room created.

The incentive and crowding-out effects work in opposite directions, and so the overall effect is an empirical matter. Negative vertical effects (crowding-out) reinforce the effects of horizontal tax competition, since they exacerbate the incentive to decrease tax rates. In contrast, positive vertical effects (incentive effect) constrain horizontal tax competition. These effects will be discussed in more detail in Section 2.3.

Since the literature on vertical interactions is new and still developing, other interpretations of possible vertical effects exist. Goodspeed (2000) has identified four comparative statics at work in a vertical externality, drawing from the work of Boadway and Keen (1996) and Besley and Rosen (1998), that are applicable when we assume the federal government is the Stackelberg leader. These four effects essentially encompass the two mentioned above. Since they can work in opposite directions he also purports a theoretically ambiguous reaction of a local government to a change in federal rates. Table 2 summarises these competing effects. The net result is, again, an empirical matter.

Finally, Wilson (1999) states that, unlike provinces, different levels of government may have many overlapping objectives, and so conflict is potentially reduced. However, the literature on vertical externalities is still developing, and many authors suggest that there is room for conflict. The exact nature of vertical interactions is still a "slippery concept", to borrow a term from Wilson (1999), and further theoretical and empirical work is needed to solidify our understanding.

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[4] Equalization could play a role in constraining this perception, as discussed in Section 2.3.

Table 2: Provincial tax setting behaviour when the federal government is a Stackelberg leader.

Comparative static	Effect of an increase in federal tax rates	Province's tax rate reaction due to an increase in the federal rate
Deadweight loss effect	- If a provincial government is only concerned with excess burden born by that province's residents, a higher provincial tax will maximize the indirect utility of the representative consumer.	+
	- If a provincial government is concerned with the federal-provincial excess burden, a lower provincial tax will maximize indirect utility of the representative consumer.	-
Revenue effect	As long as the tax base is negatively related to the federal tax rate, an increase in the provincial tax is required to maintain provincial revenues at the same level.	+
Expenditure effect	Like the above, except the provincial government may instead react by lowering expenditures, and potentially the provincial tax rate, as well.	-/0
Tax substitutability and complimentary effect	The effect on provincial tax bases depends on whether they are substitutes or compliments to the federal base.	+/-

Source: adapted from Goodspeed (2000) and Besley and Rosen (1998).

2.2 The Literature

Some important contributions to the literature have already been cited. The theories behind tax competition began in the 1980s, and work in this area has been steady since. The theoretic model first developed by Zodrow and Mieszkowski (1986) is still the basis for most current work. Wilson (1999) gives a good treatment of this model and summary of the resulting literature[5]. Notable empirical work focussing on horizontal interactions finds strong evidence for its existence (see Hayashi and Boadway (2000) for a Canadian example; Besley and Case (1995), and Becsi (1998) for the U.S.; Heyndels and Vuchelen (1998) for Belgium). In contrast to most work, Mintz and Smart (2001) show that intensification of tax competition may lead to divergence rather than convergence in tax rates, if competition is over financial as well as real capital.

However, most early work focuses on horizontal tax interactions only. A strong argument for including the interactions of the federal government is made by Keen (1998). He argues that the role of the federal government goes well beyond that of a simple device for tidying up the results of horizontal competition since its presence can generate externalities of its own. Vertical externalities were first recognized by Johnson (1988) and later in the work of Cassing and Hillman (1982), Boadway, Marchand and Vigneault (1998). Boadway and Keen (1996), Dahlby (1996) and Hoyt (2000) consider vertical tax competition theoretically and suggest some sort of federal subsidy/tax system to correct for distortions.

5 See also see Dahlby (1996) and Inman and Rubenfeld (1996), who base their work on Gordon (1983). Delage (1999) does an extensive review of horizontal tax competition models. Also notable is Mintz and Tulkens (1986) who characterized a non-cooperative fiscal equilibrium resulting from tax competition.

Dahlby (1996) likens over-exploitation of the overlapping tax base to over-exploitation of shared fishing grounds – a common property resource problem. Flowers (1988), Keen (1995) and Wrede (1996) look at vertical interactions assuming, however, revenue maximizing (Leviathan) governments. Governments in this case are seen to overtax under certain conditions.

Empirical work that includes vertical interactions is very limited. The work by Hayashi and Boadway (2000) is so far the only empirical examination of federal and provincial government reaction functions that is applied to taxes in Canada[6]. They find evidence for vertical externalities that result in a negative relationship between corporate income taxes at the federal and provincial level for certain provinces. Their work is then a natural starting point for an extension of the analysis that will be performed in this paper, as will be described later. For the U.S., empirical analysis shows the existence of vertical tax externalities that involve a positive relationship between taxes at the two levels (Besley and Rosen, 1998; Esteller-Moré and Solé-Ollé, 2000). Goodspeed (2000) finds a negative relationship between the two within twelve OECD countries.

Many recent studies suggest that the interaction between governments is one of Nash competition, whereas others suggest that the federal government may act as the Stackelberg leader (see Boadway and Keen (1996); Besley and Rosen (1996)). Hayashi and Boadway (2000) test both specifications and do not find conclusive evidence to suggest either as a more appropriate model. Alternatively, Dahlby (1996) noted that since the federal government derives 40 per cent of its revenue from Ontario alone, that Ontario may be able to exhibit some aspects of a leader.

Brief mention should be made of the other side of this issue: expenditure competition. Although it is beyond the scope of this paper to delve into this literature, it is important to mention due to its obvious linkages with tax competition[7]. Quite a few papers have examined tax and expenditure (fiscal) competition simultaneously (see, for example, Wildasin 1988; Case and Rosen 1993). The broad conclusions that are drawn are similar to the above; that under many conditions sources for inefficiency arise. However, tax competition is different in nature than expenditure competition. Boadway (1982) points out that strategic behaviour by provinces concerning public good provision is not more advantageous than acting myopically, yet the effect of strategic behaviour on tax policies is more ambiguous.

2.3 Implications of Tax Interactions

Whether or not tax competition is helpful or harmful is debateable, even if attention is restricted to the horizontal level. When the vertical dynamic is analysed, the story becomes even harder to disentangle. Below is an overview of the literature on the revenue and policy implications of tax competition, but it is by no means exhaustive.

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[6] However, Esteller-Moré and Solé-Ollé (2001) are developing a model for PIT in Canada based on a simple determination of reaction functions that incorporates the equalization system explicitly.

[7] In our empirical formulation, expenditures are used as a control variable to eliminate tax changes that may be financing expenditure competition, since it is pure tax competition that we are interested in.

The foremost concern about tax competition is the extent to which it actually results in efficiency losses (and perhaps gains). In theory, whether horizontal tax competition is beneficial or harmful to citizens depends on certain assumptions about government:

i. If it is assumed that government expenditures/taxes are used to maximize citizen welfare, then competition over tax rates will be harmful and result in under-provision of public goods. Thus a coordinated tax policy could be beneficial in this case.
ii. If, on the other hand, it is assumed that governments tend to spend/tax excessively, then horizontal tax competition alone could constrain this tendency. In this case, a decentralized tax policy could be beneficial.

We start by considering the latter assumption. Proponents of this view make reference to a Tiebout-type world where governments are seen to be like private firms, offering baskets of tax and public good provision levels, which citizens can then chose from. In this sense competition is seen as a beneficial thing that ensures efficiency and constrains the revenue-maximizing (Leviathan) tendencies of government. Wilson (1999) discusses this view and notes how the assumptions inherent in the Tiebout model are often unrealistic.

However, adding vertical competition can make the situation worse or better. Recall that positive vertical externalities (the incentive effect) can encourage both levels of government to raise rates. Therefore, to judge whether or not tax competition is beneficial when both levels of government are revenue-maximisers, we would need to fully understand which vertical effects are in place, and to what extent they dominate horizontal externalities. The overall effect is then ambiguous and would need to be evaluated empirically. So, the result that tax competition is beneficial is not robust when the vertical dynamic is included in the analysis.

Turning to the first assumption about government, the implications of tax interactions are in this case more straight-forward. The standard argument over horizontal tax competition is that it is a driving force of a race to the bottom of tax rates and therefore public good provision (See Wilson (1999); Day and Winer (1994)). There are no benefits to horizontal tax competition if governments are benevolent, since taxes would already be set at their optimum. Furthermore, Inman and Rubenfield (1996) and Pommerehne et al. (1996), among others, note that competition makes it harder to maintain a progressive tax structure. However, some still argue that the benefits from a Tiebout-like diversity in public good provision remain. Overall, in most cases considered in the literature involving benevolent governments, a policy of coordination is beneficial when tax competition is prevalent (Delage 1999).

As mentioned, vertical interactions either constrain or reinforce the effects of horizontal competition. For example, negative vertical effects between the federal and provincial governments would reinforce the tendency to reduce rates, however, the incentive effect would serve to moderate horizontal tax competition since it gives incentives to increase rates. To illustrate how vertical interactions affect dynamics, consider the progressivity example mentioned above. Dahlby (1996) contends that tax base overlap (the incentive effect) may explain why provincial tax structures in Canada are in fact more progressive than we would expect in the face of horizontal tax competition pressures, since provinces may pass on the cost of this policy to the federal government. In general, vertical dynamics become complicated when we consider the role of transfers, a topic that will be revisited later.

