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Fiscal And Tax Competitiveness

The Effects of Tax Rate Changes on Tax Bases and the Marginal Cost of Public Funds for Provincial Governments

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An econometric study of the tax sensitivity of provincial tax bases.

The Study in Brief

The Authors of This Issue

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Rigorous external review of every major policy study, undertaken by academics and outside experts, helps ensure the quality, integrity and objectivity of the Institute's research.

This Working Paper presents the methodology and results of the authors' econometric study of the tax sensitivity of provincial tax bases. It is intended as a technical supplement to the authors' C.D. Howe Institute Commentary *What Does it Cost Society to Raise a Dollar of Tax Revenue? The Marginal Cost of Public Funds.*

This study estimates the marginal cost of public funds for provincial governments for corporate income tax, personal income tax and provincial sales tax. It shows the efficiency losses from taxation vary directly with the responsiveness of a government's tax bases to tax rate increases. The authors estimate the dynamic responses of tax bases to changes in tax rates using aggregate panel data from the provinces over the period 1972 to 2006. Their preferred empirical results indicate that a one percentage point increase in corporate income, personal income, and sales tax rates is associated with a 2.3, 0.76, and 0.63 percent reduction in their respective tax bases in the short run. The corresponding long-run tax base elasticity estimates are higher – 15.50, 3.65, and 1.82 percent, respectively.

The study uses the tax base elasticity estimates to calculate the marginal cost of public funds (MCF) for the provinces' three major taxes. The authors' computations indicate that the corporate income had the highest MCF and that the sales tax had the lowest MCF in all provinces in 2006. The MCF for the personal income tax ranged from 1.45 in Alberta to 3.85 in Quebec. Their results imply that there would have been significant welfare gains in 2006 from reductions in provincial corporate income tax rates. Their computations also indicate that the equalization grant formula may reduce the perceived MCF of the provinces that receive these grants and that increases in provincial corporate and personal income taxes can cause significant reductions in federal tax revenues.

1. Introduction

It is well known that tax policy changes affect government revenue and economic efficiency. The effects of tax rate changes on government revenue depend not only on the magnitude of the change in the tax rates but also on the responsiveness of the corresponding tax bases. Consequently, understanding the behavioural responses of tax bases has been a major focus of academic and political discussions on taxation policy. How responsive are tax bases to changes in tax rates? What are the economic and welfare costs of raising tax rates?

Empirical studies of the behavioural response of tax rate changes mostly focus on the estimation of the elasticity of taxable income with respect to the net-of-tax rate (one minus the tax rate). The majority of these studies are based on US household tax return data. While earlier studies such as Lindsey (1987) and Feldstein (1995) report relatively higher taxable income elasticities well above 1, later studies, such as Auten and Carroll (1999), Long (1999), Kopczuk (2005), Gruber and Saez (2002), and Giertz (2007), find a much lower taxable income response. There is a great deal of variation in the empirical estimates of the elasticity of taxable income. Empirical results generally suggest elasticity of taxable income estimate close to 0.40 (Gruber and Saez, 2002). Saez, Slemrod, and Giertz (2009) provide an excellent survey of this taxable income literature.

On the other hand, as Gruber and Rauh (2007) have pointed out, the effects of corporate tax rate changes on its base have been largely ignored in the literature. Some of the studies that deal with corporate taxation include Mintz and Smart (2004) for Canada, Gruber and Rauh (2007) for the United States, Huizinga and Laeven (2008) for European countries, and Riedl and Rocha-Akis (2009) for OECD countries.

There is a paucity of empirical studies that employ Canadian data. Sillamaa and Veall (2001) and Mintz and Smart (2004) examine the response of personal income and corporate income tax bases to tax rates, respectively. Using tax returns data from Canadian households, Sillamaa and Veall (2001) examine the response of taxable income to the 1988 Canadian personal income tax reform. They estimate an elasticity of taxable income with respect to the net-of-tax rate close to 0.25 for working-age individuals. They obtain a much higher estimate, however, for the self-employed and higher-income individuals. Mintz and Smart (2004) investigate how income shifting by Canadian corporations affects investment, government revenue, and tax base elasticities. Using industry-level data, they also empirically estimate the elasticity of the corporate tax base with respect to the corporate income tax rate. They provide separate elasticity estimates for corporations, which they group as income "shifters" and "non-shifters." Their preferred estimation result shows a corporate tax base elasticity with respect to the net-of-tax rate of 4.9 for income "shifters" corporations.

None of the above studies, however, provides a detailed investigation of the interdependence of the tax bases, such as the effect of an increase in the corporate income tax rate on the personal income tax base or the social cost of raising tax revenue. With regard to the MCF, Dahlby and Ferede (2008) estimate models of the effects of taxes on growth, investment, and revenues to compute the MCFs for provincial governments' corporate income tax, personal income tax, and sales tax. However, that study does not estimate the responses of tax bases to tax rate changes.

The principal objective of this study is to investigate the dynamic responsiveness of tax bases to changes in tax rates using aggregate data from the ten provinces over the period 1972-2006. We

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focus on the three main taxes: personal income tax (PIT), corporate income tax (CIT), and provincial sales tax (PST). Our preferred empirical results indicate that a one percentage point increase in corporate income, personal income, and sales tax rates is associated with a 2.27, 0.76, and 0.63 percent reduction in their respective tax bases. We also find that an increase in the CIT rate increases the PIT base. The long-run tax base semi-elasticity estimates are higher than the corresponding short-run values. Our long-run elasticity estimates for the PIT are well within the range of results found in the literature. The tax base elasticity estimates for the CIT, however, are higher than those obtained in previous studies. Our computations also indicate that the equalization grant formula may drastically reduce the perceived MCFs of the provinces that receive these grants and that increases in provincial corporate and personal income taxes can cause significant reductions in federal tax revenues.

The remaining part of this paper is organized as follows. In section 2, we present a simple framework that shows how to calculate the MCF using tax base semi-elasticities, tax rates, and revenue shares of the taxes. The empirical methodology and the data are described in section 3. The estimated empirical results are presented and discussed in section 4. In section 5, we compute the MCF for the provinces using our tax base semi-elasticity estimates. Section 6 concludes.

2. Analytical Framework

The amount of tax revenue that a government collects depends on its tax rates and tax bases. The increase in total tax revenue from an increase in a tax rate depends not only on the size of the tax rate increase, but also on the changes in the tax bases as taxpayers respond to the changes in the tax rates. In this section, we focus on the effects of tax rate changes on tax bases and their ultimate effects on tax revenue. We are interested in the three main taxes imposed by provincial governments: corporate income tax rate, τ_c, personal income tax, τ_p, and general sales tax, τ_s. In almost all provinces, these taxes account for a significant part of total tax revenue. For example, in 2006 the share of these taxes was on average about 68 percent of total provincial tax revenue (see Dahlby and Ferede 2008). We assume that a particular tax base depends on all three tax rates. For example, the corporate tax base depends on the corporate tax rate because this affects the level of corporate investment and therefore the size of the corporate tax base. However, the personal income tax rate in a province may affect individuals' decisions concerning whether to incorporate their businesses. Finally, the retail sales tax rate, which falls on some business inputs, may reduce the profitability and size of the corporate sector. These examples indicate a few of the complex ways in which the corporate income, personal income, and sales tax rates affect not only their own tax bases but also the magnitudes of the other tax bases in a province. In this paper, we do not explicitly model the determinants of each tax base. We simply allow for some general, but unspecified, complementarity or substitutability among the tax bases that reflect taxpayers' responses to these tax rates.

For the three main tax rates that we are interested in, we specify tax base j as a function of the corporate, personal, and sales tax rates:

$$B_j = B_j(\tau_c, \tau_p, \tau_s) \tag{1}$$

where j = c, p, s denotes the corporate income tax (c), personal income tax (p), and sales tax (s) bases, respectively. Government tax revenue from a particular tax base is simply the product of its tax rates and the tax base. Consequently, a government's total tax revenue from the three taxes is given by

$$TR = \sum_j \tau_j B_j. \tag{2}$$

Since a tax base depends not only on its own tax rate, but also on the tax rates levied on the other tax bases, a change in a particular tax rate affects the amount of revenue that the government can collect from that source and from the other tax bases. Consequently, the effect of a change in a particular tax rate on the total tax revenue is given by

$$\frac{dTR}{d\tau_i} = B_i + \sum_j \tau_j \frac{dB_j}{d\tau_i} = B_i + \sum_j R_j \eta_{ji}, \tag{3}$$

where $R_j = \tau_j B_j$ is the revenue raised from tax base j and $\eta_{ji} = d\ln(B_j)/\, d\tau_j$ is the semi-elasticity of tax base j with respect to tax rate i. We expect the own-base elasticity, η_{ji}, to be negative because a higher tax rate leads to greater tax avoidance and tax evasion, which shrinks the tax base. The cross-base semi-elasticity, η_{ji}, may be positive if an increase in τ_i causes taxpayers to shift their activities to tax base j to avoid the tax rate increase, or it may be negative if the two tax bases are complementary. For example, a positive cross-base elasticity between the corporate and personal income tax bases might occur if, in response to an increase in the personal income tax rate, some individuals find it advantageous to incorporate their business activities. A negative cross-base elasticity between the sales tax and the personal income tax would occur if an increase in the personal income tax reduced disposable income and consumption spending. The elasticity of total revenue with respect to the tax rate on tax base i is therefore equal to

$$\rho_i = \frac{\tau_i}{TR}\frac{dTR}{d\tau_i} = s_i + \tau_i \sum_j s_j \eta_{ji}, \tag{4}$$

where $s_i = R_i/\, TR$ is the share of total tax revenue from tax base j. Note that the impact on total revenue of an increase in the tax rate on base i depends on its own-base semi-elasticity and on the semi-elasticity of other tax bases with respect to that tax rate (all weighted by their respective tax revenue shares).

We are interested in assessing the effects of tax rate changes on the total tax revenue in order to calculate the MCF for the three main tax rates levied by the provincial governments. When governments raise a tax rate, the direct cost to taxpayers is the additional revenue it generates. There is also an additional cost to taxpayers associated with the welfare losses caused by changes in the economic decisions of taxpayers. The MCF measures the loss created by the additional distortion in the allocation of resource when an additional dollar of tax revenue is raised through an increase in the tax rate. As discussed in Dahlby (2008, chap 2), in the absence of non-tax distortions, such as environmental externalities, or involuntary unemployment, the MCF for a tax rate increase on tax base i is in general given by

$$MCF_{\tau_i} = \frac{B_i}{\frac{dTR}{d\tau_i}} = \frac{B_i}{B_i + \sum_j \left(\tau_j \frac{dB_j}{d\tau_i} \right)}, \tag{5}$$

Substituting equation (4) into (5) leads to the following alternative formula for the MCF:

$$MCF_{\tau_i} = \frac{s_i}{\rho_i} = \frac{s_i}{s_i + \tau_i \sum_j s_j \eta_{ji}} = \frac{s_i}{s_i + \tau_i \eta_i}, \tag{6}$$

where $\eta_i = \sum_j s_j \eta_{ji}$.

