STUDIES IN ECONOMIC PROSPERITY

NUMBER 5 / FEBRUARY 2008

Assessing British Columbia's Incentive-Based Tax Cuts

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Contents

THE FRASER INSTITUTE

An Occasional Paper from the CENTRE FOR BUDGETARY STUDIES
A Division of The Fraser Institute

Studies in Economic Prosperity is published periodically throughout the year by The Fraser Institute, Vancouver, British Columbia, Canada.

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Editing and typesetting and design: *Kristin McCahon*

Printed and bound in Canada.

ISSN 1706-8983 (print); ISSN 1706-8991 (on-line)

Date of issue: February 2008

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Non-Technical Summary

Throughout much of the past 30 years, British Columbia's economy has lagged behind other Canadian provinces. For instance, from 1977 to 2006, British Columbia registered one of the lowest growth rates in gross domestic product (GDP) per person among the provinces. BC's economic performance was especially dismal between 1982 and 1996 during which time the province experienced Canada's lowest per person growth rate. The average growth in per person GDP between 1997 and 2001 was higher than the previous period, but was still the lowest among the provinces. In 2001, however, the province's fortunes changed. British Columbia went from being an economic laggard to having one of the fast growing economies in the country.

The change in BC's economic fortunes coincided with the election of a new government in 2001 that immediately implemented a series of tax cuts designed to improve the economy. Specifically, the new government focused on reducing personal and corporate income tax rates in order to improve the incentives for British Columbians to work, save, invest, and engage in entrepreneurial activity. The explicit goal of tax cuts was to make British Columbia's economy more competitive. But were the BC tax cuts in fact responsible for the higher economic growth rate?

The principal objective of this study is to assess the impacts of the 2001 BC incentive-based tax cuts. Numerous academic studies have examined the effects of taxes on economic growth and have found that taxes can influence growth, but the majority of these have focused on a cross-country rather than sub-national analysis. In this study, we first investigate the economic growth, investment, and revenue effects of personal and corporate income taxation across the 10 Canadian provinces from 1977 to 2006. We then use these results to assess the magnitude of the economic effects of BC's 2001 tax cuts.

Taxation and economic growth

We begin our analysis by exploring whether corporate and personal income tax rates affect per person provincial GDP growth rates. To do so, we analyze the impact of tax differences among the 10 Canadian provinces and tax changes within the provinces from 1977 to 2006. Provincial tax policies provide a good natural experiment because both corporate and personal income tax rates vary from province to province, and within each province, over the 30-year period.

To determine the impact of personal and corporate income taxes on per person GDP growth rates, our analysis controls for the influence of many other variables that have an impact on economic growth. These variables include the level of investment within the provinces, economic growth rates in the US, the prices of various commodities, and population growth. Controlling for these variables allows us to separate the impact of the tax changes on economic growth from the influence of these other variables.

Our statistical results indicate that higher provincial corporate and personal income taxes are associated with lower per person GDP growth rates. In addition, increases in the rates of provincial corporate income tax seem to hamper growth more than increases in personal income tax rates. More specifically, we find that a 10 percentage point cut in a province's corporate income tax rate is associated with a 1 to 2 percentage point increase in the per person GDP growth rate. Similarly, a 10 percentage point reduction in the top personal income tax rate causes a one percentage point increase in the growth rate. Basically, our results indicate that all else being equal, provincial corporate and personal income tax cuts spur economic growth.

Taxation, productivity, and investment

Related to the finding that personal and corporate income tax cuts do affect economic growth, it is important to analyze *how* the tax rate changes affect growth. Personal and corporate income tax cuts have an impact on economic growth in two main ways: through changes in productivity and changes in investment.

Productivity is the ability of our economy to transform inputs like raw materials and labour into valuable goods and services. Increased productivity, that is, producing more with the same set of inputs, largely comes down to individuals and businesses putting more effort into their work as well as working smarter, and changes in personal and business tax rates which improve the incentives to do so. The level of investment in machinery and equipment that workers have at their disposal is one of the principal drivers of productivity growth. In addition, technological advances are often embodied in new machinery and equipment.

Our results indicate that provincial corporate income taxes do indeed affect economic growth through their influence on investment and productivity. We find that personal income tax rates have an effect on provincial economic growth primarily through their influence on the level of investment. More specifically, our analysis suggests that a 10 percentage point reduction in the corporate tax rate is associated with a 5.76 percentage point increase in the ratio of private investment to GDP. Similarly, a 10 percentage point cut in the top personal income tax rate is related to a 5.96 percentage point rise in the ratio of private investment to GDP. Put simply, our results show that corporate and personal income tax rate cuts lead to significantly higher levels of investment in the economy, which in turn positively influences economic growth.