Few empirical attempts have yet been made at quantifying the magnitude of efficiency losses/gains from vertical or horizontal tax interactions[8]. Dahlby (1996) makes reference to earlier calculations that found the perceived MCPF for increases in provincial PIT rates was considerably less than its true social cost. Keen (1998) found that tax revenues are on average lower in federal countries[9]. Qualitative analysis of the Canadian context suggests the potential for harmful tax competition is somewhat constrained by institutional factors. However, the potential for tax competition exists due to the wide range of tax powers of the provinces and the high degree of overlap in federal and provincial tax bases. The share of government revenue raised by the provinces has been increasing over the years, however, our system of national agreements and harmonisation[10] all serve to minimise distortions and constrain the potential for harmful tax competition. The relatively small number of provinces (compared to the U.S.) has an ambiguous effect on tax competition; Keen and Kotsogiannis (2000) note that efficiency losses should be smaller with fewer provinces present, however it is well recognised that strategic interactions between provinces are more important when their numbers are small (see Wilson 1999).

Dahlby and Wilson (1996) derive an interesting conclusion from a comparison of Canada and Australia based on the fact that Australia has fewer overlapping bases between levels of government. They note that compared to Australia, Canadian corporate taxes are lower, consistent with the theory of horizontal externalities; and consumption taxes are higher, consistent with the theory of vertical externalities. Dahlby and Wilson (1996) call for improvements to the equalization and intergovernmental transfer system as a means of correcting for these externalities. Courchene (1999) adds to this by noting that on at least two occasions attempts by Ottawa to lower federal PIT and CIT rates to make overall levels more comparable with the U.S. were offset by the provinces taking up the vacated tax room. He concludes that the overall level of taxation (after adjusting for exchange rate effects) in Australia is lower than that in Canada, perhaps due to the fact that more tax sources are shared in Canada.

Turning now to the role of intergovernmental transfers, no direct investigation of the relationship between Equalization and tax competition has been made[11], and various theories

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[8] As well, the literature on fiscal federalism has mainly addressed efficiency concerns regarding only administrative or allocative costs, rather than outright efficiency losses attributable to co-occupation of tax bases within the system (Mintz and Tulkens 1996; Keen 1998; see for example Musgrave 1969, Boadway 1982).

[9] However, he acknowledges that this does not necessarily mean tax rates are lower since governments could be on the wrong side of the Laffer curve.

[10] Cremer and Gahvari (2000) point out that harmonization will not prevent tax competition inefficiencies if tax evasion is possible.

[11] Forthcoming work by Esteller-Moré and Solé-Ollé will include a variable for the national average tax rate (for equalization purposes) in the reaction functions of recipient provinces. Results suggest that equalization receiving provinces are more likely to respond to an increase in the national average tax rate with an increase

on the impact of Equalization have competing results. For example, in the Mintz Report (Canada 1998) and in Smart (1998) it is suggested that Equalization discourages horizontal tax competition for recipient provinces. If a recipient provinces engages in tax competition by reducing CIT, and this results in an increase in the tax base, then the gains made could be offset by a reduction in Equalization payments. However, Smart (1998) also shows that an increase in the standard Equalization tax rate provides an incentive for recipient provinces to also increase rates, since they are partially compensated through Equalization. Therefore, whether Equalization encourages or discourages tax competition for recipient provinces depends on the sensitivity of the tax base – the more sensitive, the greater the adjustment in Equalization transfers. Interestingly, as the tax base becomes more mobile, the potential for tax competition becomes greater, but so too is tax competition discouraged due to adjustments in Equalization[12]. Thus the net effect is ambiguous. In terms of vertical interactions, Hayashi and Boadway (2000) and Keen (1998) note that if a recipient province were to increase its tax rate in response to a federal increase, the impact on its tax revenues may be mitigated by an increase in Equalization payments that would result from any decrease in the tax base. This insulation from the full adverse consequences of raising rates could intensify vertical fiscal externalities[13]. Clearly the effects of Equalization on tax competition are different not only between the horizontal and vertical scale, but also between recipient and non-recipient provinces. Further analysis of the resulting incentives needs to be clearly mapped out.

3 Methodology

3.1 The Model

Following Boadway and Hayashi (2000) the tax setting functions used in this paper are based on the basic tax competition model of Zodrow and Mieszkowski (1986). Keen and Kotsogiannis (1996) extended the tax competition model to include both the federal and provincial governments.[14] Governments act as Nash competitors and choose tax rates to

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in taxes, since it increases grant levels further. However, these same recipient provinces are less likely to react to neighbours tax changes (tax competition).

12 Of course, this then depends on whether the base is being lured away from a have or have-not province, and on whether that province is in or out of the standard. We do not delve into the complexities of this here, but it is helpful to keep them in mind.

13 This is only true if vertical tax externalities are characterized by a positive relationship between tax rates at the two levels.

14 Many small but significant modifications are made to the model developed by Boadway and Hayashi (2000). First, we extend the model to allow for an individual analysis of three provinces and two aggregates of provinces; in Boadway and Hayashi (2000) only Ontario and Quebec are analysed individually. As well, capital taxes are included since they are an important source of revenue, especially for the province of Quebec. Most of the data is obtained from two sets of Provincial Economic Accounts (PEAs) that are non-continuous over the period A linking formula is applied to better justify merging the series. Expenditures as a per cent of GDP (local included in provincial figures) are used in place of deficits to represent government budget constraints, since the former could eliminate the role of expenditure competition – although in practice the two give nearly identical results. Other small changes are made to the list of exogenous variables; these are described in detail in Sections 3.2 and 3.3.

maximise the government objective function[15]. The government's objective function includes both revenues and the capital stock as arguments since revenues finance public services while the capital stock generates income and employment. The solution to the maximisation problem gives tax setting functions where a government's tax rate depends on the tax rates of other governments and a set of exogenous variables. Three steps are taken to render the model estimable. First, tax rates are normalised through a logit transformation to ensure that the distribution of the dependent variable matches the statistical properties of the error terms. Second, tax rates of other regions enter the model linearly, with a one period lag to reflect delays in decision making. Finally, it is assumed that governments change their tax rates to their desired rate slowly, through a partial adjustment mechanism. These assumptions yield the following six-equation model[16]:

$$\Gamma_s = \alpha + \alpha_F \Gamma_{s-1} + \alpha_O \tau^O_{S-1} + \alpha_Q \tau^Q_{S-1} + \alpha_A \tau^A_{S-1} + \alpha_W \tau^W_{S-1} + \alpha_M \tau^{AT}_{S-1} + \alpha'_E Z^F_S + \varepsilon^F_S$$
$$\tau^O_S = \beta + \beta_F \Gamma_{s-1} + \beta_O \tau^O_{S-1} + \beta_Q \tau^Q_{S-1} + \beta_A \tau^A_{S-1} + \beta_W \tau^W_{S-1} + \beta_M \tau^{AT}_{S-1} + \beta'_E Z^O_S + \varepsilon^O_S$$
$$\tau^Q_S = \gamma + \gamma_F \Gamma_{s-1} + \gamma_O \tau^O_{S-1} + \gamma_Q \tau^Q_{S-1} + \gamma_A \tau^A_{S-1} + \gamma_W \tau^W_{S-1} + \gamma_M \tau^{AT}_{S-1} + \gamma'_E Z^Q_S + \varepsilon^Q_S$$
$$\tau^A_S = \delta + \delta_F \Gamma_{s-1} + \delta_O \tau^O_{S-1} + \delta_Q \tau^Q_{S-1} + \delta_A \tau^A_{S-1} + \delta_W \tau^W_{S-1} + \delta_M \tau^{AT}_{S-1} + \delta'_E Z^A_S + \varepsilon^A_S$$
$$\tau^w_S = \eta + \eta_F \Gamma_{s-1} + \eta_O \tau^O_{S-1} + \eta_Q \tau^Q_{S-1} + \eta_A \tau^A_{S-1} + \eta_W \tau^W_{S-1} + \eta_M \tau^{AT}_{S-1} + \eta'_E Z^W_S + \varepsilon^W_S$$
$$\tau^{AT}_S = \phi + \phi_F \Gamma_{s-1} + \phi_O \tau^O_{S-1} + \phi_Q \tau^Q_{S-1} + \phi_A \tau^A_{S-1} + \phi w \tau^W_{S-1} + \phi_M \tau^{AT}_{S-1} + \phi'_E Z^{AT}_S + \varepsilon^{AT}_S$$

where Γ and τ are the tax rates of the federal and provincial governments in period s respectively. F, O, Q, A, W and AT are superscripts for the federal government, Ontario, Quebec, Alberta, Western provinces (B.C., Saskatchewan and Manitoba), and the Atlantic provinces, respectively. It is not possible to analyse each province separately since, given data availability, we would run out of degrees of freedom. We chose to aggregate Western and Atlantic provinces, since their economies are reasonably similar and likely experience similar shocks[17]. Z is a matrix of exogenous variables specific to each region. The system is estimated as a seemingly unrelated regression (SUR) system in order to account for likely contemporaneous shocks to the error terms. Since we are only working with 36 observations, and we have lagged-dependent variables, and the number of regressors is relatively large, we could expect errors in our inferences if we relied upon test statistics whose properties are only known asymptotically (Davidson and McKinnon 1993). To mitigate this, a non-parametric bootstrap procedure is used to obtain p-values that are less likely to over-reject[18]. Appendix 2 presents the original asymptotic p-values and their bootstrap counterparts.