The other variables are as defined above. Equation (6) shows that the MCF from a particular tax base depends not only on its own base, tax rate, and semi-elasticity, but also on the weighted average of other tax bases' semi-elasticity with respect to the tax rate (weighted by their revenue shares). Clearly, the MCF_{τ_i} will be greater than (less than) 1 if η_i is negative (positive). If ρ_i is negative and the government is operating on the downward-sloping section of its total revenue Laffer curve with respect to τ_i, the MCF_{τ_i} is not well defined because a tax rate reduction would increase total tax revenue and make taxpayers better off. Similarly, the MCF_{τ_i} is infinite if τ_i is set at its total revenue-maximizing rate of $-s_i/\eta_i$. In general, we expect government to set $\tau_i < -s_i/\eta_i$ to minimize the distortions in resource allocation, subject to achieving an equitable distribution of the total tax burden.

It almost always takes some time for tax bases to adjust in response to changes in tax rates. As a result, the short-term and long-term responses of tax bases can be quite different (see Slemrod 1998). As Giertz (2008) and Saez, Slemrod, and Giertz (2009) explain, the efficiency costs of tax rate increases depend on the long-term responses. This may be particularly relevant for corporate income tax, as businesses may take a long time to adjust their level of investment, and in some cases their production location, in response to tax rate changes. To this point, our discussion of the MCFs has not explicitly taken into account the dynamic responses of tax bases to tax rates. Since it takes time for tax bases to adjust fully in response to any change in tax rates, we expect the MCF funds, in general, would be greater in the long run as the tax base adjusts for a tax rate change. Below, we outline a methodology for computing the MCFs based on the dynamic responses of the tax bases to tax rate increases.

Let δ_v be the present value of a dollar received v years in the future, where $\delta_v = 1/(1+r)^v$ and r is the discount factor used to value future income. Let PV be the present value of a dollar received for n years where $PV = \sum_{v=0}^{n} \delta_v$. The marginal cost of public funds from a tax rate increase can be defined as the present value of the harm inflicted on taxpayers in raising an additional dollar (in present value terms) of total tax revenue from a small tax rate increase:

$$MCF_{\tau_i} = \frac{B_{i0}PV}{B_{i0}PV + \sum_j \tau_j \left[\delta_0 \Delta B_{ji0} + \delta_1 \Delta B_{ji1} + \delta_2 \Delta B_{ji2} + \ldots + \delta_n \Delta B_{jin}\right]}, \quad (7)$$

where B_{i0} is tax base i in the current period and Δ Bjiv is the reduction in the tax base j from an increase in τ_i in year v in the future. Let β jiv be the percentage reduction in tax base j in v years in the future from the increase in τ_i where $\beta_{jiv} = \Delta B_{jiv} / B_{j0}$. The MCF can then be written as

$$MCF_{\tau_i} = \frac{B_{i0}PV}{B_{i0}PV + \sum_{j=1}^{m} \tau_j B_{j0} \left[\delta_0 \beta_{ji0} + \delta_1 \beta_{ji1} + \delta_2 \beta_{ji2} + \ldots + \delta_n \beta_{jin}\right]}, \quad (8)$$

or

$$MCF_{\tau_i} = \frac{B_{i0}}{B_{i0} + \sum_{j=1}^{m} \tau_j B_{j0} \left[\sum_{v=0}^{n} \omega_v \beta_{jiv}\right]}, \quad (9)$$

where $\omega_v = \frac{\delta_v}{PV}$. Multiplying the numerator and the denominator by the current tax rate τ_i and dividing the numerator and the denominator by current total tax revenues, R, yields the following formula for the MCF:

$$MCF_{\tau_i} = \frac{s_i}{s_i + \tau_i \sum_{j=1}^{m} s_j H_{ji}} = \frac{s_i}{s_i + \tau_i H_i}, \quad (10)$$

where s_j is the share of current revenues from tax base j, $H_{ji} = \left[\sum_{v=0}^{n} \omega_v \beta_{jiv}\right]$ and $H_i = \sum_{j=1}^{m} s_j H_{ji}$. H_{ji} is the present-value, weighted-average percentage reduction in tax base j from a one percentage point increase in τ_i. It is the dynamic equivalent of η_{ji} in the static model, and we will refer to it as the dynamic semi-elasticity of tax base j with respect to the tax rate on tax base i. H_i is the dynamic semi-elasticity of the total tax base with respect to τ_i. In section 5, we use estimates of the semi-elasticities of the tax bases to calculate the MCFs based on the dynamic semi-elasticities.

3. Methodology and Data

3.1 Methodology

We are interested in examining the sensitivity of tax bases to changes in tax rates. Obviously, tax bases may take some time to adjust fully in response to any change in tax rates. Thus, in order to account for the persistence of tax base changes to changes in tax rates, following Buettner (2003) and Reidl and Rocha-Akis (2009) we specify a dynamic tax base regression by including a one-period lagged value of the dependent variable as an explanatory variable. This helps us capture long-run effects of tax rate changes on tax bases (see also Carroll and Hrung 2005, 429, and the references contained therein).

More specifically, we specify an empirical model for the three major taxes as:

$$\ln B_{jgt} = \alpha_{0j} + \lambda_j \ln B_{jgt-1} + \eta_{jc}\tau_{cgt} + \eta_{jp}\tau_{pgt} + \eta_{js}\tau_{sgt} + X + \mu_g + \theta_t + u_{jt}, \quad (11)$$

where $j = c, p, s$. In equation (11), $\ln B_{jgt}$ is the log of tax base j in province g in year t, and τ_{jgt} is the corresponding provincial statutory tax rate. μg and θ_t denote provincial fixed effects and time effects, respectively. X includes a vector of various control variables.

We estimate equation (11) separately for the three tax bases using province-level aggregate panel data. We are interested in coefficient estimates, η_{ji}, which show the percentage response of the tax base j due to a one percentage point change in the tax rate i. Thus, the coefficients of the tax rates in the above regression provide the short-run semi-elasticity of the tax base with respect to the tax rates. For example, η_{jc} denotes the short-run semi-elasticity of tax base j with respect to the corporate tax rate (c). We expect the own semi-elasticity, η_{jj}, to be negative, implying that an increase in the statutory tax rate reduces its corresponding tax base. If the coefficient is zero, it indicates that the tax base do not respond to changes in the tax rate. Positive coefficients, on the other hand, indicate that tax bases rise when tax rates are increased.

With our dynamic specification, it is possible to estimate the long-run tax base semi-elasticities, which can be obtained by multiplying the coefficient estimates by $1/(1-\lambda_j)$. We expect that $0 < \lambda_j < 1$. Note that our basic specification does not control for gross domestic product (GDP); consequently, it captures the dynamic response to changes in tax rates (see also Carroll and Hrung 2005).

Previous studies of the elasticity of taxable income use the net-of-tax rate – that is, 1 minus the tax rate – rather than the tax rate as an explanatory variable. These studies provide the elasticity of tax bases with respect to the net-of-tax rate. However, it is straightforward to obtain the elasticity of a tax base with respect to its own net-of-tax rate by multiplying the own semi-elasticity estimates of equation (11) by minus the net-of-tax rate. One can, for instance, use the mean value of the tax rates to conveniently transform the semi-elasticity estimates into elasticity with respect to the net-of-tax-rate values. A similar transformation can also yield tax base elasticity estimates from the semi-elasticity estimates. We use such transformations to make our results comparable with those from previous studies.

In empirical analyses of tax base elasticities, one major problem is what kind of tax base proxy to use. Various studies use different proxies, and results may well depend on which tax base proxy is used. This is particularly true for studies that rely on aggregate, rather than individual-based, data. Fortunately, in Canada, there is a readily available tax base dataset, which is used by the federal government in its equalization payments calculations. This is a rich and very useful dataset on which actual policy decisions are made. Thus, in this study, we use business income and general sales tax bases from this dataset. In our corporate income tax base regression, the dependent variable is the log of the business income tax base. Similarly, in our sales tax base regression, the dependent variable is the log of the general sales tax base. We use personal taxable income as a measure of the personal income tax base. Since the provinces vary greatly in size, we divide the tax base by the province's total population to make comparisons across provinces possible. Moreover, in order to account for the effect of inflation, all tax bases are deflated by the province's respective GDP deflator.[1]

Since our ultimate objective is to use the empirical results to compute the MCF for provincial governments, we use provincial, rather

1 We use the GDP deflator (1997 = 100), rather than the consumer price index (CPI), as a complete dataset on provincial CPI is not available prior to 1979.

than combined federal and provincial, statutory tax rates in our analysis. Another advantage of this approach is that it is helpful to assess whether provincial and federal tax rates have differential effects on tax bases.

Various factors may affect a province's tax base other than its own tax rates. Our sets of control variables include the price of the province's major export commodities, other provinces' tax rates, and the relevant federal tax rate where applicable. The inclusion of the federal and other provinces' tax rates helps us check for the presence of vertical and horizontal corporate tax externalities in the federation. To assess the cross-effects of tax rates on tax bases, we also include the tax rates that are not directly related to the tax base. For example, we include sales and income tax rates in the corporate tax base regressions.

One feature of a dynamic panel model, such as that used here, is the correlation between the lagged dependent variable and the province-specific fixed effects. In such cases, the OLS and the within-group fixed effects estimation methods give biased and inconsistent estimates. To address this problem, a number of solutions are proposed in the literature. The most recent and commonly used estimation methods are the first differenced general methods of moments (GMM) in Arellano and Bond (1991) and the Blundell and Bond (1998) system GMM. However, these methods are designed for dynamic panel data with large number of panels and small time periods. For a dataset with a small number of panels, such us ours, these methods provide severely biased and imprecise estimates (see Judson and Owen 1999). Thus, in this paper, we use a standard instrumental variable (IV) estimation method. As in Devereux, Lockwood, and Redoano (2007), we instrument for the lagged dependent variables using their respective second-period lagged values of the dependent variables and other additional variables as instruments.

Another related common empirical challenge in estimating taxable income elasticities is the possible endogeneity of tax rates. This is particularly true in a graduated income tax system. In Canada's corporate income tax system, the statutory tax rate is constant (flat) and it does not directly depend on taxable income. This implies that the issue of the endogeneity of the corporate tax rate is less of a concern in our case. Thus, following Mintz and Smart (2004), we treat the CIT rate as exogenous in our corporate income tax base regression. Similarly, the sales tax rate is basically constant regardless of the tax base or the amount of one's purchase. Thus, we also treat the sales tax rate as exogenous in our general sales tax base regression.

It is well known that, in a progressive income tax system, the marginal tax rate depends on taxable income. If this problem is not addressed, it will bias our own semi-elasticity estimate. Thus, as commonly used in the literature, in our personal income tax base regression we treat the PIT rate as endogenous. The most common challenge in empirical studies of taxable income elasticity is what instrument to use for the tax rate. A valid instrument should be fairly correlated with the tax rate but not with the tax base. In studies based on aggregate data, such as ours, it is generally very difficult to come up with such instruments. The literature indicates there is an association between taxation and a government's political ideology. For OECD countries, Tavares (2004) finds evidence that right-wing governments generally focus on spending cuts to reduce budget deficits while left-wing governments tend to raise taxes. Reed (2006) also finds that, in the United States, the tax burden is higher when Democrats control a state legislature. Thus, as instruments for the PIT rate, we use dummy variables equal to 1 if the governing political party of the province is Liberal or New Democratic Party (NDP) and zero otherwise. Our instrument choice implicitly implies that tax rates are higher when the governing party belongs to the left. We check the validity of the instruments using a standard Hansen over-identification test.