Tax rates and revenue

Policy makers are often concerned that when tax rates are cut, governments will bring in less money. In this study, we have estimated the impact of reductions in provincial corporate income taxes on corporate tax revenue, and we have estimated the affect of reductions in the top provincial marginal personal income tax rate on personal income tax revenue. We have also looked at the impact of both on total tax revenue.

Our results show that when provincial corporate income tax rates are low, increases in the tax rate result in increased corporate income tax revenue. However, when the corporate income tax rate exceeds some critical value, corporations will have a strong incentive to minimize the taxes they pay by shifting their investments and profits to other jurisdictions. In other words, there is a rate beyond which increases in the rate reduce corporate income tax revenue. Specifically, we found that that rate is between 12 and 14 percent. Our analysis indicates that when provincial corporate income tax rates exceed these levels, provincial corporate tax revenue falls. That said, provincial government policy should not be focused on attempting to maximize corporate income tax revenues because the corporate income tax rate affects GDP growth and the provincial government's other tax revenues.

This study also analyzes the effects of top provincial personal income tax rate on personal income tax revenues, but there is no strong statistical support for the existence of a revenue-maximizing rate. However, this analysis did not take into account the effects of the personal income tax on economic growth, so this result should be interpreted with caution.

Estimating the economic effects of BC's tax cuts

In 2001, British Columbia's newly elected government enacted a series of incentive-based tax cuts. In an attempt to make the province's economy more competitive, the government initially reduced the corporate income tax rate by 3.0 percentage points from 16.5 percent to 13.5 percent. Then in 2005 it further reduced the rate to 12.0 percent. As a result, BC went from having the second highest provincial corporate income tax rate in Canada to having the third lowest. Furthermore, in 2001 the government also implemented a 25 percent across-the-board personal income tax rate reduction. With it, British Columbia went from having the second highest top marginal personal income tax rate (19.7%) to the second lowest (14.7%), behind only Alberta. Finally, in 2001 the province also eliminated the general corporate capital tax.

In estimating the effects of the tax cuts, we find that the reductions will result in significant long-run economic gains for British Columbia. Specifically, with the 4.5 percentage point corporate income tax rate cut (16.5% to 12%) BC's long-run, per capita GDP will increase by 18 percent compared to the level that would have prevailed in the absence of the tax cut. Similarly, BC's 5.0 percentage point decrease in the top personal income tax rate (19.7% to 14.7%) will increase long run per person GDP by 7.6 percent compared to the level that would have prevailed in the absence of the personal income tax rate cut. It is worth noting that in the long term, the impact of the corporate income tax rate cut is about twice as large as the effect of a personal income tax rate cut.

Conclusion

While the impact of personal and corporate income tax cuts have been hotly debated in Canada, our study finds that lower corporate and personal income tax rates lead to higher levels of investment and faster rates of economic growth. Our results also show that British Columbia's 2001 personal and corporate income tax cuts made BC's economy more competitive and were partly responsible for the province's higher economic growth rate from 2002 to 2006. One important implication of this finding is that other Canadian provincial governments could realize higher output and growth gains if they adopt similar pro-growth tax policies

1. Introduction

The impact of taxation on growth and investment has been hotly debated both in academic and political circles. Proponents of tax cuts point to the effects that taxes have on incentives to work, save, and invest, and argue that reducing tax rates will boost economic growth. The tax cuts introduced by the government of British Columbia (BC) in 2001 are an important example of this type of pro-growth tax policy. The tax reform was introduced in two stages. In an attempt to make BC's economy more competitive, the government reduced the corporate income tax (CIT) rate initially by 3.0 percentage points with an additional 1.5 percentage point reduction in 2005. The government also cut the personal income tax (PIT) rate by about 25 percent. The capital taxes on non-financial corporations were also eliminated.[1] The tax reform was based on the premise that the cut in the marginal tax rates would encourage the incentive to work, invest, and conduct entrepreneurial activity, all of which would help spur growth in the province.

A number of theoretical and empirical studies have examined the effects of taxes on growth. Using cross-country and sub-national government data, previous studies have indicated that taxes can influence growth. While the majority of the literature on taxation and growth has focused on cross-country analysis, only a few researchers have investigated the issue using data from sub-national governments, particularly US states.