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15 Hayashi and Boadway (2000) also test a version of the model where the federal government acts as a Stackelberg leader and could not find conclusive evidence to support this specification. Therefore, we adopt the Nash specification.

16 The lagged dependent variable appears through the correction for an AR(1) process in the errors.

17 The model is somewhat sensitive to the choice of groupings. We chose the grouping that is most logical *a priori.*

18 The number of bootstraps was 9999, and following standard procedure, residuals were centred and rescaled before being resampled.

Horizontal effects are present if the coefficient on a lagged provincial tax rate is significant in an equation where a provincial tax rate is the dependent variable. For example, $\beta_A > 0$ says that a decrease in Alberta's tax rate leads to a decrease in Ontario's tax rate. In other words, Ontario reacts to Alberta's tax rate. Vertical effects may plausibly appear with either a positive or a negative sign in any of the six equations where the federal tax rate appears. A positive sign would suggest an incentive effect, where, for example, a provincial government raises its tax rate in response to an increase in the Federal rate. In this case, each order of government perceives the MCPF to be greater than the true MCPF and tax rates may be set too high. A negative vertical interaction would suggest either that one level of government is crowded-out by an increase in the tax rate of the other order of government or that governments take up the tax room vacated by the tax reduction of another level of government[19].

The framework of the model described above is applied to both CIT and PIT in Canada. There are slight differences in the exogenous variables used and the calculation of tax rates between the two versions of the model. These differences are described in turn below.

3.2 Data – CIT

The analysis covers the years 1963 to 1998, which is the longest time series possible given data availability. All of the data, unless otherwise specified, come from the *Provincial Economic Accounts* (PEA) available through CANSIM. However, due to revisions in PEA data series, data are available in two discontinuous groups, one ranging from 1961-1991, and the other from 1981-1998. We apply a linking equation in order to create a series that is continuous over our sample period[20]. Fortunately, whether or not we use this linking procedure, our results are not dramatically affected.

Tax rates are calculated as average effective rates, to capture changes in the tax rate as well as those in tax credits, exemptions, etc. in one summary statistic. Hayashi and Boadway (2000) calculate the tax rate as the ratio of corporate income tax revenues to corporate profits. We do the same with one addition; we include capital tax revenues in the numerator of this ratio. This makes comparisons between provinces more just, since provinces rely on capital taxes to a greater or lesser extent. Once the average rates for each jurisdiction are calculated, they are logit scaled to conform with the distribution of the error terms, which in principle can take on any value between positive and negative infinity[21].

Elements in the Z matrix include two types of variables: i) those that influence the calculation of the average tax rates, and ii) those that influence tax decisions *other than* tax interactions. Regarding the former, since we are using an average tax rate calculation, non-

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[19] See the discussion in Section 2.1.

[20] Taking 1981 as the linking year, we apply the growth rate of the earlier series to extend the modern series back in time. This way, the growth rates of the historical series are maintained, but any levels shifts between series are at least accounted for.

[21] If T_s is the average effective tax rate, the logit scaled tax rate is equal to $\log(T_s) - \log(1-T_s)$

policy elements, such as the business cycle, could cause the calculated rate to fluctuate even if no policy changes were made. Since what needs to be isolated is only changes in tax rates, exemptions, credits, etc. due to policy changes, non-policy elements such as inflation and the business cycle are controlled for. The national GDP price deflator (1992=100) controls for inflation in all six equations. Two variables are used to capture the business cycle, namely the capital utilization rate, and real GDP growth rates. The national capital utilisation rate and province-specific real GDP growth rates are used in each equation, deflated by the nation-wide deflator.

Regarding the second type of exogenous variable, policy variations that have nothing to do with tax competition also need to be controlled for. While the three variables mentioned above can serve this purpose, other variables are needed. An international interest rate is included since it is implied from the theoretical argument developed in Hayashi and Boadway (2000) and relates to the assumption of imperfect capital mobility due to adjustment costs. As well, real per capita wages are included for each jurisdiction, since the demand for labour affects the demand for capital inherent in each government's objective function. A set of dummy variables for governing parties of each jurisdiction (except the aggregates) is included, excluding the initial year in office. These variables may pick up tax policy decisions other than those influenced by tax interactions. As well, some measure of the government budget constraint needs to be included. Hayashi and Boadway (2000) use public sector deficits as a proportion of GDP in each jurisdiction, however we use provincial-local expenditures[22] as a proportion of GDP in each jurisdiction instead. Using expenditures controls for both the budget constraint and tax changes that may finance expenditure competition rather than tax competition. Substituting expenditures for deficits does not substantially alter the key findings[23]. Table 3 lists the variables that comprise the Z matrix. In theory, by controlling for other factors that could affect tax rates, the model examines the existence and extent of strategic horizontal or vertical interaction between jurisdictions.[24].

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[22] Provincial and local expenditures are combined since provinces have different mixes of provincial and local responsibilities for spending. Total provincial-local expenditures are calculated net of transfers between the two.

[23] Attempts were made to see if other exogenous variables were necessary in the model, particularly to model the unique impact of oil and gas prices on Alberta's economy. We found that including Alberta's total royalty revenues or oil prices (gas prices were not available over the period) did not improve estimation, and provincial GDP likely accounted for this variation already. A dummy variable for the National Energy Program was also included (for 1980-84 as well as 1976-84, to capture pre-NEP price controls) but it also did not much alter the results. Finally, we examined whether including transfers from the federal government to the provinces affected the results, and they did not. Despite the fact that transfers are a large portion of provincial revenues and so could easily affect tax decisions, federal transfers are perhaps already accounted for by the variables modelling the provincial economic situations and current levels of expenditures. In any case, transfers would need to be included as a choice variable in this model. As well, the one percentage point tax point transfer for CIT that occurred in 1977 for all provinces did not affect the main results and so was excluded.

[24] Note that the significance of any one exogenous variable is not of particular interest in this context. Since this employs a kitchen sink approach in attempting to draw out all of the factors affecting tax rates other than competition, there is undoubtedly approximate collinearity between some of these variables.

Table 3: Exogenous variables for the CIT version of the model

	Exogenous Variables – CIT version
PC_s^i	Dummies for the Progressive Conservatives (for Federal, Alberta and Ontario)
ND_s	Dummies for the New Democratic Party (for Ontario and B.C.)
UN_s	Dummies for the Union Nationale (for Quebec)
PQ_s	Dummies for the Parti Québécois (for Quebec)
SC_s	Dummies for the Social Credit Party (for Alberta and B.C.)
e_s^i	Ratio of total expenditures (combined provincial and local, net of transfers) to GDP (%)
w_s^i	Log of per capita wages (in 1992 prices)
g_s^i	GDP growth rate (in 1992 prices, %)
π_s	Inflation rate (%)
κ_s	Capital utilization rate (%)
r_s	International interest rate (%)
tp_s	Dummy variable for the CIT tax point transfer (from 1977 on)

Note: Variables with superscript *i* take on different values for the federal and provincial governments.

3.3 Data – PIT

In general, the model to estimate interactions in the field of PIT in Canada is similar to that described above for CIT. Although we have not modelled it explicitly, an analogous government objective function for labour can be developed as the one done for capital in Hayashi and Boadway (2000) which motivates their model specifications. Here, governments are assumed to value labour for the revenue and employment it can provide, while accounting for the costs associated with providing services. Other than the differences mentioned below, the procedures and data used for the PIT version are the same as those used for the CIT version.

Tax rates for PIT are also calculated as average effective rates, to capture the complexity of the tax system in one summary statistic. It might appear useful to consider another measure, such as the marginal rates for high income earners since it is assumed that tax competition for PIT is more intense over the well-educated or upper income groups of the population[25]. However, there are several reasons to continue using an average measure. First,

[25] Indeed, it is often mentioned that tax competition puts pressure on a system of vertical redistribution.

the complexity of surcharges and deductions makes it difficult to derive a marginal rate that is meaningful. It can also be argued that migration is responsive to average and not marginal tax rates. Thus, tax rates are calculated as total PIT revenue divided by total wages and salaries.[26]

During our sample period, provincial PIT revenues are, in general, calculated using a tax-on-tax system.[27]. Thus we expect to see a positive relationship between taxes at the federal and provincial levels. This may appear to constrain our analysis of vertical dynamics, but in many ways it does not. First, if we do not see any relationship between levels of government, then we can assume that other effects are dominating the positive effect of the tax-on-tax system that we know to exist *a priori*. As well, including the vertical dynamic ensures that we do not see spurious correlations between provincial tax rates that are in fact due to changes in federal rates.