All our regressions include time-invariant province-specific fixed effects. Where appropriate, we also include yearly dummies to control for shocks that are common to all provinces. Basically, we employ the full "difference-in-difference" estimation strategy. The only exception is when we include the federal CIT and PIT rates. These variables change only over time, and their inclusion in the corporate and personal income tax base regressions precludes the use of time dummies. Thus, when the federal tax rates are included as control variables, we exclude time dummies.

As explained in section 2, our ultimate objective is to compute the MCF of the three main taxes for all the provinces. We use the semi-elasticities estimates along with tax revenue shares and tax rates to calculate the MCFs. We also take into account the cross-effects of tax rates on tax bases in our computation. Obviously, tax shares and tax rates change over time. In order to shed some light on the evolution of the cost of raising government revenue over time, we compute the MCF annually. We also make similar calculations based on five-year moving average values of tax shares.

3.2 Data

Our empirical specification is estimated using annual aggregate panel data from the ten provinces for the period 1972-2006. The data on statutory marginal tax rates and personal taxable income were obtained from various issues of *Finances of the Nation* (formerly *National Finances*) published by the Canadian Tax Foundation. The dataset on provincial taxable income was obtained from various issues of *Income Statistics* (formerly *Tax Statistics on Individuals*) published by the Canada Revenue Agency. The business income tax and general sales tax bases are those used by the federal government in its equalization payment calculations and were obtained from Finance Canada. The business income tax base is used as a corporate income tax base. A brief description of the data and definitions of the variables used in our empirical analysis is provided in Appendix Table A-1.

In Table 1, we present the key variables of interest for all the provinces. Over the period under consideration, there is a great deal of variation in real tax bases across provinces. On a per capita basis, Alberta has the highest corporate income tax base, followed by Ontario and Quebec. Alberta also has the largest sales tax base, even though the province does not levy a general sales tax. When we look at the personal income tax base, Ontario has the largest tax base, followed by Quebec and British Columbia.

One of the important variables to be used in the MCF computation is the contribution of the three taxes to total tax revenue. Table 1 also shows the average tax shares for the period 1972-2006. Total tax revenue is defined as the sum of income taxes, consumption taxes, property and related taxes, and other taxes. In all provinces, the three taxes account for a significant share of total tax revenue. Alberta has the largest corporate income tax share, as the province has no sales tax. Quebec, on the other hand, has the lowest corporate income tax share, but the highest personal income tax share, indicating the province's heavy dependence on personal income taxation. The Atlantic provinces have the highest sales tax shares. Table 1 also shows the provincial statutory tax rates for the initial, final, and whole sample period.

Table 2 below provides the summary statistics of the main variables used in our empirical analysis.

4. Results

In this section, we present the dynamic tax base regression results for the three main taxes: corporate income, personal income, and general sales taxes.

4.1 Corporate Income Tax

The most important tax that businesses face is the corporate income tax. In Canada, all provinces and the federal government levy corporate income taxes, and the applicable tax base is more or less the same across jurisdictions. We begin our analysis with the corporate tax base regression estimates presented in Table 3. In a dynamic panel data model such as ours, the lagged dependent variable is correlated with the provincial fixed effects and the error term. Consequently, treating

Table 1: Profile of Canadian Provinces, 1972-2006

	NL	PEI	NS	NB	QB	ON	MB	SK	AB	BC
Average real tax base per capita (in 1997 dollars)										
Corporate income tax [a]	1,345	1,405	1,653	1,700	2,982	3,636	1,917	2,048	4,825	2,519
Personal income tax	8,722	9,711	11,166	10,685	12,304	15,410	11,698	10,773	13,512	14,613
Sales tax [a]	7,197	7,510	8,585	8,425	8,718	10,175	8,340	8,577	11,757	10,839
Average tax revenue shares (%), 1972-2006										
Corporate income tax	4.89	4.66	5.91	5.47	4.77	10.23	6.87	6.15	14.41	7.10
Personal income tax	29.71	27.97	36.81	30.55	42.84	36.58	35.71	32.31	38.54	32.87
Sales tax	32.66	28.20	26.87	26.73	15.92	23.28	22.06	18.94	0.00	21.05
Provincial statutory CIT rate (%)										
1972	13.00	10.00	10.00	10.00	12.00	12.00	13.00	12.00	11.00	13.00
2006	14.00	16.00	16.00	12.00	9.90	14.00	14.00	14.00	10.00	12.00
1972-06	14.79	13.14	14.46	14.31	9.07	14.27	15.83	15.34	12.84	14.97
Provincial statutory top marginal PIT rate (%) [b]										
1972	16.92	16.92	18.10	19.51	28.00	14.03	19.98	18.80	16.92	14.34
2006	19.64	18.37	19.25	17.84	24.00	17.41	17.40	15.00	10.00	14.70
1972-06	20.37	18.68	19.36	19.48	27.53	17.71	18.99	18.70	14.00	17.72
Provincial general sales tax rate (%)										
1972	7.00	8.00	7.00	8.00	8.00	5.00	5.00	5.00	0.00	5.00
2006	8.00	10.60	8.00	8.00	7.95	8.00	7.00	7.00	0.00	7.00
1972-2006	10.23	9.83	8.91	9.22	8.10	7.43	6.29	6.29	0.00	6.33

[a] This is only for the period 1977-2006.
[b] The PIT rates includes applicable surtaxes; note that Quebec residents also receive a refundable tax abatement of 16.5% of basic federal tax, which reduces their federal tax liability.

Source: Appendix A; authors' calculations.

this variable as exogenous can lead to biased estimates. To solve this problem, we use the instrumental variable (IV) estimation method, treating the lagged dependent variable as endogenous. The lagged dependent variable is instrumented with two-period lagged values of the dependent variable and a one-period lagged value of the unemployment rate. This implicitly assumes that corporate profitability falls during an economic downturn and rises during a recovery. We test the validity of the instruments using the standard Hansen over-identifying restriction test.

In column 1 of Table 3, we estimate the corporate tax base on just the provincial statutory CIT rate. As expected, the coefficient is negative and statistically significant. The coefficient estimate indicates that a one percentage point increase in the provincial CIT rate (say, raising the statutory CIT rate from 0.14 to 0.15) results in a reduction in the corporate tax base by 1.71 percent. The lagged dependent variable is positive and statistically significant. The coefficient is less than 1, indicating that the effect of the CIT rate on its base gets larger in the long run.

In column 2 of Table 3, we include the federal CIT rate and the weighted average CIT rate of the provinces (weighted by their GDP) as control variables. This helps us to check for the presence of vertical and horizontal corporate tax externality in the federation. In order to accommodate the

Table 2: Summary Statistics. 1972-2006

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Log of real CIT tax base per capita	300	7.6345	0.5538	5.1536	8.9291
Log of real taxable income per capita	350	9.3013	0.4168	8.1475	9.9978
Log of real sales tax base per capita	300	9.0878	0.1928	8.6387	9.6485
Provincial statutory CIT rate	350	0.1390	0.0268	0.0550	0.1700
Provincial statutory top marginal PIT rate	350	0.1925	0.0413	0.1000	0.3300
Provincial sales tax rate	350	0.0721	0.0299	0.0000	0.1200
Average CIT rate of other provinces	350	0.1314	0.0099	0.1077	0.1586
Average top PIT of other provinces	350	0.1976	0.0207	0.1500	0.2591
Average sales tax rate of neighbors	350	0.0669	0.0323	0.0000	0.1100
Federal statutory CIT rate	350	0.3202	0.0530	0.2212	0.4060
Federal Statutory PIT rate	350	0.3386	0.0712	0.2422	0.4700
Log of export price	350	4.6562	0.4507	2.7408	5.4558
Provincial unemployment rate	350	0.0958	0.0382	0.0260	0.2020
Log of real provincial GDP per capita	350	10.0448	0.2903	9.2298	10.7194

Table 3: Dynamic Corporate Income Tax Base Regressions, 1977-2006

Dependent variable: log of real per capita business tax base, ln(CITbase)it

Variables	Instrumental Variable *(1)*	Instrumental Variable *(2)*	Instrumental Variable *(3)*	Instrumental Variable *(4)*	Instrumental Variable *(5)*
ln(CITbase)it-1	0.912***	0.602***	0.522***	0.853**	0.855**
	(0.334)	(0.084)	(0.095)	(0.401)	(0.397)
CITprov	-1.714*	-2.849***	-2.737***	-2.278**	-2.631**
	(0.908)	(1.072)	(1.014)	(1.129)	(1.158)
PITprov			0.351	-1.012	-0.874
			(0.642)	(0.690)	(0.695)
PSTprov			2.139	0.153	0.941
			(3.410)	(3.029)	(2.963)
PSTprov X RSTdummy			-2.292*	0.250	0.267
			(1.189)	(1.474)	(1.460)
Federal CIT		-1.657***	-0.946**	—	—
		(0.379)	(0.457)		
Other provinces CIT		-3.426*	-4.756**	-7.118*	-7.648*
		(1.891)	(2.014)	(4.324)	(4.438)
Log export price			0.173**	0.133	0.122
			(0.088)	(0.095)	(0.093)
Log per capita GDP					0.345
					(0.211)
Constant	—	—	—	—	—
Province effects	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	No	No	Yes	Yes
Over-id test (p-value)	0.814	0.327	0.595	0.555	0.633
Adj. R-Squared	0.627	0.524	0.541	0.647	0.647
Number of obs.	280	280	280	280	280

Note: Robust standard errors are in parentheses. Significance level is indicated by * for 10 %, ** for 5%, and *** for 1 %. The instruments for the lagged dependent variable are one period lagged unemployment rate and two period-lagged values of the dependent variable.

federal CIT rate, we drop time dummies in column (2). The vertical tax externality literature indicates that, as provincial and federal corporate income taxes co-occupy the provincial tax base, an increase in the federal CIT rate reduces the corporate tax base (see Dahlby and Wilson 2003). Thus, if the hypothesis of vertical externality in corporate income tax is valid, we expect the coefficient of the federal CIT rate to be negative. Our results indicate that, as expected, the coefficient of the federal CIT rate is negative and statistically significant. This provides empirical support for the presence of vertical externality in the Canadian corporate income tax system. The provincial CIT rate is still negative and statistically significant. Note in particular that the corporate tax base is more responsive to the provincial than to the federal CIT rate, as the absolute value of the coefficient estimate of the former is higher. This is expected because corporations can easily avoid an increase in the provincial CIT rate by shifting their profits to other provinces, but they cannot avoid federal CIT rate increases through income shifting to other provinces (see Mintz and Smart 2004).

The literature on horizontal tax competition suggests that, due to the mobile nature of tax bases, tax rates in other provinces can have a positive effect on a province's tax base. That is, when other provinces raise their tax rates, the tax base shifts from the higher-tax jurisdiction to a lower-tax jurisdiction (see Hayashi and Boadway 2001). If the standard horizontal tax competition argument is valid, we expect the coefficient of other provinces' tax rates to be positive. Our result shows that, contrary to the prediction of the horizontal vertical externality, the coefficient of this variable is negative and statistically significant. This result is surprising but not implausible.