Canada's provincial governments' tax policies provide a good natural experiment for the study of the effects of tax rates on growth. However, to the best of our knowledge, there have been no empirical studies of the effects of fiscal policies on the growth of Canadian provinces. The principal objective of this paper is to investigate the effects of taxation on growth using data from 10 Canadian provinces over the period 1977 to 2006. We use the empirical results to assess the revenue, investment, and growth rate effects of the 2001 British Columbia incentive-based tax cuts.

We begin our analysis by exploring the effects of tax rates on growth, private investment, and revenue. Our empirical results indicate that higher taxes are associated with lower private investment and slower economic growth. These results are broadly consistent with previous cross-country and sub-national studies of taxation and growth. More specifically, our analysis suggests that a 10 percentage point cut in the statutory corporate income tax rate is associated with a temporary 1 to 2 percentage point increase in the per capita GDP growth rate. Similarly, a 10 percentage point reduction in the top marginal personal income tax rate is related to a temporary one percentage point increase in the growth rate. The CIT rate seems to have a stronger adverse impact on growth and investment than the PIT rate. In general, the empirical results indicate that, other things remaining constant, tax cuts encourage private investment and spur growth.

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1 Unlike personal and corporate income taxes, each province defines the capital tax base differently, which makes inter-provincial comparison less straightforward. This paper does not deal with the effects of capital taxes. For an extensive analysis of the impact of capital tax in Canada, see Clemens, Emes, and Scott, 2002; and Chen and Mintz, 2003. An excellent review of the empirical evidence on capital gains tax is also available in Milligan, Mintz, and Wilson, 1999.

We have conducted simulation exercises of the 2001 BC tax cuts based on parameter values from our econometric model, and they indicate that the 2001 tax cuts resulted in significant long-run output gains. In particular, our simulation results indicate that the 4.5 percentage point CIT rate cut will boost the long-run GDP per capita in BC by 18 percent compared to the level that would have prevailed in the absence of the CIT tax cut. Another way of expressing the impact of the CIT rate cut is in terms of the present value of the increase in future output. Assuming a discount rate of 10 percent, we found that the present value of the output gain from the 2001 CIT rate cut is about 53 percent of current output. The corresponding present value of the output gain from the 2001 PIT rate cut was about 12 percent of current output.

We also analyzed the responsiveness of tax revenues to changes in PIT, CIT, and sales tax rates by estimating regression equations for total tax revenue on these tax rates and other control variables using annual data for the period 1972-2006. We paid particular attention to the responsiveness of corporate tax revenue that has become a focus of considerable discussion among fiscal policy commentators (see, for example, Reynolds, 2007). Our analysis suggests that there is a non-linear, Laffer curve type relationship between corporate tax rates and corporate tax revenue. The parameter estimates indicate that the provincial CIT rate that maximizes provincial CIT revenues is between 12 and 14 percent. Our analysis therefore indicates that provincial corporate tax revenue falls when provincial CIT tax rates exceed these levels. It should be emphasized, however, that a provincial government's policy with regard to its CIT rate should not be based on attempting to maximize CIT revenues. That is because the CIT rate affects the provincial government's other tax bases and even if it did not have an effect on other revenues, the marginal cost of raising tax revenue at the revenue-maximizing tax rate is extremely high, in fact, infinite.

Our analysis of the effects of taxes on tax revenues, investment, and growth, allows us to calculate the marginal cost of public funds (MCF) for corporate and personal income taxes and sales taxes. Our estimates of the MCF for the BC government based on the short-term economic adjustments are generally in line with previous estimates. The MCF for the PIT rate is 1.04 which is lower than the MCF for the CIT, 1.44. The MCF for the sales tax was only 0.88. However, when we incorporated the long-run output effects from tax changes, the MCF for the PIT increased to 1.50 based on a 10.0 percent discount rate for future tax revenues. Perhaps most importantly, our analysis indicates that the present value of a provincial government's total tax revenues declines if it increases its CIT rate. This implies that if CIT rates are cut, citizens will be better off, and current and future expenditures on public services can be increased, or other taxes cut.

The paper is organized as follows. In section 2, we review the literature on the effects of taxation on growth. We also provide a brief discussion of the literature on tax rates and tax revenue. Our econometric results on the effects of provincial tax rates on growth, investment, and tax revenues are presented in section 3. Based on these estimation results, in section 4 we simulate the impacts of the 2001 tax reform in BC on the province's growth rate and its future output. In section 5, we calculate the marginal cost of funds for the BC government. Section 6 contains our conclusions and highlights the implications of the study for other provinces.