Regarding the exogenous variables, we continue to have two types of variables but modify some of them to reflect the different tax base in question. We continue to have three variables that influence the calculation of the average tax rates. However, we replace one of our measures of the business cycle (capital utilization rate) with the growth rate of the unemployment rate, specific to each jurisdiction, to better reflect cyclical variations in the tax base. This is also a variable employed in Besley and Rosen (1998), however we use the growth rate to achieve a stationary variable.

The variables used to control for non-tax-competition policy variations differ slightly from the CIT version of the model. Dummy variables are included for the PIT tax point transfers that fall within the sample period, since each represents a coordinated change in the distribution of taxing powers between levels of government. Since WWII, the proportion of taxes collected by the provinces has steadily increased, mostly through formal arrangements allocating further spending responsibilities to the provinces. Failure to account for these transfers, could result in spurious correlations between the tax rates of the provinces, and the relationship between levels of government would not reflect policy choices (within the tax-on-tax system). Thus we account for tax policy conducted in formal agreements, and search for interactions that occur outside of these agreements. We add a dummy variable for the National Energy Program (NEP) period from 1980-84 since the program reflects a realignment of rents in the oil and gas industry which particularly affects Alberta. Although this variable did not significantly affect the results on the CIT side, it does on the PIT side. Again, exclusion of this variable could cause spurious correlations between provincial rates. Finally, the per cent of the population in each jurisdiction between 16 and 64 years of age is included as a measure of the stock of human capital and to capture effects related to the mobility of labour[28]. The international interest rate was removed, since we relax our

[26] We adjust Quebec's rate to account for recoveries of federal tax-point abatements under contracting out agreements. The value of the Quebec tax abatement is subtracted from PIT revenues in that province. From 1965 to 1976, the value of the Quebec tax abatement was between 22 to 24 points (per cent of Basic Federal Tax). From 1977 until now the value has been 16.5 points, 3 of which are for the Youth Allowance.

[27] Provinces begin to move to the tax-on-income system in 2000.

[28] Besley and Rosen (1998), used similar variables: one for the proportion of the population between 5 and 17, and one for that over 65. We experimented with including net in-migration and population growth, but these

assumptions about capital mobility in order to focus on labour mobility, and since it did not affect the results. Table 4 below lists the variables that comprise the Z matrix for the PIT version of the model[29]. Finally, the dummy variables for governing parties were removed for the Alberta equation, since they were collinear with the dummy variables for tax point transfers.

Table 4: Exogenous variables for the PIT version of the model

	Exogenous Variables – PIT version
PC_s^i	Dummies for the Progressive Conservatives (for Federal and Ontario)
ND_s	Dummies for the New Democratic Party (for Ontario and B.C.)
UN_s	Dummies for the Union Nationale (for Quebec)
PQ_s	Dummies for the Parti Québécois (for Quebec)
SC_s	Dummies for the Social Credit Party (B.C.)
e_s^i	Ratio of total expenditures (combined provincial and local, net of transfers) to GDP (%)
w_s^i	Log of per capita wages (in 1992 prices)
g_s^i	GDP growth rate (in 1992 prices, %)
π_s	Inflation rate (%)
$\mu_s^{\ i}$	Growth rate of unemployment (%)
p_s	Population between 16-64 (%)
$tp_{s,y}$	Dummy variables (six) for the PIT tax point transfers (1964, 1965, 1966, 1967, 1972, 1977)
nep_s	Dummy variable for energy price regulations in Alberta (1980-84)

Note: Variables with superscript *i* take on different values for the federal and provincial governments.

did not contribute significantly. This age category captures the majority of taxpayers and it is movements in this age group that are important. As well, labour productivity growth was not significant.

[29] As with the CIT version, other variables were tested, but were excluded if their coefficient was insignificant and if they did not affect the main tax interactions. Such variables include: population growth rates, productivity growth rates (to capture labour mobility effects). Transfers from the federal government as a per cent of GDP were included, but cannot be supported by this model in its current form since they need to be modelled as a choice variable, and interestingly, do not affect the results in any case.

4 Results

4.1 The model

There are a number of issues to consider when interpreting these results. A positive or negative coefficient indicates that some sort of externality is evident, but it does not tell us much about the nature of this externality, especially whether it is beneficial or detrimental, or even the direction of changes in tax rates. We employ our economic intuition to fill in these aspects. As well the comparative static mechanisms behind vertical externalities especially, are not yet well formed in the literature.

It is also important to recognise that this is a partial analysis since we consider the tax decisions over two different tax bases in isolation. Governments do not earmark funds, and could finance a cut in one type of tax with an increase in another. However, it is still valuable to compare one tax policy at a time since competition may exist over one base and not another. As well, we are only examining interactions between Canadian jurisdictions, and do not include tax policy changes in nearby U.S. states, which are not easily comparable. Although it is sometimes asserted that some provinces compete more with certain U.S. states than with other Canadian provinces, competition within jurisdictions of a country should not be minimised. Moving costs may be higher between nations than between provinces, and other institutional factors can make moving a head-office or subsidiary to another province easier than moving abroad.

The use of average rates has important consequences for our interpretation of results. If a tax increase has no impact on revenues, then this rate increase will not be picked up in our calculated rate. Thus, not seeing evidence of an externality does not mean that governments don't exhibit tax competitive behaviour, but rather than any such behaviour does not have a significant revenue impact. In many ways this is not a problem. We are only interested in tax competition due to its potential to constrain expenditures on public goods, and so if a competitive tax rate change has no revenue effects it is benign in some sense. Still, there are problems that can arise due to the divergence between rate and revenue changes[30]. Consider for example the vertical "revenue effect" discussed in Table 2. If a province increases its tax rate, as long as the base is negatively related to its rate, the federal government would have to increase taxes in order to keep the same revenues. If keeping revenues constant is in fact the target, our model would not pick up this dynamic, even though both jurisdictions increased rates. However, we have no viable alternative to using average tax rates, and so we must contend with the inherent limitations. As well, both the incentive and crowding-out effects referred to in Hayashi and Boadway (2000) are visible when using average rates.

Finally, recall that tax rates were logit transformed, so that their statistical properties conformed with that of the error terms. Thus the coefficients in Tables 5 and 6 no longer represent a linear relationship between tax rates. However, they are still informative about relative impacts, since a bigger coefficient still implies a stronger interaction.

[30] This sort of proxy breaks down most evidently if an increase in taxes causes a decrease in revenues.

4.2 Econometric Issues

The Durbin-Watson statistic for serial correlation is reported for each equation in Tables 5 and 6. However, since the model contains lags we expect the statistic to be biased towards not-rejecting the null of serial uncorrelation. To further test for serial correlation of the residuals, bootstrapped Gauss-Newton Regression (GNR) tests were employed, and in all cases the null hypothesis of serial independence was not rejected at any standard significance level. Thus, it is valid to resample from the residuals for the bootstrap procedure on the p-values of the coefficients.

Another important concern is whether or not the data are stationary. To test for the presence of unit roots in all of our time-series data, we employed the augmented Dickey-Fuller tests (ADF) using Campbell and Perron's lag selection procedure. The results are presented in Appendix 1. We cannot reject the null hypothesis of a unit root for a few series, notably the majority of our CIT tax rate series. However, there are a few ways to rationalise using these series without differencing. The theoretical framework used by Hayashi and Boadway (2000) does not allow the coefficients on lagged dependent variables to take on values equal to unity. Thus a unit root is only implied when the only coefficient to be significantly different from zero is the own tax rate[31]. Although the own tax rates are highly significant for Γ_s (PIT), there are other variables that are significant in this equation so we can reject a unit root on theoretical grounds. We are implicitly differencing by including a lag of the own tax rates, and so have to some extent mitigated the potential for an unbalanced equation. In addition, none of the unit root tests available so far have very good finite sample properties (Davidson and McKinnon 1993). Visual inspection confirms this, since although CIT rates appear more stationary than PIT rates, the former rejects the null of a unit root more frequently. It can be almost impossible to reject the null of non-stationarity if the series is not stable over the entire sample period (ibid.), so exogenous changes to the level or trends in the tax series could also explain why our CIT series in particular do not reject. Finally, if we were to analyse tax rates in first differences, we would lose too much valuable information; there is far too little variation in tax rates to support the idea that governments respond to changes in the growth rates of neighbouring jurisdictions. Thus the analysis must remain in levels.

[31] This is so, since the partial adjustment mechanism inherent in the model is as follows, taking the federal government's tax rate Γ as an example: $\Gamma_s - \Gamma_{s-1} = \lambda_F\left(\Gamma^*_s - \Gamma_{s-1}\right)$, where Γ^* is the desired tax rate of the federal government. Thus a unit root is implied if $\lambda_F = 0$.