It is known that provinces are highly interdependent and that their relationships to tax bases may not be explained fully by the simple horizontal tax competition hypothesis, as commonly discussed in the literature. This is particularly true in the case of corporate taxation. Since the operations of corporations and their respective affiliates in various jurisdictions are interrelated, a higher tax rate in other jurisdictions may reduce the profitability (and hence the tax base) of a corporation even if it is not located in that jurisdiction. In fact, there may be a negative horizontal fiscal externality (rather than the usual positive externality) in corporate taxation. For example, think of a corporation that is based in Quebec but supplies its products to other corporations based in Ontario. If the corporate tax rate in Ontario rises, then the (after-tax) profitability of corporations based in that province falls. This may reduce Ontario-based corporations' demand for inputs from Quebec-based corporations. Thus, in this case, a higher corporate tax rate in Ontario adversely affects a corporation that is located and operating in Quebec. This feature of interdependence of businesses operating in closely interrelated jurisdictions is not addressed fully in the horizontal tax competition literature. So, if this interdependence is stronger than the standard horizontal tax competition argument, the coefficient of other provinces tax rate can be negative.

As compared to column 1 of Table 3, in column 2 the magnitude of the coefficient of the lagged dependent variable, while still positive and significant, drops significantly. Thus, the exclusion of time dummies lowers the coefficient estimate.

In column 3, we include additional control variables – specifically, the statutory top marginal PIT and the provincial sales tax rates. Unlike personal and corporate income taxes, sales tax systems vary across the provinces. The harmonized provinces levy a value-added-based tax (VAT) on a relatively broader tax base, which is the same as, or very similar to, the federal goods and services tax (GST) base; the other provinces use a retail sales tax (RST) whose tax base may include capital goods. The effects of these taxes can be different on income taxes, as they may affect economic activity and investment differently (see Smart and Bird 2009). We account for these possible differential effects on the CIT tax base by including the sales tax rate and the sales tax rate interacted with the *RSTdummy*, which takes the value of 1 in provinces and years in which an RST tax is in place. As in Mintz and Smart (2004), we also include the log of an index of US producers' prices for the province's major export commodity (the log of the export price). This helps us capture the effects of fluctuations in the world prices of major exports.

An increase in the top marginal PIT rate may encourage taxpayers to shift their reported income away from personal income to corporate income (see Gordon and Slemrod 2000). Thus, we expect the top PIT rate to have a positive effect on the corporate tax base. The PIT rate is, as expected, positive but statistically insignificant. While the sales tax rate is positive and insignificant, the sales tax rate interacted with the *RSTdummy* is negative and significant. This indicates that, in RST-based provinces, retail sales taxes have adverse effects on the corporate tax base. The provincial CIT rate, federal CIT rate, and other provinces' CIT rates are all still negative and statistically significant. This suggests that the negative effects of the provincial and federal CIT rates on corporate tax bases are robust to the inclusion of various control variables.

In column 4 of Table 3, we drop the federal CIT rate and include yearly dummies to capture shocks that are common to all provinces. Basically, in this regression, we are employing the full difference-in-difference estimator. As in Mintz and Smart (2004), we treat the CIT rate as exogenous. However, as before, the lagged dependent variable is treated as endogenous and instrumented with two-period lagged values of the dependent variable and a one-period lagged value of the unemployment rate. The validity of the instruments is confirmed with the Hansen's over-identification restriction test statistic. This is our preferred regression that we use in the computation of the MCF of the provinces in Section 5. Comparing columns 4 and 3, we see that the coefficient of the lagged dependent variable is higher, while the coefficient of the CIT rate is slightly lower in the former. As we will see later, our computation of the MCF depends on these two coefficients.

Our preferred results in column 4 show that the short-run semi-elasticity of the corporate tax base is about –2.27. This also implies a long-run semi-elasticity of –15.50. As expected, the corporate tax base is more responsive to tax rate changes in the long run.

How do our estimates compare with those of previous studies? Because of differences in specification and the types of tax rate measures employed, it is difficult to make direct comparisons with earlier results. Furthermore, only few studies estimate corporate tax base elasticity. Our long-run corporate tax base semi-elasticity estimate is outside the range obtained by Riedl and Rocha-Akis (2009), which is methodologically the closest to that of our paper. They, however, employed effective average tax rate rather than statutory rates. Huizinga and Laeven (2008) also report a lower semi-elasticity estimate for European countries, with an average semi-elasticity estimate of –1.31.

Mintz and Smart (2004) estimate the elasticity of the corporate tax base with respect to the net-of-tax rate (that is, 1 minus the tax rate) using industry-level data for Canada. In order to make our results comparable to those of their study, we convert the semi-elasticity estimates to elasticity (with respect to the net-of-tax rate) estimates by multiplying our coefficient estimates by the negative of the net-of-tax rate. Mintz and Smart use the combined federal and provincial corporate income tax rate in their analysis. Thus, we evaluate our semi-elasticity estimate at the mean value of the combined provincial and federal corporate income tax rate (45.3 percent for the period 1977-2006).[2] Such a transformation indicates that our preferred long-run semi-elasticity estimate corresponds to elasticity with respect to a net-of-tax rate of about 8.5; Mintz and Smart (2004), in contrast, report a net-of-tax rate of 4.9.

2 In the presence of time dummies, the coefficient estimates would be the same whether one uses the provincial CIT rate or the combined provincial and federal CIT rate. This is because the federal CIT rate changes only over time and its effects can be picked up by the yearly dummies.

In column 5 of table 3, we check the robustness of our results by including the log of real per capita income as a proxy of the provinces' macroeconomic conditions, as in Mintz and Smart (2004) and Huizinga and Laeven (2008). We expect this variable to be positive on the grounds that this variable is a good indicator of general profitability for businesses – the corporate tax base is likely to be high when the economy performs well. The coefficient estimates are still significant, suggesting that our semi-elasticity estimate is robust to the inclusion of this variable.

4.2 Personal Income Tax

Personal income tax is the most important revenue source for all provinces. Thus, understanding how the personal income tax base responds to changes in its own and other tax rates is of considerable importance. In this section, we present the dynamic personal income tax base regression results. Currently, in all provinces except Alberta – which has had a flat personal income tax rate system since 2001 – marginal tax rates increase from one income tax bracket to another. With a progressive marginal tax rate structure, one empirical challenge for studies based on aggregate data, such as ours, is which tax rate to use. Ideally, we would like to use average marginal income tax rates, weighted either by income or by the number of people in the tax brackets. However, a complete dataset for the period under consideration is unavailable. Thus, as commonly used in the literature, we use the statutory top personal income tax rate, although this should not be much of a problem since most of the responses of personal taxable income to changes in tax rates are due to behavioural responses of high-income groups (see Saez, Slemrod, and Giertz 2009). Furthermore, the largest part of provincial income tax revenue comes from the top income group, suggesting the importance of the top marginal tax rate.

For our personal income tax base regression, we use the log of real provincial personal taxable income per capita as the dependent variable. We have relatively a longer dataset for the personal taxable income, which covers the period 1972-2006. As Kopczuk (2005) explains, the use of personal taxable income as a tax base poses an empirical challenge, as its definition changes over time due to tax reforms. In our case, this problem is particularly important due to the tax reform of 1988, which significantly expanded the personal income tax base by eliminating a number of exemptions and deductions. The reform also reduced the number of income tax brackets from 11 to 4. The change in the tax brackets also affected provincial governments' tax rates, as most of the rates at that time were given as a percentage of the federal rate. We try to address this problem by including a dummy variable (*dum88*) that is equal to 1 after the tax reform and zero otherwise. Since the objective of the reform was to expand the personal income tax base, we expect the coefficient of *dum88* to be positive.

We begin our analysis in column 1 of Table 4 by regressing the log of real personal income tax base per capita on the personal income tax rate. The regression also includes time- and province-specific fixed effects in addition to the tax reform dummy (*dum88*). As expected, the coefficient of the 1988 tax reform dummy (*dum88*) is positive and significant, suggesting that, indeed, the tax reform expanded the personal income tax base. The coefficient of the personal income tax rate is negative and statistically significant. The result indicates that the short-run own semi-elasticity of the personal income tax base is about –0.22 – that is, a one percentage point increase in the top marginal PIT rate is associated with a 0.22 percent reduction in personal taxable income. Using a similar approach as before, the result implies that the long-run own semi-elasticity of the personal tax base is about –1.20. Alternatively, evaluating at the mean combined federal and provincial top PIT rate of 53 percent, our basic result implies that the taxable income elasticity with respect to the net-of-tax rate is 0.57. This result is well within the range of estimates obtained in previous studies. Our result is also surprisingly comparable to those obtained by Sillamaa and Veall (2001) for high-income individuals.

Table 4: Dynamic Personal Income Tax Base Regressions, 1972-2006

Dependent variable: log of real per capita personal income tax base, ln(PITbase)it

Variables	Instrumental Variable (1)	Instrumental Variable (2)	Instrumental Variable (3)	Instrumental Variable (4)	Instrumental Variable (5)	Instrumental Variable (6)
ln(PITbase)it-1	0.816***	0.794***	0.794***	0.424***	0.407***	0.791***
	(0.028)	(0.030)	(0.031)	(0.059)	(0.058)	(0.030)
PITprov	-0.224***	-0.268***	-0.327***	-0.694***	-1.744***	-0.762**
	(0.082)	(0.087)	(0.127)	(0.172)	(0.431)	(0.353)
CITprov		0.208*	0.222***	0.672***	0.950***	0.272**
		(0.121)	(0.123)	(0.217)	(0.271)	(0.133)
PSTprov		-0.491	-0.540	-1.610**	-2.367***	-0.738*
		(0.392)	(0.400)	(0.650)	(0.745)	(0.429)
PSTprov X RSTdummy		0.067	0.090	0.269	0.538**	0.093
		(0.119)	(0.125)	(0.209)	(0.246)	(0.126)
Other provinces PIT			-0.173	-0.284	0.237	-1.351
			(0.446)	(0.183)	(0.293)	(1.016)
Log export price			0.011	0.059***	0.097***	0.022
			(0.013)	(0.022)	(0.026)	(0.014)
Dum88	0.107***	0.122***	0.112***	0.294***	0.292***	0.064
	(0.021)	(0.022)	(0.030)	(0.032)	(0.031)	(0.049)
Federal PIT				-0.458	-0.305*	—
				(0.146)	(0.162)	
Constant	—	—	—	—	—	—
Province effects	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	No	No	Yes
Over-id test (p-value)			—		0.928	0.418
Adj. R-squared	0.992	0.992	0.992	0.974	0.970	0.992
Number of obs.	330	330	330	330	330	330

Note: Robust standard errors are in parentheses. Significance level is indicated by * for 10 %, ** for 5%, and *** for 1 %. The instrument for the lagged dependent variable is two period-lagged values of the dependent variable. In columns (5) and (6), the instruments for the provincial PIT rate are dummy variables for the Liberal and NDP parties.

In column 2 of Table 4, we include the corporate income tax rate, the sale tax rate, and the sales tax rate interacted with the *RSTdummy* as control variables. The literature suggests that an increase in the corporate tax rate motivates people to shift their income from corporate to personal income. If this is true, then we expect the coefficient of the CIT rate to be positive. A higher sales tax rate also can be viewed as a tax on labour. In this case, the coefficient of the sales tax rate is expected to be negative. The estimated regression result shows that the personal income tax rate is still negative and significant, suggesting the robustness of this relationship to the inclusion of the control variables. As expected, the coefficient of the corporate tax rate is positive and significant, while the sales tax rate is negative but statistically insignificant.