4.3 Results for the CIT version of the model

Table 5 presents the coefficient estimates and bootstrapped p-values for zero restrictions on each coefficient.

Table 5: Coefficient estimates– CIT

CIT	DEPENDENT VARIABLES (TAX RATES)					
	FEDERAL Γ_s	**ONTARIO** τ_S^O	**QUEBEC** τ_S^Q	**ALBERTA** τ_S^A	**WESTERN** τ_S^W	**ATLANTIC** τ_S^{AT}
Constant	0.9228 (0.4006)	0.8861 (0.4609)	2.2706 (0.1531)	-0.1849 (0.8773)	1.3578 (0.2975)	-2.0423 * (0.0999)
Γ_{s-1}	0.2967 (0.1740)	-0.3111 ** (0.0369)	-0.4083 * (0.0892)	-0.5410 ** (0.0146)	-0.1642 (0.4663)	0.0912 (0.5591)
τ_{S-1}^O	0.4565 * (0.0929)	0.1878 (0.5272)	0.3397 (0.3885)	1.2426 *** (0.0055)	-0.2559 (0.4417)	0.3116 (0.2498)
τ_{S-1}^Q	0.1917 (0.2478)	0.3348** (0.0335)	0.8766 *** (0.0004)	-0.3848 * (0.0896)	0.4574 ** (0.0232)	0.1909 (0.2474)
τ_{S-1}^A	0.0541 (0.6334)	0.0498 (0.6628)	0.2433 (0.2461)	0.2632 (0.2009)	0.3115 ** (0.0252)	0.1527 (0.2130)
τ_{S-1}^W	-0.5135 *** (0.0073)	-0.1485 (0.3926)	-0.6210*** (0.0089)	-0.1520 (0.5090)	0.0506 (0.8446)	-0.3930 ** (0.0369)
τ_{S-1}^{AT}	-0.1383 (0.4537)	0.2636 (0.1514)	0.2229 (0.3990)	0.1664 (0.4903)	0.2981 (0.1943)	0.2472 (0.2489)
PC_s^i	0.0189 (0.7450)	0.0081 (0.9254)		0.2307 (0.2620)		
ND_s		-0.1310 (0.2667)				
UN_s			0.0108 (0.9211)			
PQ_s			0.0526 (0.5630)			
SC_s				0.0882 (0.5872)		
e_s^i	-0.0073 (0.6805)	-0.0275 (0.2561)	-0.0204 (0.4173)	0.0259 * (0.0612)	-0.0179 (0.5257)	0.0269 (0.1466)
w_s^i	-0.3004 (0.3304)	0.7554 (0.1063)	0.2584 (0.7803)	-0.3695 (0.3151)	0.6669 (0.3859)	-0.1381 (0.6902)
g_s^i	-0.0210 (0.2420)	-0.0210 * (0.0677)	-0.0370 ** (0.0433)	-0.0034 (0.6415)	-0.0073 (0.4812)	-0.0262 *** (0.0025)
π_s	0.0254 ** (0.0308)	-0.0092 (0.4071)	0.0054 (0.7402)	0.0041 (0.8540)	0.02434 (0.2041)	-0.0032 (0.7533)
κ_s	-0.0192 (0.1466)	-0.0143 (0.1518)	-0.0208 (0.1444)	-0.0120 (0.3698)	-0.0146 (0.2320)	0.0037 (0.6684)
r_s	0.0139 ** (0.0342)	-0.0047 (0.4178)	0.00325 (0.7216)	0.0027 (0.7974)	0.0024 (0.7864)	0.0091 (0.1487)
R(bar)^2	0.7986	0.8723	0.8857	0.8936	0.8845	0.8373
DW	1.9350	1.6580	2.2770	2.2671	1.9559	2.4772

Note: Bootstrapped empirical P-values in parentheses. *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 levels, respectively.

4.3.1 Negative Vertical Tax Interactions

We find strong evidence for vertical CIT interactions. The federal tax rate has a significant negative effect on the rates of the provinces of Ontario, Quebec, and Alberta. It should be noted that we cannot be certain of the direction of this interaction since we could be picking up decreases in the federal rate that cause increases in these provincial tax rates or vice versa. However, since tax rates for CIT at the federal level were generally increasing over the 1963-1998 sample period, it is tempting to conclude that a crowding-out effect is at work[32].

Recall that the tax rates in our model are logit transformed, and therefore the coefficients in Table 5 cannot be immediately interpreted. To render the coefficients easier to understand we could convert our coefficients into elasticities of the effective tax rates. Although we have not done so for all estimated coefficients, we use some of the more interesting results as an example. To illustrate, in 1998, the results imply that a 1 per cent increase in the federal CIT rate would lead to a 0.12 per cent decrease in Ontario's rate, or a 0.35 per cent decrease in Alberta's rate.[33]

As mentioned previously, some reductions in federal CIT (and PIT) were made in the mid 1980s, after which Ontario was observed to take up some of the tax room created (Courchene 1999). In any event, for these interactions the federal government is the first-mover. In only one case was a province the first-mover: the rates of Western provinces negatively affect federal revenues. This result is harder to interpret and may be picking up other exogenous factors, such as influences from the U.S.

It is interesting to note that Ontario, Quebec and Alberta are the only three provinces that are not part of the tax collection agreement for corporate income tax, for most years within the sample period. This raises the question of whether coordination of some form, even if over collection, plays a role in constraining negative interactions (the crowding-out effect) between levels of government. Another feature that may partly explain these interactions is deductibility of taxes between levels, which can be used as a way to exert an effect similar to "crowding-out". For example, provinces in the 1980s started to increase their capital tax collections, making use of the fact that capital tax collected was deductible from federal tax[34]. However, in 1988 a limit on deductibility was set, which could have constrained provincial revenues and perhaps partly explain the appearance of crowding-out. As a final contribution to the picture, it is interesting to note that the federal government has

[32] As discussed earlier, this could reflect decreases in the tax rates or the tax revenues (without a rate change) of provinces. Although we cannot distinguish between the two, they have the same impact.

[33] To be clear, we are discussing a one per cent change in the tax rate as opposed to a one percentage point change in the rate.

[34] For example, Quebec increased its capital taxes in 1982, just following the recession. The tax made use of the fact that provincial capital taxes are deductible at the federal level. Therefore we know anecdotally that this sort of effect has occurred, but since we saw no significant interaction of the federal government reacting to Quebec, it must not have had a large enough effect on revenues. As well, the combined effect of certain provinces may be significant, whereas one province alone might not be large enough to impact the federal government significantly.

no incentive to crowd-out an equalization receiving province since any revenue losses they incur will have to be made up in equalization payments.

Hayashi and Boadway (2000) found negative vertical interactions that are similar to our results. They found that Quebec responds negatively to the federal tax rate, which is confirmed by our results. As well, they found that the aggregate of all provinces other than Quebec and Ontario also responds negatively to the federal tax rate. When this aggregate is broken down further in our estimation, the only province to retain this relationship with the federal government is Alberta, suggesting that their result could have been driven by that province alone. The impact of the federal government on Ontario is new to this specification.

4.3.2 Positive Vertical Tax Interactions

Only one instance of the "incentive effect" was found (where two levels of government have a positive relationship between their tax rates). The federal tax rate responds positively to changes in Ontario's tax rate. This result was also found by Hayashi and Boadway (2000). This implies that when Ontario is the first-mover in tax rates it has a different interaction with the federal government then when the latter moves first. As mentioned, this effect in theory involves one government passing on costs of tax increases to the other, and it makes sense that only Ontario has this effect on federal revenues due to the size of its economy. If we again translate the coefficient in Table 5 into an elasticity, then based on 1998 effective tax rates a one per cent change in Ontario's rate generates a 0.55 per cent change of the same direction in the federal rate.

The concern over tax base overlap is that it is the "public sector version of the common property resource problem …" (Dahlby 1996; 401). In other words, that jurisdictions may fail to take into consideration tax externalities resulting from tax base overlap. By incorrectly perceiving the MCPF to be lower than the true MCPF, jurisdictions may set tax rates too high.[35] However, this is not a foregone conclusion. Keen (1998) points out that a positive relationship between the revenues of different levels of government could point to a beneficial externality. He gives the example of a state taxing cigarettes and spending the proceeds on highways, and a federal government that taxes gasoline. If an increase in state taxes finances more highway improvements, and that in turn increases the demand for gas, then federal revenues will also benefit. Thus overall we cannot conclude whether Ontario and the federal government are underestimating the social MCPF and overtaxing the common base, or if there are positive externalities that link the revenues of the two levels, or even both at different times.

Equalization could increase the incentive for a recipient province to attempt to pass on costs of tax increases to the federal government, since equalization provides further insulation from any decline in the tax base (Hayashi and Boadway 2000). Therefore, it is interesting to remark that none of the recipient provinces exhibit this vertical externality on the federal government, although it could be that the impact is too small to be significant.

[35] Keen (1998) also notes that if state taxes are deductible against federal taxes, this increases the chances that states (or provinces) will respond positively to increases in federal taxes.

Finally, both types of vertical dynamics could be in effect at different points in time between jurisdictions. The lack of a significant relationship does not rule out the possibility that competing vertical dynamics are at work at various points over the sample period.

4.3.3 Horizontal Tax Interactions

We found significant evidence of horizontal CIT tax externalities, most of which support the conclusion that horizontal tax competition exists among certain provinces. Three main interactions of interest emerge from the results. First, Alberta was observed to be competing with the tax rate of Ontario. This likely reflects the diversification of the Alberta economy over the period, making competition over the tax base more plausible, and recent commitments by both governments to decrease taxes. Secondly, Ontario was observed to be competing with the tax rate of Quebec. Historically, Quebec has had lower CIT rates than Ontario, and Ontario has mimicked several tax credits or exemptions undertaken in Quebec. This result accords well with intuition. Thirdly, the Western provinces were seen to compete with the tax rates in Alberta, which is also intuitive given Alberta's dominant economy in the region[36]. We cannot conclude whether the positive relationship in tax rates we observe is picking up joint increases or decreases (or both) in tax rates. However, we have hopefully removed variation in tax rates that finance expenditure competition by including expenditures as a variable. Therefore we are likely observing tax decreases associated with competition over the tax base.

As well, the Western provinces were observed to compete with tax rates of Quebec. This result is somewhat surprising, since there is also a negative relationship between these two provinces when the west moves first. However, it may reflect a sort of chain reaction: since the West competes with Alberta, which competes with Ontario, which in turn competes with Quebec, the appearance of the West competing with Quebec may represent the ends of the chain reaction[37].

Horizontal interactions are, in general, stronger in absolute value than vertical interactions. For example, after transforming the coefficients into elasticites using 1998 effectve tax rates, a one per cent change in Ontario's tax rate would generate a 1.18 per cent reaction in the tax rate of Alberta. Similarly, given elasticities in 1998, Ontario would change its tax rate by 0.41 per cent given a tax reduction in Quebec while Western provinces would change their tax rates by 0.50 per cent given a one per cent tax reduction in Quebec.

Two other negative horizontal relationship were detected, one between the Atlantic and Western provinces, and the other between Alberta and Quebec. As discussed above (see

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[36] It is logical to question how much of this result is driven by B.C. within the Western provinces. Indeed when we perform the estimation with an alternate grouping where B.C. is analysed separately, (and the remaining Western and Atlantic provinces are grouped into one), we see that B.C. does in fact respond to Alberta. However, the model is somewhat sensitive to the choice in groupings of provinces, so we retain the grouping that *a priori* is the most logical.

[37] The fact that the interaction has a negative coefficient when lagged in the reverse order may simply reflect the limitations of our lag structure using annual data.

footnote 2) relationships with a negative coefficient likely reflect events that had different impacts on each province's revenues (such as a decrease in imports from one province to other). Thus although they may point to some externality, they do not indicate tax competition in the classic sense[38]. Another possible explanation could be that B.C. (as a dominant part of the Western aggregate) and the Atlantic provinces are part of the tax collection agreement whereas Quebec is not. Finally, the role of exogenous factors not controlled for in the model, such effects coming from the U.S., could also partly explain the appearance of negative horizontal interactions.

These results are different in many ways from those obtained by Boadway and Hayashi (2000). For example, both studies found an interaction between Ontario and Quebec, but which province acts as the first-mover is reversed[39]. As well, the larger aggregate of provinces used in their study was seen to respond to tax rates in Ontario, which given our results could be driven largely by Alberta. We found further instances of tax competition, made possible since more provinces were analyzed separately.

Recalling the discussion over whether equalization would encourage or discourage recipient provinces from engaging in tax competition, we find that no recipient province engages in horizontal tax competition[40] (Quebec is an exception, but they are the first-mover in the interaction with Ontario). However, this of course does not imply that equalization is a causal factor in this lack of observed tax competition. Nevertheless, if we assume that Equalization reduces the incentive to engage in tax competition, it suggests that movements in the tax base are considered more important than any self-serving effect on the national average tax rate[41]. This is in line with the common claim that recipient provinces should be as concerned about Ontario's economy as they are about their own. Further analysis of the role of equalization in tax competition should include whether or not the province is part of the standard, whether they are competing with a province that is part of the standard, and how mobile the tax base is between jurisdictions.

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[38] However, horizontal tax competition may not be so straight-forward after all. Mintz and Keen (2001) conclude that tax competition has very different results on tax rates, depending on whether competition is over real business investment or financial capital. If it involves the latter, and firms engage in income-shifting, then tax rates may start to diverge rather than converge. In particular, some regions may reduce tax rates to attract the tax base, whereas others may maintain high rates and tolerate the loss of the financial capital base through income shifting. This sort of effect could partly explain the negative interactions we observed, especially those involving Quebec, which is well known for its low statutory tax rates.

[39] Note that in attempting to replicate the results of Hayashi and Boadway (2000), it was found that their interaction of Quebec reacting positively to changes in Ontario's rates no longer existed after incorporating revisions to PEA data, using the same sample period.

[40] A result confirmed in preliminary results from Esteller-Moré and Solé-Ollé (2001).

[41] Recall that the basic equalization formula is as follows:

$$\begin{matrix} Equalization \\ per \\ Capita \end{matrix} = \begin{matrix} national \\ average \\ tax \\ rates \end{matrix} \begin{pmatrix} \begin{matrix} five \\ province \\ per\ capita \\ base \end{matrix} - \begin{matrix} province \\ own \\ per\ capita \\ base \end{matrix} \end{pmatrix}$$

Finally, recall that vertical interactions that put downward pressure on provincial tax rates can exacerbate horizontal tax competition. Indeed we did see that the provinces that experienced a negative vertical interaction with the federal government are also involved in horizontal tax competition effects. Again, we do not have enough information to judge how much of an influence vertical dynamics play on horizontal ones, but it is interesting to note.

4.4 Results for the PIT version of the model

4.4.1 Positive Vertical Tax Interactions

We observe only positive vertical PIT interactions between levels of government, which, as will be shown, has a straightforward yet interesting interpretation. The federal government's tax changes have a positive effect on the tax rates of Ontario, Quebec, Alberta, Western and the Atlantic provinces. At first glance, this appears to be a simple result of the tax-on-tax system for PIT in Canada. With a tax-on-tax system, provinces set their tax rates to be a certain percentage of basic federal tax (BFT). So if the federal government legislates a tax increase, and provinces do not adjust their rates, they nonetheless experience an increase in revenues and effective rates. Of course, provinces have the freedom to set their rates as desired, and can make use of special instruments such as high-income surtaxes (which have been used in recent years). Nevertheless, in practice major tax changes were automatically carried through to the provinces during the sample period. When we convert our coefficients into elasticites of the effective provincial rate with respect to the lagged federal rate, we find that Alberta and the Western provinces tend to follow federal tax increases more closely than do Ontario and Quebec[42]. To illustrate, again using 1998 effective rates, Alberta responds to a one per cent change in federal tax rates by a 0.97 per cent change in their rate while Ontario and Quebec would respond by only 0.35 per cent and 0.36 per cent of their tax rates, respectively.

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[42] Recall that tax rates have been logit transformed and therefore coefficients in Table 6 are not directly interpretable.