In column 3 of Table 4, we include the weighted average tax rate of other provinces' PIT rates (weighted by each province's GDP) and the log of the index of US producers' prices as additional control variables. The former is used to check for the possible effects of horizontal tax externality; the latter captures the effects of changes in the world prices of the main export commodity of each province. If the hypothesis of horizontal externality in personal income taxation is valid, we expect the coefficient of other provinces' tax rates to be positive. Generally, an increase in the world price of major export commodities has favourable impacts on the total economy and taxable income.[3] Thus, we expect the coefficient of the log of the export price to be positive. However, these additional control variables are all statistically insignificant. In fact, the coefficient of the other provinces' PIT rate has an unexpected negative sign, but it is statistically insignificant. The log of the export price has the expected positive sign, but it is also statistically insignificant.

In column 4 of Table 4, we control for the federal PIT rate to check for the presence of vertical externality in personal income taxation. Since the federal and provincial governments co-occupy the same tax base, an increase in the federal PIT rate reduces the tax base and, as a result, has a negative impact on provincial tax revenue. If the hypothesis of vertical externality is valid, we expect the coefficient of the federal PIT rate to be negative. Note also that, for reasons explained above, we drop the yearly dummies. The estimated results are more or less similar to those we find in column 2 of Table 4, the only difference being that the log of the export price is now statistically significant and the sales tax rate is also negative and statistically significant. The coefficient of the federal PIT rate is negative, as expected, but it is statistically insignificant.

So far we have treated the PIT rate as exogenous. However, it is well known that, in a progressive income tax system, the marginal tax rate depends on taxable income. Thus, in this case, the PIT rate can be endogenous, and if the problem is not addressed it will bias our own semi-elasticity estimate. So, as explained before, we use dummy variables for the governing political party as instruments for the PIT rate. The validity of these instruments is verified using the standard over-identifying restriction test. Comparing columns 5 and 4 of Table 4, we see that, when the PIT rate is treated as endogenous, there is a significant increase in the magnitude of the coefficient of the PIT rate. Now, the coefficient of the federal PIT rate is negative and statistically significant, providing empirical support for the hypothesis of vertical externality in personal income in the federation.

Finally, in column 6 of Table 4, we drop the federal PIT rate and include yearly dummies. We also use the same set of instruments as in column 5. All coefficients of the tax rates have their respective expected signs and are statistically significant. The over-identification test shows that our instruments for the PIT rate and the lagged dependent variable are valid. This is our preferred regression, which we use in our computation of the MCF. The preferred regression estimate indicates that the short-run and long-run own semi-elasticities of the personal income tax base are about –0.76 and –3.65, respectively. When we evaluate these estimates at the average statutory top PIT rate of 19.25 percent, we obtain short-run and long-run taxable income elasticities of about –0.15 and –0.70. Alternatively, evaluating at the mean combined top PIT rate of 53 percent, our estimates show a long-run elasticity of taxable income with respect to the net-of-tax rate of about 1.72, which is higher than that obtained by Sillamaa and Veall (2001) using individual tax returns data. Since we use top PIT rate, the response of the tax base is generally expected to be higher.

4.3 General Sales Tax

In this section, we estimate the effects of provincial sales tax rates on sales tax bases. Currently, as noted, all the provinces except Alberta impose a general sales tax. The federal government also imposes the VAT-based GST. During the period under consideration, there was no variation in the GST, so we do not include it in our regression. As before, we employ an IV estimation method, but since the sales tax rate does not depend on the base, we treat the sales tax rate as exogenous. However, we treat the lagged-dependent variable as endogenous and, as is common in the literature, we use the two-period lagged value of the dependent variable as an instrument.

3 In some provinces (for example, Alberta) the boom-and-bust cycle of the economy is largely a reflection of fluctuations in the world price of major export commodities.

Table 5: Dynamic General Sales Tax Base Regressions, 1977-2006

Dependent variable: log of real per capita General Sales tax base, ln(PSTbase)it

Variables	**Instrumental Variable (1)**	**Instrumental Variable (2)**	**Instrumental Variable (3)**	**Instrumental Variable (4)**
ln(PSTbase)it-1	0.661***	0.635***	0.650***	0.655***
	(0.062)	(0.067)	(0.066)	(0.068)
PSTprov	-0.554*	-0.649**	-0.660**	-0.628**
	(0.302)	(0.327)	(0.326)	(0.321)
CITprov		0.254	0.289	0.321
		(0.235)	(0.233)	(0.231)
PITprov		-0.096	-0.073	-0.159
		(0.147)	(0.144)	(0.157)
Unemployment			-0.524**	-0.546**
			(0.253)	(0.260)
Neighbors' sales				-0.529
tax rate				(0.412)
Neighbors' price level				-0.007
Log export price				(0.056
Constant	—	—	—	—
Province effects	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes
Adj. R-Squared	0.881	0.879	0.882	0.882
Number of obs.	280	280	280	280

Note: Robust standard errors are in parentheses. Significance level is indicated by * for 10 %, ** for 5%, and *** for 1 %. The instrument for the lagged dependent variable is two period-lagged value of the dependent variable.

We first estimate the sales tax base on just the provincial sales tax rate (see Table 5). The variable is as expected negative and statistically significant. The estimated coefficient value is –0.55, which suggests that a one percentage point increase in the provincial sales tax rate is associated with a fall in the sales tax base of 0.55 percent.

In column 2 of Table 5, we include the corporate income tax rate and the top marginal personal tax rate as control variables. While these variables are insignificant, the sales tax rate is still negative and statistically significant. In column 3, we include the provincial unemployment rate as an additional control variable to capture the effects of the business cycle on the sales tax base. During an economic downturn, the sales tax base tends to fall as the income and confidence of people fall in response to economic uncertainty. Thus, we expect that an increase in the unemployment rate reduces the sale tax base. As expected, the unemployment rate is negative and statistically significant. The sales tax rate, however, continues to be negative and statistically significant, suggesting the robustness of our result to the inclusion of additional control variables.

Finally, in column 4 of Table 5, we include the average sales tax rate (weighted by population) and the aggregate price level of neighbouring provinces as additional control variables. If a province's sales tax rate is higher than that of its neighbours, the result may be cross-border shopping and smuggling from the lower-tax provinces – that is, a lower sales tax rate in neighbouring provinces can reduce a province's sales tax base. Thus, we expect the coefficient of other provinces' sales tax rates to be positive. The coefficient of neighbouring provinces' sales tax rates is negative but statistically insignificant. The neighbours' price level is also insignificant. More important, the coefficient of the sales tax rate is, as expected, negative and significant. This is our preferred regression. Our results indicate that the short-run semi-elasticity of the sales tax base is about –0.63. This implies that a one percentage point increase in the sales tax rate results in a fall in the sales tax base of about 0.63 percent. The long-run sales tax base semi-elasticity is about –1.82. Thus, as expected, the effect of the sale tax rate on the tax base is higher in the long run.

4.4 Robustness Checks

We subject our preferred tax base regressions to various robustness checks. Specifically, we include province-specific time trends, treat the CIT rate as an endogenous variable, estimate the tax bases as a system of equations, and exclude Quebec from the personal income and corporate income tax base regressions. We also check the use of the combined federal and provincial PIT rate, taking into account the Quebec Abatement. The results of the robustness checks are shown in Appendix B.

As explained in our main analysis, we include yearly dummies to control for time effects that are common to all provinces. One may want to control for province-specific time trends as well. When we include province-specific time trends, there is not much qualitative change in our results. Not surprisingly, however, there is a change in the magnitude of the coefficient estimates.

In our main analysis, we treat the CIT rate as exogenous. As a robustness check, we also treat the CIT rate as endogenous. The instruments used are a dummy variable for the NDP party, the log of per capita government spending, and the share of provincial population that is 65 and older. The coefficient estimate is now higher in absolute magnitude and significant only at 10 percent. The coefficient of the lagged dependent variable is also lower in absolute magnitude. As a result, the effect on the long own-semi elasticity estimate is actually downward in absolute value.

Arguably, tax bases in a given province are interrelated, as they are all part of the economy – that is, there may be a potential correlation in the error terms of the three tax base regressions. In this case, one can obtain some efficiency gain by estimating the three tax base regressions simultaneously as a system of equation. We estimate the three tax bases simultaneously using the three-stage least square (3SLS) methods. The own semi-elasticities are still negative and significant. As compared to our preferred tax base regressions, the coefficient estimates of the PIT rate and the sales tax rate are now lower in absolute value. The coefficient estimate of the CIT rate, however, is slightly higher in absolute value.

We also check the robustness of our corporate income and personal income tax base regression results to the exclusion of Quebec from the analysis. The CIT and PIT own semi-elasticity estimates are now lower in absolute value, but still statistically significant. In the personal income tax base regression, the sales tax rate is now negative and significant.

Our analysis focuses on estimating the sensitivity of tax bases to provincial tax rates. One may be interested, however, in using the combined federal and provincial tax rate. The federal CIT rate changes only over time, thus the yearly dummies pick up the effects of the federal tax rate. That is, in the presence of yearly dummies, there is no difference in the coefficient estimates whether one uses the combined federal and provincial marginal CIT rate or just provincial CIT rates, as in this paper. However, unlike the federal CIT rate, the federal PIT rate differs between Quebec and other provinces. This is because the Quebec Abatement reduces the federal tax rate in Quebec by 16.5 percent. As a way of a robustness check, we re-estimate our preferred personal income tax base regression using the total marginal PIT rate (the combined provincial and federal rate). The results are shown in column 2 of Appendix Table B-2. The coefficient estimate for the combined federal and PIT rate is the same as the one in our preferred regression. This is not surprising because the yearly dummies pick up the effects of the federal PIT rate. So the Quebec federal PIT Abatement (which is constant throughout the period) is picked up by the yearly dummies. There is, however, a slight change in the magnitude of the coefficient estimates of the control variables.

5. Tax Base Elasticities and the MCF

As discussed in Section 2, the tax base semi-elasticity estimates can be used to calculate the MCF for the three main taxes imposed by the provincial governments. The first step in calculating the MCF is to compute the dynamic semi-elasticities. Our econometric model employs a one-year lag to capture the dynamic response of the tax bases to tax rate increases. With this model, the proportional reduction in tax base *j* from a one percentage point increase in τ_i, *v* years in the future, is

$$\beta_{jiv} = \left(1 + \lambda_j + \lambda_j^2 + \ldots + \lambda_j^v\right)\eta_{ji} \quad , \tag{12}$$

where $\beta_{ji0} = \eta_{ji}$ is the short-run semi-elasticity of tax base j with respect to τ_i; as v becomes very large, β_{jiv} approaches $\eta_{jj}/(1 - \lambda_j)$, the long-run semi-elasticity of tax base j with respect to τ_i. Therefore, in our model, the dynamic semi-elasticities of the tax bases are defined by

$$H_{ji} = \left[\sum_{v=0}^{n}\omega_v\left(1 + \lambda_j + \lambda_j^2 + \ldots + \lambda_j^v\right)\eta_{ji}\right]. \tag{13}$$

Our computations of H_{ji} are based on n = 100 years and r = 0.05. It should be stressed that the magnitudes of the dynamic semi-elasticities depend on the estimated values of the coefficients of the tax rate variables and the lagged dependent variables in our models as well as on the assumed discount rate.