Table 6: Coefficient Estimates– PIT

PIT	DEPENDENT VARIABLES (TAX RATES)					
	FEDERAL Γ_s	ONTARIO τ_S^O	QUEBEC τ_S^Q	ALBERTA τ_S^A	WESTERN τ_S^W	ATLANTIC τ_S^{AT}
Constant	-5.0807 *** (0.0065)	-1.3551 (0.5638)	-9.3329 *** (0.0019)	-1.0133 (0.7866)	1.601 (0.5242)	-1.832 (0.5171)
Γ_{s-1}	0.6546 *** (0.0000)	0.3531 * (0.0891)	0.3615 ** (0.0294)	0.9733 *** (0.0015)	0.4906 ** (0.0160)	0.4739 (0.0111)
τ_{S-1}^O	0.3201 ** (0.0225)	0.6663 *** (0.0017)	0.1203 (0.5766)	0.3058 (0.2977)	0.1342 (0.4413)	-0.0541 (0.7876)
τ_{S-1}^Q	-0.1466 (0.3039)	-0.1144 (0.5719)	-0.2599 (0.3574)	0.1667 (0.5674)	0.1127 (0.5323)	0.0879 (0.5436)
τ_{S-1}^A	0.0422 (0.7290)	-0.2179 (0.1543)	0.0743 (0.7066)	0.0389 (0.8833)	-0.2984 (0.1394)	-0.1472 (0.4300)
τ_{S-1}^W	-0.3188 (0.1582)	-0.0011 (0.9969)	-0.0237 (0.9437)	0.1522 (0.7799)	0.3392 (0.3430)	0.0897 (0.7727)
τ_{S-1}^{AT}	0.0579 (0.7996)	0.3318 (0.2703)	0.2645 (0.4540)	-0.2934 (0.5438)	0.0291 (0.9310)	0.3640 (0.3689)
PC_s^i	-0.0267 (0.1364)	-0.1453 (0.0038)		-------		
ND_s		-0.1621 *** (0.0044)				
UN_s			-0.0990 * (0.0979)			
PQ_s			-0.0056 (0.8470)			
SC_s				------		
e_s^i	-0.0044 (0.5194)	0.0056 (0.6431)	0.0144 (0.1646)	-0.0056 (0.5416)	-0.0081 (0.4749)	0.0035 (0.6988)
w_s^i	0.2310 (0.5444)	-0.9512 * (0.0750)	0.0335 (0.9503)	-0.7888 (0.1670)	0.2943 (0.5111)	0.1875 (0.7080)
g_s^i	-0.0167 *** (0.0094)	-0.0106 (0.1512)	0.0030 (0.7499)	0.0038 (0.2897)	-0.0004 (0.9270)	-0.0070 ** (0.0388)
π_s	-0.0034 (0.5385)	-0.0141 (0.1018)	0.0027 (0.7491)	-0.0004 (0.9691)	-0.0023 (0.7676)	-0.0046 (0.5226)
$\mu_s^{\ i}$	-0.0023 *** (0.0110)	-0.0010 (0.3755)	0.0011 (0.5087)	-0.0002 (0.8049)	0.0003 (0.6517)	-0.0005 (0.4711)
p_s^i	0.0449 * (0.0785)	0.0174 (0.5572)	0.0832 *** (0.0082)	0.0330 (0.5490)	-0.0045 (0.8911)	-0.0060 (0.8384)
nep_s				0.0837 (0.2181)		
tp_s - 1964	0.0443 (0.4374)	0.0935 (0.2029)	0.1029 (0.2065)	0.0283 (0.7941)	0.1184 (0.1483)	0.0243 (0.7425)
tp_s - 1965	-0.0827 (0.1639)	0.1571 ** (0.0433)	-0.6954 *** (0.0000)	0.0703 (0.5457)	0.0919 (0.2796)	0.1802 (0.0476)
tp_s - 1966	-0.1366 (0.3286)	-0.0340 (0.8704)	0.1319 (0.5988)	0.2872 (0.3353)	0.1951 (0.3187)	0.0906 (0.5650)

tp_s - 1967	0.2115 *** (0.0045)	0.1008 (0.2457)	0.3837 *** (0.0089)	0.1571 (0.2553)	0.0110 (0.9017)	0.1237 (0.1764)
tp_s - 1972	-0.0698 (0.1604)	-0.0183 (0.7834)	0.0600 (0.4044)	-0.0193 (0.8472)	-0.0500 (0.4816)	0.1068 (0.1533)
tp_s - 1977	-0.1750 *** (0.0158)	0.1781 ** (0.0347)	0.3637 *** (0.0005)	0.3367 *** (0.0123)	0.1890 ** (0.0187)	0.1850 ** (0.0213)
R(bar)^2	0.9709	0.9855	0.9958	0.9683	0.9832	0.9911
DW	2.3127	2.1840	2.1801	2.4674	2.3482	2.5441

Note: Bootstrapped empirical P-values in parentheses. *, ** and *** indicate statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. Note that the high R-bar squared is partially due to the tax-on-tax system.

However, the results are interesting for two reasons. The first is that Quebec shares the same positive relationship with the federal government as the other provinces, even though it was the only province to not be part of the tax-on-tax system during the sample period. This supports the claim that Quebec follows the federal government's tax changes actively, while surrounding provinces are doing so somewhat more passively. Secondly, it is not a foregone conclusion that we should see a positive relationship between levels of government with a tax-on-tax system. Provinces have the power to adjust tax rates, and in theory could keep their revenues constant when the federal government changes its rates. Also, negative vertical interactions, (crowding-out or taking-up room) are still possible within a tax-on-tax system. Deductions and surcharges can also be used to achieve revenue objectives without altering statutory rates. Thus, if we were to see no relationship between Ontario and the federal government, for example, then we could conclude that other dynamics are outweighing the institutional pressures towards a positive relationship. However, since we do in fact see a positive relationship in all cases, we can conclude that this positive effect is stronger than any other effects that might exist. Of course, the incentive-effect also can be present, which would strengthen the positive relationship between levels. Indeed, the incentive-effect cannot be disentangled from the positive relationship associated with the tax-on-tax system.

In only one case is a province the first-mover, and again it is Ontario. We see a positive relationship between Ontario and the Federal government when Ontario is the first mover. This is the same interaction seen with CIT earlier, and also by Boadway and Hayashi (2000), so it confirms the notion that Ontario is unique in its capacity to impact tax rates of the federal government. This type of interaction (incentive-effect) and the possible role of tax complimentarity, were discussed above in Section 4.3.2.

4.4.2 Horizontal Tax Interactions

We found no evidence for horizontal tax competition in Canada. Most of the coefficients on provincial interactions are positive, and none were significant. When we consider the time period in question, this is not a surprising result. Generally, labour is assumed to be less mobile that capital, and so competition over this tax base would then be less intense[43]. As well, in the past there were fewer PIT tax reductions than CIT tax cuts. It will be interesting to re-estimate the PIT model once the full effect of recent federal and provincial PIT tax cuts have taken their full effect. Another factor to consider is that any mobility of labour might be more influenced by government expenditures than by tax rates alone. Indeed, most of the literature on labour mobility focuses on inter-jurisdictional differentials in net fiscal benefits (NFBs) – the difference between benefits received from government expenditures and taxes paid. In our model we control for tax base changes due to changes in government expenditures and wages (which include public sector wages). For example, nurses attracted to another province because of higher salaries is an example of competition over labour, which is the tax base, but is not tax competition per se.

While we have not found evidence of horizontal tax competition, it is nonetheless interesting consider the role of a tax-on-tax system in constraining tax competition. Although it is not a system of full coordination, we did see that negative vertical effects (crowding-out) are missing in the domain of PIT. Negative vertical effects could exacerbate horizontal tax competition by putting further downward pressure on tax rates. Thus it will be interesting to see if a TONI system for PIT (like that already in existence for CIT), coupled with an increasing climate of tax-cutting policies, will open the door to PIT tax competition in the years to come.

5. Conclusions

Evidence for tax interactions between the federal and provincial governments are estimated using a model extended from Hayashi and Boadway (2000) that assumes governments act as Nash competitors. The period of estimation is 1963 to 1998, and is carried out for CIT and PIT in turn. We find evidence of both horizontal and vertical tax interactions over CIT, but little evidence of such interactions over PIT. To summarize briefly, the main findings are as follows. For CIT in Canada, tax interactions indicative of tax competition are observed involving Quebec, Ontario, Alberta and an aggregate of Western provinces (excluding Alberta). We also find a few significant relationships between provinces that have negative coefficients, which may not be indications of tax competition but warrant further investigation. Vertical CIT interactions (with both positive and negative coefficients) are observed between the federal government and Quebec, Ontario, Alberta and the Western provinces. For PIT in Canada, we observe no horizontal tax interactions, and so we have no evidence for tax competition. All vertical PIT interactions observed are positive and are interpreted largely as a result of the tax-on-tax system, except for one interaction between Ontario and the Federal government. For both PIT and CIT, Ontario is unique in its capacity to affect tax rates of the federal government, and is involved in a dynamic consistent with the incentive effect.

In many ways we would expect to see greater competition over CIT than PIT, given the general assumption that labour is less mobile than capital. However, other contributing factors could exist. For example, it will be interesting to revisit this type of analysis after all

[43] Despite the relative immobility of labour, PIT rates can be considered part of the package in attracting business. However, to evaluate this requires moving beyond a partial analysis of tax rates, which we have not yet attempted.

provinces have moved to a tax-on-income (TONI) system for PIT, to see how arrangements influencing vertical interactions may in turn influence horizontal ones. Nevertheless, knowing the scope of tax competition historically provides an important background when evaluating current tax interactions. For example, these results could have implications for discussions over efficient tax base distribution, and tax coordination versus decentralisation.

There is much further work to be done in analyzing tax interactions in Canada. Future research could consider different types of taxation simultaneously, to move beyond the partial analysis done here. As well, analysis can be carried out for different groupings of provinces. Alternatively, a more focussed analysis of the interactions between Ontario and the federal government could be carried out. An important extension would be to look at the role of equalization on tax setting in a more systematic fashion.