The provincial governments' MCF for the corporate income tax, personal income tax, and sales tax were computed using the coefficient estimates in column 4 of Table 3, column 6 of Table 4, and column 4 of Table 5. Only the coefficient estimates that were significant at the 5 percent level were used in computing the MCF. The values of the non-significant coefficients were set at 0. The coefficients of the lagged dependent variables and the short-term semi-elasticities that were used in the calculations are shown in the matrices below, where the first row shows the coefficients for the corporate income tax, the second row for the personal income tax, and the third row for the sales tax:

$$\lambda = \begin{bmatrix} 0.853 \\ 0.791 \\ 0.655 \end{bmatrix},$$

$$\eta = \begin{bmatrix} -2.278 & 0 & 0 \\ 0.272 & -0.762 & 0 \\ 0 & 0 & -0.628 \end{bmatrix}.$$

The dynamic semi-elasticities, computed according to (13), are

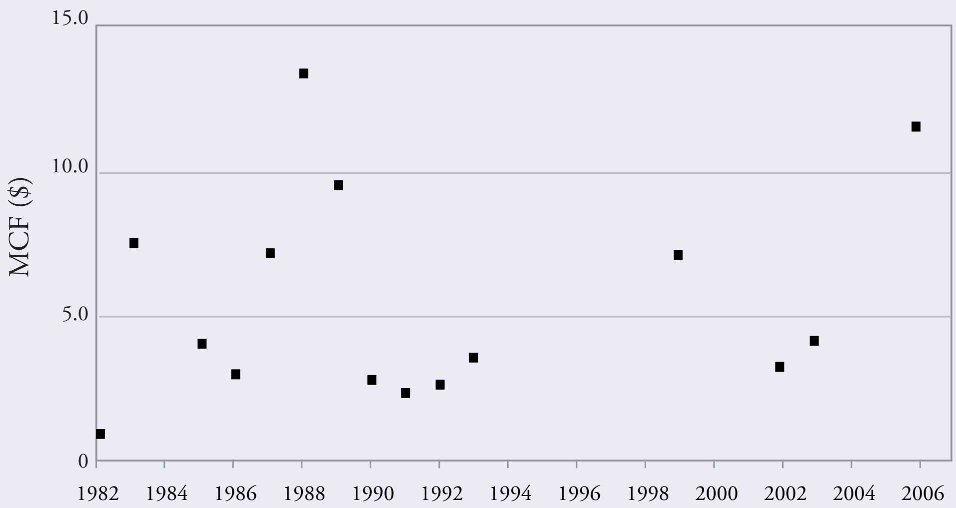
$$H = \begin{bmatrix} -12.116 & 0 & 0 \\ 1.101 & -3.085 & 0 \\ 0 & 0 & -1.668 \end{bmatrix}.$$

The computations of the MCF are based on the coefficient in the *H* matrix as well as on the share of total tax revenue of each of the three taxes and the tax rates, which, in general, vary from province to province and year to year. Here we highlight some of our key findings.

5.1 Base Case Computations of the MCF

Table 6 shows our computations of the MCF for the ten provinces in 2006. In line with expectations concerning the tax sensitivity of provincial business tax bases, our results indicate that the MCF for the provincial corporate income tax is very high. For four provinces – Ontario, Nova Scotia, Ontario, Prince Edward Island, and Saskatchewan – the MCF was not computed because in these provinces a corporate income tax rate reduction would increase the current value of the government's total tax revenue. Consequently, a reduction in the corporate income tax in 2006 would have been welfare improving in these provinces. For the other provinces, the MCF for the CIT ranged from 2.25 in Manitoba to 40.83 in Alberta. In all the provinces except Quebec, the MCF for the CIT exceeds the MCF for the personal income tax, although in Manitoba the MCF for these two taxes is about the same. The reasons for the reversal in ranking of the MCF of the CIT and PIT in Quebec will be discussed

Figure 1: The MCF for Corporate Income Tax, British Columbia, 1982-2006



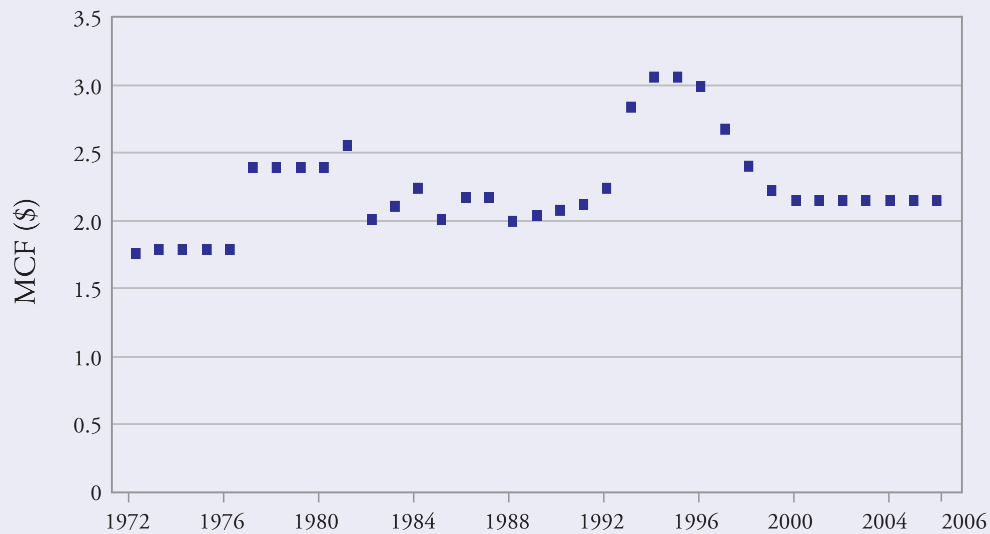
Source: Authors' calculations.

below. Our computations also show that the MCF for the CIT varies widely from year to year. Figure 1 shows the computed values of the MCFCIT for British Columbia. From 1972 to 1981, the MCFCIT was not computed because a CIT rate cut would have increased the current value of the province's total tax revenue. This was also the situation in 1984, 1994 to 1998, 2001, and 2004. In the other years in which the MCFCIT had positive values, it ranged from 0.96 in 1982 to 184.39 in 2000. The reason for these wide fluctuations is the large year-to-year changes in the CIT's share of total tax revenue in British Columbia. In other words, random fluctuations in the size of the CIT base produce large year-to-year variations in our computed MCF. This suggests that a more appropriate procedure for calculating the MCF is to use five-year moving averages for the tax shares, which reduces the variation in the MCF to some degree, although year-to-year variations are still quite large. For example, for British Columbia, using the average revenue shares over the previous five years, the MCFCIT was 12.22 in 2002, 8.87 in 2003, 7.48 in 2004, 6.14 in 2005, and 8.70 in 2006. Although year-to-year fluctuations in the MCF for the CIT are large even when we use a five-year moving average, the main point is clear: the cost of increasing provincial tax revenue through a corporate tax rate increase is very high, and in some provinces corporate tax rate reductions would increase the current value of the government's total tax revenue.

The MCF for the PIT in 2006 ranged from 1.45 in Alberta to 3.85 in Quebec. The MCFPIT is generally higher in the Atlantic provinces than in the three western provinces. For Ontario, the MCFPIT was 2.16 in 2006. Figure 2 shows how the MCFPIT has varied in Ontario since 1972: during the mid-1990s, the MCFPIT exceeded 2.50, and in 1994 and 1995 it exceeded 3.00. These calculations indicate that, even in Canada's largest province and industrial heartland, the cost of raising additional revenue through the personal income tax has been relatively high.

The provincial sales tax had the lowest MCF, ranging from 1.00 in Alberta to 1.21 in Prince Edward Island. The figure for Alberta is based on the fact that the province does not have a general sales tax – that is, $\tau_s = 0$. In addition, our regression equations indicate that an increase in provincial sales tax does not have a significant impact on the other provincial tax bases – that is, $\eta_{cs} = \eta_{ps} = 0$. Substituting these values in equation (6) implies that the MCF from introducing a

Figure 2: The MCF for Personal Income Tax, Ontario, 1972-2006



Source: Authors' calculations.

"small" sales tax in Alberta would be 1.00, much lower than the MCF for the CIT and PIT.

In broad terms, our computations indicate that corporate income tax had the highest MCF and sales tax the lowest, which is consistent with previous research, such as Arnold (2008) and Johansson et al. (2008), on the distortionary effects of taxes. Our results indicate that there would have been significant welfare gains in 2006 from reductions in provincial corporate income tax rates, with a revenue-neutral switch to higher provincial sales taxes, in Alberta, British Columbia, Manitoba, New Brunswick, and Quebec. In the other five provinces, a cut in the CIT rate would have increased the current value of total tax revenue and, therefore, would not have required an offsetting provincial sales tax increase. This endorsement for a greater emphasis on sales taxes is consistent with the advice that many economists have provided governments over the years, but this policy option usually has been firmly resisted because of the perceived regressivity of a sales tax. The adverse distributional effects of provincial sales taxes are a concern, although typically exaggerated in the data, which focus on annual consumption spending by income level; accordingly, measures need to be taken to protect vulnerable groups, such as low-income seniors. However, the potential gains from a greater emphasis on sales tax revenue are so large that this tax policy option should be carefully considered by provincial government officials and the public.

If the option of increasing reliance on provincial sales taxes is not politically feasible, then reductions in CIT rates with offsetting revenue-neutral increases in PIT rates would yield welfare improvements in all the provinces except Quebec. The situation in Quebec is anomalous because that province has had the highest personal income tax rates combined (until recently) with relatively low corporate income tax rates.[4] As noted above, our econometric model indicates that higher CIT

4 Although the Quebec government levies a high marginal tax rate on its residents' incomes, the federal personal income tax rate is reduced by 16.5 percent because of the Quebec Abatement, an arrangement whereby Quebec receives a lower federal transfer in exchange for increased tax room. However, the lower federal PIT rate does not reduce the Quebec government's MCF from a PIT rate increase because it is the provincial tax rate that determines the provincial government's MCF, not the combined federal and provincial marginal tax rate. On the other hand, as our results below indicate, an increase in the Quebec government's personal income tax rate has a lower impact on federal revenues than in other provinces because of the Quebec Abatement.

Figure 3: The MCF for Corporate Income Tax and Personal Income Tax, Quebec, 1972-2006

Source: Authors' calculations.

rates increase the PIT base, which helps to reduce the MCF for the CIT, especially in Quebec, where the PIT rate is high.

Figure 3 shows the MCFPIT and the MCFCIT for Quebec over a 35-year period. From 1978 to 1985, however, the MCFPIT could not be computed because a PIT rate reduction would have increased the current value of total tax revenue in Quebec. Note also that the MCFCIT in Quebec was less than 1.00 in the mid-1980s because a CIT rate increase would increase the PIT base, resulting in a significant increase in PIT revenues given Quebec's high PIT rates. Subsequent adjustments in the PIT and CIT rates have narrowed the gap between the MCF for the PIT and the CIT in Quebec.

Although the focus of our research has been on the provincial governments' MCF for corporate income, personal income, and sales taxes, our regression results also can be used to compute the federal government's MCF for these taxes, because the federal tax bases are just the sum of the provincial tax bases. The federal government's MCF is, of course, important in itself for tax policy and expenditure evaluation purposes, but a comparison of the federal MCF with that of the provincial governments a measure of the vertical fiscal imbalance in the federation.