Appendix 1: Unit Roots

Table 7: Tests for Unit Roots

Variable	ADF Test Statistic	Variable	ADF Test Statistic
PIT		**CIT**	
Γ_s	-1.397	Γ_s ***	-3.768
τ_S^O *	-2.607	τ_S^O	-1.414
τ_S^Q ***	-5.337	τ_S^Q *	-2.610
τ_S^A **	-3.064	τ_S^A	-1.247
τ_S^W **	-3.160	τ_S^W	-1.910
τ_S^{AT} ***	-5.154	τ_S^{AT}	-1.824
Exogenous variables			
μ_s^F **	-3.450	p_s^F *	-2.812
μ_s^O ***	-4.046	p_s^O *	-2.629
μ_s^Q ***	-3.787	p_s^Q *	-2.865
μ_s^A **	-3.151	p_s^A	-2.288
μ_s^w ***	-4.495	p_s^w *	-2.672
μ_s^{AT} ***	-4.744	p_s^{AT} **	-2.369
w_s^F *	-2.665	g_s^F ***	-3.777
w_s^O **	-3.316	g_s^O **	-3.592
w_s^Q ***	-4.308	g_s^Q **	-3.341
w_s^A *	-2.642	g_s^A **	-3.549
w_s^W **	-3.594	g_s^W ***	-4.527
w_s^{AT} ***	-4.680	g_s^{AT} ***	-7.306
e_s^F	-1.843	π_s	-1.871
e_s^O	-2.534	κ_s **	-3.984
e_s^Q	-2.495	r_s	-2.519
e_s^A	-2.142		
e_s^W	-1.884		
e_s^{AT}	-2.581		

Note: The test statistic report is chosen according to Campbell and Perron's lag selection procedure. If no lag value is significant, a zero lag is chosen. The ***, ** and * indicate that the null hypothesis of a unit root can be rejected at the 1%, 5% and 10% critical levels, respectively.

Appendix 2: Bootstrap p-values and asymptotic counterparts

Table 8: Asymptotic-distribution based p-values and their bootstrapped counterparts (in parentheses)- CIT model

CIT	DEPENDENT VARIABLES (TAX RATES)					
	FEDERAL Γ_s	**ONTARIO** τ_S^O	**QUEBEC** τ_S^Q	**ALBERTA** τ_S^A	**WESTERN** τ_S^W	**ATLANTIC** τ_S^{AT}
Constant	0.2328 (0.4006)	0.2751 (0.4609)	0.0348 (0.1531)	0.8171 (0.8773)	0.1416 (0.2975)	0.0135 (0.0999)
Γ_{s-1}	0.0237 (0.1740)	0.0015 (0.0369)	0.0147 (0.0892)	0.0001 (0.0146)	0.3239 (0.4663)	0.4301 (0.5591)
τ_{S-1}^O	0.0192 (0.0929)	0.2953 (0.5272)	0.2305 (0.3885)	0.0000 (0.0055)	0.3065 (0.4417)	0.1197 (0.2498)
τ_{S-1}^Q	0.0830 (0.2478)	0.0006 (0.0335)	0.0000 (0.0004)	0.0110 (0.0896)	0.0003 (0.0232)	0.0967 (0.2474)
τ_{S-1}^A	0.5124 (0.6334)	0.5386 (0.6628)	0.0720 (0.2461)	0.0259 (0.2009)	0.0013 (0.0252)	0.0890 (0.2130)
τ_{S-1}^W	0.0000 (0.0073)	0.2247 (0.3926)	0.0001 (0.0089)	0.2892 (0.5090)	0.7287 (0.8446)	0.0025 (0.0369)
τ_{S-1}^{AT}	0.3027 (0.4537)	0.0374 (0.1514)	0.2433 (0.3990)	0.3388 (0.4903)	0.0743 (0.1943)	0.0829 (0.2489)
PC_s^i	0.6270 (0.7450)	0.8870 (0.9254)		0.4190 (0.2620)		
ND_s		0.0839 (0.2667)				
UN_s			0.8779 (0.9211)			
PQ_s			0.3680 (0.5630)			
SC_s				0.0553 (0.5872)		
e_s^i	0.5304 (0.6805)	0.0735 (0.2561)	0.2136 (0.4173)	0.0013 (0.0612)	0.3120 (0.5257)	0.0264 (0.1466)
w_s^i	0.1290 (0.3304)	0.0093 (0.1063)	0.6719 (0.7803)	0.1180 (0.3151)	0.1833 (0.3859)	0.5592 (0.6902)
g_s^i	0.0681 (0.2420)	0.0037 (0.0677)	0.0012 (0.0433)	0.4854 (0.6415)	0.2927 (0.4812)	0.0000 (0.0025)
π_s	0.0007 (0.0308)	0.2311 (0.4071)	0.6419 (0.7402)	0.7828 (0.8540)	0.0640 (0.2041)	0.6756 (0.7533)
κ_s	0.0266 (0.1466)	0.0297 (0.1518)	0.0344 (0.1444)	0.1909 (0.3698)	0.0997 (0.2320)	0.5718 (0.6684)
r_s	0.0017 (0.0342)	0.2580 (0.4178)	0.6294 (0.7216)	0.7172 (0.7974)	0.7173 (0.7864)	0.0517 (0.1487)

Table 9: Asymptotic-distribution based p-values and their bootstrapped counterparts (in parentheses) – PIT model

PIT	DEPENDENT VARIABLES (TAX RATES)					
	FEDERAL Γ_s	**ONTARIO** τ_S^O	**QUEBEC** τ_S^Q	**ALBERTA** τ_S^A	**WESTERN** τ_S^W	**ATLANTIC** τ_S^{AT}
Constant	0.0000 (0.0065)	0.3167 (0.5638)	0.0000 (0.0019)	0.6516 (0.7866)	0.2897 (0.5242)	0.2728 (0.5171)
Γ_{s-1}	0.0000 (0.0000)	0.0013 (0.0891)	0.0001 (0.0294)	0.0000 (0.0015)	0.0000 (0.0160)	0.0000 (0.0111)
τ_{S-1}^O	0.0000 (0.0225)	0.0000 (0.0017)	0.3114 (0.5766)	0.0789 (0.2977)	0.2219 (0.4413)	0.6743 (0.7876)
τ_{S-1}^Q	0.0911 (0.3039)	0.3362 (0.5719)	0.0687 (0.3574)	0.3746 (0.5674)	0.3379 (0.5323)	0.3223 (0.5436)
τ_{S-1}^A	0.5787 (0.7290)	0.0124 (0.1543)	0.5203 (0.7066)	0.7942 (0.8833)	0.0129 (0.1394)	0.2170 (0.4300)
τ_{S-1}^W	0.0214 (0.1582)	0.9954 (0.9969)	0.9045 (0.9437)	0.6098 (0.7799)	0.0947 (0.3430)	0.6582 (0.7727)
τ_{S-1}^{AT}	0.6584 (0.7996)	0.0574 (0.2703)	0.2024 (0.4540)	0.2882 (0.5438)	0.8864 (0.9310)	0.0776 (0.3689)
PC_s^i	0.0079 (0.1364)	0.0000 (0.0038)		-------		
ND_s		0.0000 (0.0044)				
UN_s			0.0018 (0.0979)			
PQ_s			0.7250 (0.8470)			
SC_s				------		
e_s^i	0.2493 (0.5194)	0.3861 (0.6431)	0.0063 (0.1646)	0.2753 (0.5416)	0.2079 (0.4749)	0.5061 (0.6988)
w_s^i	0.2712 (0.5444)	0.0007 (0.0750)	0.9118 (0.9503)	0.0121 (0.1670)	0.2431 (0.5111)	0.4996 (0.7080)
g_s^i	0.0000 (0.0094)	0.0073 (0.1512)	0.5700 (0.7499)	0.0798 (0.2897)	0.8880 (0.9270)	0.0002 (0.0388)
π_s	0.2911 (0.5385)	0.0042 (0.1018)	0.5858 (0.7491)	0.9475 (0.9691)	0.6369 (0.7676)	0.2939 (0.5226)
$\mu_s{}^i$	0.0000 (0.0110)	0.1109 (0.3755)	0.2324 (0.5087)	0.0257 (0.8049)	0.4883 (0.6517)	0.2820 (0.4711)
p_s^i	0.0017 (0.0785)	0.3118 (0.5572)	0.0000 (0.0082)	0.6861 (0.5490)	0.8230 (0.8911)	0.7287 (0.8384)
nep_s				0.0257 (0.2181)		
tp_s - 1964	0.1850 (0.4374)	0.0376 (0.2029)	0.0429 (0.2065)	0.6937 (0.7941)	0.02763 (0.1483)	0.6478 (0.7425)
tp_s - 1965	0.0153 (0.1639)	0.0008 (0.0433)	0.0000 (0.0000)	0.3604 (0.5457)	0.1010 (0.2796)	0.0019 (0.0476)
tp_s - 1966	0.1145 (0.3286)	0.7776 (0.8704)	0.3663 (0.5988)	0.1275 (0.3353)	0.1071 (0.3187)	0.3402 (0.5650)

tp_s - 1967	0.0000 (0.0045)	0.0625 (0.2457)	0.0000 (0.0089)	0.0754 (0.2553)	0.8578 (0.9017)	0.0422 (0.1764)
tp_s - 1972	0.0155 (0.1604)	0.6284 (0.7834)	0.1491 (0.4044)	0.7516 (0.8472)	0.2584 (0.4816)	0.0197 (0.1533)
tp_s - 1977	0.0000 (0.0158)	0.0001 (0.0347)	0.0000 (0.0005)	0.0000 (0.0123)	0.0000 (0.0187)	0.0000 (0.0213)

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