In order to calculate the federal MCF, we use the regression results in column 3 of Table 3 and column 5 of Table 4, which, as expected, show that the corporate and personal income tax bases are less sensitive to a federal tax rate increase than to a provincial tax rate increase because the former cannot be avoided by shifting activity across provincial boundaries and because we expect that a federal sales tax rate increase has the same effects as a provincial sales tax increase (column 4 of Table 5). The last row in Table 6 shows our estimates of the federal government's MCF. Again, as expected, the MCF for the CIT and the PIT, at 1.71 and 1.17, respectively is substantially lower than that for any province, while the MCF for a general sales tax, at 1.11, not surprisingly, is similar to the provincial MCF given that it is computed with the same coefficient estimates. These results indicate a significant vertical fiscal imbalance in the federation in the sense that the federal government can raise additional tax revenue at much lower cost, at the margin, than can the provincial governments. In recent years, the federal government has cut corporate income,

Table 6: The Marginal Cost of Public Funds for Corporate Income Tax, Personal Income Tax, and General Sales Tax, Provincial and Federal Governments, 2006

	Corporate Income Tax	Personal Income Tax	General Sales Tax
	marginal cost of public funds ($)		
British Columbia	11.64	1.83	1.13
Alberta	40.83	1.45	1.00
Saskatchewan	*	1.86	1.13
Manitoba	2.25	2.16	1.13
Ontario	*	2.16	1.15
Quebec	2.57	3.85	1.15
New Brunswick	4.30	2.22	1.15
Nova Scotia	*	2.46	1.15
Prince Edward Island	*	2.31	1.21
Newfoundland & Labrador	30.31	2.54	1.15
Federal Government	1.71	1.17	1.11

* The MCF is undefined because a small reduction in the corporate income tax rate would increase the current value of the government's total tax revenue, resulting in a social welfare gain.

personal income, and sales tax rates, and it is useful to consider the federal government's overall MCF as a weighted average of the these three taxes, with weights based on their relative share of federal tax revenue. The resulting weighted average MCF for the federal government was 1.26 in 2006.

It is interesting to compare our regression-based results for the federal government's MCF with those obtained by Baylor and Beauséjour (2004) using a dynamic computable general equilibrium model. If we convert their marginal distortionary loss calculations into estimates of the MCF, they obtained an MCF of 1.40 for the CIT, 1.30 for the PIT, and 1.10 for a consumption tax. Our estimates of the MCF for the CIT are somewhat higher than theirs, but, as pointed out above, our estimates vary considerably from year to year because of fluctuations in the business tax base. Our results for the MCF for the PIT are somewhat lower that those of Baylor and Beauséjour and earlier computations by Dahlby (1994). Finally, our estimates for the sales tax are very similar to those of Baylor and Beauséjour for a consumption tax. They also compute a weighted average MCF of 1.30, which is remarkably close to our weighted average of 1.27. It is also close to the value of 1.30 that Dahlby (2009) computes for Canada using a dynamic growth model with public sector debt. While there are differences in the estimates of the MCF, it must be remembered that our estimates are based on a regression model while previous results are based on simulation models using "best guess" values for key parameters. Given that the comparators have been derived using completely different approaches, we are more impressed by the similarity of the results than by the differences.

5.2 The Effects of Equalization Grants on the MCF of the Recipient Provinces

Our computations of the provincial governments' MCF are based on how their tax revenue responds to tax rate increases, given the tax sensitivity of their three main tax bases. However, for many of the provinces, transfers from the federal government are an important source of revenue. While the Canada Health Transfer and the Canada Social Transfer are not dependent on the provincial governments' tax policies, entitlements for equalization grants may be affected by the tax rates provincial governments impose. As noted by

Smart (1998) and Dahlby (2002), the equalization grant formula may reduce the provinces' perceive MCF because it compensates provinces with higher transfers if their tax bases are decline as a result of a tax rate increase. As Smart puts it, "the [equalization] grants in effect subsidize increases in distortionary taxes by equalization-receiving governments" (2007, 1208).

Dahlby (2008, chap 10) shows how the formula for the MCF can be modified by taking into account a *base equalization effect and a rate equalization effect* from the equalization grant formula. The base equalization effect is the compensation that a province receives through the equalization formula when its tax base declines, and it has the potential to dramatically reduce the provincial government's MCF. This effect is especially important for small provinces or those that were not part of the five-province standard, which was used in Canada until recent years, for computing equalization entitlements. The rate equalization effect reflects the impact of a province's tax rate changes on the total revenue that is equalized or, equivalently, its effect on the standard tax rate that is used to compute equalization entitlements. This effect is potentially important only for a large province, such as Quebec, which has a large share of the total tax base.

Without going into the details of the derivations, which follow the model described in Dahlby (2008, chap 10) with modification to reflect the five-province standard used in Canada during most of the period under study, the MCF formula can be modified as follows for a province receiving equalization grants:

$$MCF_{\tau_i} = \frac{s_i}{s_i + \tau_i \sum_{j=1}^{m} s_j m_j H_{ji} + s_i \rho_i}, \quad (14)$$

where mj is the base equalization effect and is given by

$$m_j = \frac{\left(\tau_j - (1 - Ip)\tau_j^e\right)}{\tau_j}, \quad (15)$$

where p is the province's share of the population, I is an indicator variable that takes a value of 1 if the province was part of the five-province standard for calculating the equalization standard and zero otherwise, and τ_j^e is the standard tax rate used to calculate equalization entitlements with respect to tax base j. Note that, if the province's share of the population is very small or if it was not part of the five-province standard, and if its tax rate is equal to the standard tax rate, then m_j would be zero and the province's total revenue would not be affected by the reduction in its tax base caused by an increase in its tax rate, because the increase in equalization entitlements would offset the tax revenue losses from the decline in the tax base. If $m_j = 0$ for all tax bases, then the base equalization effect would mean that the province's effective MCF was equal to 1. Note also that the equalization formula can result in an MCF that is less than 1 if the recipient province's tax rate, τ_j, is less than $(1 - Ip)\tau_j^e$ because, in this case, the province's additional equalization entitlement exceeds the tax revenue lost when its tax base declines.

The other effect that is incorporated in equation (14) is the rate equalization effect, ρ_i, which is defined as

$$\rho_i = b_i\left(\frac{B_i^e}{B_i} - 1\right), \quad (16)$$

where b_i is the province's share of tax base i and B_i^e is the standard tax base used to calculate equalization entitlements. If the province is "deficient" in the tax base, ρ_i is positive and the rate equalization effect will lower the province's MCF. If the province's per capita base exceeds the standard tax base, then ρ_i is negative and the rate equalization effect will raise the province's MCF. Since the term in brackets in equation (16) is multiplied by the province's share of the total tax base, the rate equalization effect is only important for large recipient provinces such as Quebec.

Table 7 shows the MCF for the provinces that received equalization grants in 2006 if they took into account the effects of the equalization grant system on their revenue in making their taxation decisions. These computations indicate that the

Table 7: The Perceived Marginal Cost of Public Funds for Corporate Income Tax, Personal Income Tax, and General Sales Tax, Provinces Receiving Equalization Payments, 2006

	Corporate Income Tax	Personal Income Tax	Provincial Sales Tax
	marginal cost of public funds ($)		
British Columbia	1.17	0.99	1.02
Saskatchewan	1.44	0.94	1.01
Manitoba	1.27	1.01	1.01
Quebec	0.83	1.44	1.04
New Brunswick	0.95	1.01	1.02
Nova Scotia	1.59	1.06	1.02
Prince Edward Island	1.69	1.03	1.07
Newfoundland & Labrador	1.14	1.07	1.02

Source: Authors' calculations.

MCF for the CIT and the PIT would be greatly reduced. Note that three provinces – Nova Scotia, Prince Edward Island, and Saskatchewan – that were on the downward-sloping section of the Laffer curve for the CIT rate, according to the calculations in Table 6, are now on the upward-sloping section and their MCF ranges from 1.44 for Saskatchewan to 1.69 for Prince Edward Island. Note also that the MCFCIT for Quebec is now less than 1, again showing the potentially large impact that the equalization formula can have on the provincial MCFCIT. There are similar, although less dramatic, reductions in the MCFPIT for the equalization-receiving provinces.

Studies by Dahlby and Warren (2003) for Australia, Hayashi and Boadway (2001), Esteller-Moré and Solé-Ollé (2002), and Smart (2007) for Canada, and Buettner (2005) for Germany indicate that the tax rates of subnational governments are affected by equalization grants. Smart (2007), which is the most rigorous study of the quantitative effects of equalization grants on subnational governments tax rates, finds that, when the percentage of capacity deficiencies that are equalized increases from 50 to 100, the recipient provinces' average effective tax rates increase by about seven percentage points. His results indicate that Canada's equalization grant system has promoted significantly higher levels of taxation by the recipient provinces; they are also consistent with the dramatic reduction in the MCF that we calculate and present in Table 7.

Are the induced higher rates of taxation by recipient provinces a good thing? Models developed by Köthenbürger (2002) and Bucovetsky and Smart (2006) show that, in the presence of interprovincial tax base mobility, an equalization grant formula, by inducing higher rates of taxation, can offset the effects of interprovincial tax competition and provide a correction for the horizontal tax externality. Smart concludes, however, that "the effects of tax competition within the federation on tax rates are negligible, so that equalization grants cannot be interpreted as (however unintentional) a corrective device for tax competition, and the tax-raising effect of the grants is deleterious to consumer welfare" (2007, 1210). Note that Smart's conclusion regarding the weakness of interprovincial tax competition in explaining provincial tax-rate setting is consistent with our empirical results, as we find little evidence that tax rates in other provinces affect a given province's tax base. Consequently, we may conclude that, to the extent to which recipient provinces' tax policies are affected by the equalization grant formula, they underestimate the distortionary effects of their taxes and the marginal cost of raising provincial tax revenue.

5.3 Vertical Tax Externalities

Another potential source of bias in the provincial governments' tax policies is the vertical tax externality that arises when two levels of government tax the same, or closely related, tax bases.[5] In simple terms, if two levels of government share a tax base, an increase in the tax rate by one level will normally (but not always) reduce the revenue the other level can collect at its existing tax rates because the tax base shrinks when the combined tax rate increases. If both levels of government ignore the effect of their tax rates on the tax revenues of the other level, then the combined tax rates of the two levels may be "too high" in the sense that the total marginal cost of raising tax revenue exceeds the marginal benefit of the projects that are funded, because the governments ignore the losses taxpayers in other jurisdictions sustain. The potential for underestimating the total marginal cost of raising tax revenue by the federal and provincial governments is very significant because all the major tax bases – personal income, corporate income, and sales and excise taxes – are taxed by both levels of government. It is not possible at this time to estimate the size of this bias, but some information about the importance of these vertical tax externalities can be gleaned from our estimates of the tax base elasticities. Our results indicate that a provincial corporate income tax rate increase that would raise an additional dollar of tax revenue for the provincial government would lower federal tax revenue by an amount that ranges from $0.78 in Manitoba to $2.09 in Quebec.[6] An additional dollar of provincial personal income tax revenue would reduce federal revenue by $0.75 in Quebec and $0.89 in the other provinces. Our results also indicate that the vertical tax externality is relatively minor for provincial sales taxes: an additional dollar of provincial sales tax revenue would reduce federal revenue by $0.10. These computations suggest, although far from conclusively, that the overlap of federal and provincial corporate and personal income tax bases may cause Canadian governments to underestimate the true of cost of raising additional tax revenue.

6. Conclusions

The effects of an increase in a tax rate on tax revenue, economy efficiency, and social welfare depend on the tax sensitivity of a government's tax bases. As a result, it is important to understand the degree of the sensitivity of tax bases to tax rate changes. A large number of studies have examined the elasticity of taxable income using data from individual tax returns, but the literature has largely ignored the responsiveness of the corporate tax base. Recently, however, some studies have tried to address this gap. Studies that focus exclusively on Canada are also quite limited – to our knowledge, only Sillamaa and Veall (2001) and Mintz and Smart (2004) provide tax base elasticity estimates for Canadian PIT and CIT, respectively.

In this paper, we have examined the dynamic response of tax bases to changes in tax rates using annual panel data from the provinces for the period 1972-2006. We focused on the three main taxes levied by Canadian governments: corporate income tax, personal income tax, and general sales tax. Our analysis makes two important contributions to the empirical literature. First, we provide estimates of the short-run and long-run tax base elasticities for the three taxes using provincial data. While previous studies focus mostly on the static response of tax bases, we provide estimates of dynamic responses and incorporate the possible cross-effects of tax rates on other tax bases. Our preferred empirical results

5 For models of the biases in fiscal decisions created by vertical tax externalities, see Boadway and Keen (1996); Dahlby (1996); Keen (1998); Keen and Kotsogiannis (2002); and Dahlby and Wilson (2003).

6 There are large variations across provinces in the effect of a provincial CIT rate increase on federal revenue because this includes the effects on federal personal income tax revenue as well on federal corporate income tax revenue, and there are large variations in the relative size of the provinces' corporate and personal income tax bases.

suggest that a one percentage point increase in corporate income, personal income, and sales tax rates is associated with a 2.27, 0.76, and 0.63 percent reduction in their respective tax bases in the short run. The long-run own semi-elasticity estimates of CIT, PIT, and sales tax bases are 15.50, 3.65, and 1.82, respectively. Our long-run elasticity estimates for the PIT are well within the range of those obtained in previous studies. The tax base elasticity estimates for the CIT, however, are higher than those obtained in similar studies.

Second, we use the tax base elasticities to compute the MCF for the three taxes. Our computations indicate that, over the study period, corporate income tax had the highest MCF and sales tax the lowest. The MCF for the personal income tax in 2006 ranged from 1.45 in Alberta to 3.85 in Quebec. Only in Quebec was the MCF for corporate income tax lower than the personal income tax. Our results indicate that there would have been significant welfare gains in 2006 from reductions in provincial corporate income tax rates, with a revenue-neutral switch to higher provincial sales taxes, in Alberta, British Columbia, Manitoba, New Brunswick, and Quebec. In the other five provinces, a cut in the CIT rate would have increased the current value of total tax revenue and, therefore, would not have required an offsetting provincial sales tax increase. Our computations also indicate that the equalization grant formula may drastically reduce the perceived MCF of the provinces that receive these grants and that increases in provincial corporate and personal income taxes can cause significant reductions in federal tax revenue.

Several caveats need to be mentioned concerning the definition and interpretation of our measures of the MCF. First, they assume that the burden of a tax rate increase falls completely on the residents of the province. Second, we have ignored non-tax distortions, such as involuntary unemployment, which may significantly affect the magnitude of the MCF. Third, we have ignored the vertical and horizontal tax externalities that can arise in a federation and that may cause a province's perceived MCF to depart from its full marginal cost – that is, the costs or benefits that accrue to residents of other provinces. Finally, we have ignored the distributional effects of tax – since taxes that impose a disproportionate burden on low-income individuals have a high "social" cost, the distributional effect of a tax increase should be incorporated into our computation of the MCF. These issues go well beyond the scope of the current paper, however, and should be included in future work on the measurement of the marginal cost of public funds in Canada.

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Appendix Table A-1: Definitions of Variables and Data Sources

Variable	Description	Source
Corporate income tax base (CITbase)	Business tax base used in equalization payment calculations	Finance Canada
Personal income tax base (PITbase)	Personal taxable income	Canada Revenue Agency, *Income Statistics (formerly Tax Statistics on Individuals)*
General sales tax base (PSTbase)	Provincial general and Miscellaneous sales tax base used in equalization payment calculations	Finance Canada
Corporate marginal tax rate (CITprov)	Provincial statutory top marginal corporate income tax rate (General rate)	*Finances of the Nation (formerly National Finances)*
Top personal marginal tax rate (PITprov)	Provincial income tax rate of the top income bracket	*Finances of the Nation (formerly National Finances)*
Sales tax rate (PSTprov)	Provincial sales tax rate (PST)	*Finances of the Nation (formerly National Finances)*
Federal CIT rate	Federal government Corporate income tax rate	*Finances of the Nation (formerly National Finances)*
Federal PIT rate	Federal government top personal income tax rate	*Finances of the Nation (formerly National Finances)*
Total tax revenue	The sum of provincial income, consumption, property and related, and other tax revenues	Statistics Canada, Public Finance Historical Data 1965/66-1991/92, catalogue no. 68-512 (1972-1988) and CANSIM (1989-2006) Table 385-0001.
Population	Total provincial population	CANSIM Table 051-0001.
GDP deflator	Gross Domestic Product, implicit price index (1997=100)	Statistics Canada, Provincial Economic Accounts
Export price	The US Producers Price Index for provinces' major exporting commodities.	US Bureau of Labor Statistics available at http://data.bls.gov/PDQ/servlet/SurveyOutputServlet
Unemployment rate	Provincial annual unemployment rate	Statistics Canada, CANSIM Table 282-0002

Source: Authors' calculations.

Appendix Table B-1: Robustness Checks for Corporate Income Tax Base Regressions, 1977-2006

Dependent variable: log of real per capita business tax base, ln(CITbase)it

Variables	**With Provincial Rends** *(1)*	**Endogenous CIT Rate** *(2)*	**Excluding Quebec** *(3)*	**3SLS** *(4)*
ln(CITbase)it-1	0.703**	0.693**	0.843*	0.737***
	(0.335)	(0.281)	(0.452)	(0.213)
CITprov	-3.429*	-4.102*	-2.213*	-2.414**
	(1.769)	(2.223)	(1.196)	(1.160)
PITprov	-0.989	-0.920	-1.030	-0.759
	(0.720)	(0.678)	(0.740)	(0.887)
PSTprov	-0.282	0.694	1.786	0.441
	(3.156)	(2.754)	(3.050)	(2.794)
PSTprov X RSTdummy	-0.165	-0.011	-0.427	-0.000
	(1.814)	(1.144)	(1.367)	(1.072)
Federal CIT	—	—	—	—
Other provinces CIT	-10.727**	-12.808	-8.032	-7.756
	(5.400)	(8.025)	(5.602)	(6.046)
Log export price	0.154	0.141	0.125	0.136
	(0.119)	(0.089)	(0.103)	(0.081)
Log per capita GDP				
Constant	—	—	—	—
Province effects	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	yes	yes
Province trends	yes	no	no	no
Over-id test (p-value)	0.888	0.204	0.559	—
Adj. R-Squared	0.689	0.695	0.620	0.876
Number of obs.	280	280	252	280

Note: Robust standard errors are in parentheses. Significance level is indicated by * for 10 %, ** for 5%, and *** for 1 %. The instruments for the lagged dependent variable are the same as those of Table 3 (one period lagged unemployment rate and two period-lagged values of the dependent variable). In column (2) the provincial CIT rate is also treated as endogenous. The instruments used are: dummy variable for the NDP party, log of per capita government spending, and the share of provincial population that is 65 and over. In column (4) the instruments for the systems of equations are: two period lagged values of the dependent variables, dummies for the liberal and NDP parties, contemporaneous and one period lagged value of the provincial deficit to GDP ratio.

Appendix Table B-2: Robustness Checks for Dynamic Personal Income Tax Base Regressions, 1972-2006

Dependent variable: log of real per capita personal income tax base, ln(PITbase)$_{it}$

Variables	With Provincial Trends (1)	Using Combined PIT Rate (2)	Excluding Qubec (3)	3SLS (4)
ln(PITbase)it-1	0.622***	0.787***	0.768***	0.775***
	(0.066)	(0.030)	(0.033)	(0.033)
PITprov [a]	-0.863**	-0.762**	-0.686**	-0.426*
	(0.379)	(0.368)	(0.375)	(0.238)
CITprov	0.017	0.235*	0.379*	0.283*
	(0.154)	(0.127)	(0.203)	(0.145)
PSTprov	-0.944**	-0.752*	-0.839*	-0.737*
	(0.479)	(0.438)	(0.474)	(0.384)
PSTprov X RSTdummy	0.252	0.083	0.102	0.118
	(0.176)	(0.124)	(0.146)	(0.118)
Other provinces PIT [b]	-1.617	-1.504	-0.488	-0.430
	(1.597)	(1.230)	(1.093)	(0.737)
Log export price	-0.020	0.020	0.021	0.013
	(0.017)	(0.014)	(0.015)	(0.012)
Dum88	0.126*	-0.046	0.109**	2.321
	(0.066)	(0.126)	(0.052)	(0.380)
Federal PIT	—	—	—	—
Constant	—	—	—	—
Province effects	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Province trends	yes	No	No	No
Over-id test (p-value)	0.132	0.413	0.153	—
Adj. R-squared	0.992	0.992	0.992	0.993
Number of obs.	330	330	297	280

Note: Robust standard errors are in parentheses. Significance level is indicated by * for 10 %, ** for 5%, and *** for 1 %. In columns (1) through (3) the instruments are the same as those used in Table 4. In column (4) the instruments for the systems of equations are: two period lagged values of the dependent variables, dummies for the Liberal and NDP parties, contemporaneous and one period lagged value of the provincial deficit to GDP ratio.

[a] In column (2) the tax rate is combined provincial and federal top PIT rate.

[b] In column (2) the tax rate is based on other provinces' combined provincial and federal top PIT rate.

Appendix Table B-3: Robustness Checks for Dynamic General Sales Tax Base Regressions, 1977-2006

Dependent variable: log of real per capita General Sales tax base, ln(PSTbase)$_{it}$

Variables	**With Provincial Trends (1)**	**3SLS (2)**
ln(PSTbase)it-1	0.428***	0.790***
	(0.084)	(0.051)
PSTprov	-0.693*	-0.485*
	(0.391)	(0.273)
CITprov	-0.237	0.099
	(0.214)	(0.180)
PITprov	-0.052	-0.104
	(0.152)	(0.185)
Unemployment	-1.439***	-0.469**
	(0.346)	(0.190)
Neighbors' sales tax rate	0.370	-0.599
	(0.527)	(0.324)
Neighbors' price level	-0.063	-0.011
	(0.051)	(0.041)
Log export price	-0.106***	-0.043***
	(0.025)	(0.016)
Constant	—	—
Province effects	Yes	Yes
Year dummies	Yes	Yes
Province trends	Yes	No
Adj. R-Squared	0.900	0.962
Number of obs.	280	280

Note: Robust standard errors are in parentheses. Significance level is indicated by * for 10 %, ** for 5%, and *** for 1 %. The instrument for the lagged dependent variable is two period-lagged value of the dependent variable. In column (2) the instruments for the systems of equations are: two period lagged values of the dependent variables, dummies for the Liberal and NDP parties, contemporaneous and one period lagged value of the provincial deficit to GDP ratio.

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