2. Literature Review

Cross-country empirical growth studies

Both neoclassical and endogenous growth theories predict that fiscal policies in general, and distortionary taxes in particular, affect economic growth (see Myles, 2000 for a survey of the theoretical studies on taxation and growth). In the neoclassical growth models, taxes have only temporary effects on growth, whereas in the endogenous growth models, taxes can permanently affect the growth rate. However, even though taxes have a temporary effect on growth rates in the neo-classical model, that "temporary" effect can still last for many years and the cumulative effect of the tax rate change through a temporary change in the growth rate can still be very significant.

A number of studies have examined the connection between taxation and economic growth over the past two decades using data from a cross-section of countries. The empirical studies, however, generally differ in their methodology and their measures of the tax burden. In one strand of the empirical literature, researchers use the aggregate tax rate, usually constructed as a ratio of total tax revenue to GDP. To control for tax progressivity, they also include a measure of the aggregate effective marginal tax rate obtained by regressing total tax revenue on GDP.[2]

One of the earlier attempts to examine the empirical relationship between taxes and growth was by Koester and Kormendi, 1989. They examined the effects of average and marginal tax rates on the level and growth of output using data from 63 countries. They used the aggregate average tax rate, measured as tax revenue divided by GDP, to capture the burden of taxation. They also generated aggregate effective marginal tax rates by running a regression of total tax revenue on GDP. The coefficient of GDP from this type of regression is interpreted as a marginal tax rate. They found that average and marginal tax rates affect growth adversely.[3]

One subtle problem associated with using the aggregate average tax rate to measure the tax burden is that any change in the tax revenue to GDP ratio must be accompanied by a similar change in at least one other fiscal variable (relative to GDP) because of the government's budget constraint. Helms, 1985, argued that studies that examine the effects of fiscal policy on growth should explicitly take into account the government budget constraint and the associated implicit assumption of financing. Following Helms, 1985, Kneller *et al.*, 1999 and Bleaney *et al.*, 2001 divided government expenditures and revenue into various categories and estimated their effects on growth. The empirical results from these studies suggest that distortionary taxes reduce growth. For instance, the Kneller *et al.*, 1999, econometric results indicate that a reduction of distortionary taxation by 1 percent of GDP is associated with between a 0.1 and 0.2 percent annual increase in the growth rate.

2 Engen and Skinner, 1996; Wasylenko, 1997; Dahlby, 2000b; and Veldhuis and Clemens, 2006, provided a survey of some of the earlier literature on taxation and growth.

3 Subsequent empirical studies such as Miller and Russek, 1993; Kneller *et al.*, 1999; Bleaney *et al.*, 2001; Folster and Henrekson, 2001; and Padovano and Galli, 2002, used a similar methodology.

Folster and Henrekson, 2001, used panel data from rich countries (including Canada) over the period 1970 to 1995 to examine the effects of taxation and government expenditure on growth. They used total tax revenue and total government expenditure, both relative to GDP, as measures of fiscal policy. They found a negative association between taxation and growth. Furthermore, the empirical results of this study suggest that the negative relationship between government size and growth becomes more robust as econometric problems are properly addressed.

Due to lack of data, many of the previous studies used average tax rates (usually the ratio of total tax revenue to GDP) as a measure of tax rates in their analysis of the tax-growth linkages. However, theoretical growth models suggest that it is the marginal tax rate that influences an individual's decision to invest, to save, and to work. Thus, an interesting issue is whether average or marginal tax rates explain differences in growth. Padovano and Galli, 2002, examined this issue empirically using panel data from 25 industrialized countries (including Canada) from 1970 to 1998. Their results show that while effective marginal tax rates affect growth negatively, effective average tax rates do not seem to have any statistically significant effect on growth.

Lee and Gordon, 2005, studied the growth effects of personal and corporate income tax rates using 5-year period panel data from about 70 countries for 1970 to 1997. What makes their study unique is that it used statutory corporate and personal income tax rates rather than aggregate average tax rates. For the personal income tax, they experimented with an effective marginal rate, an average tax rate on labour income, and a weighted average statutory individual income tax rate, in addition to the top statutory tax rate. Their empirical results suggest that a 10 percentage point reduction in the statutory corporate tax rate is associated with a one to two percentage point increase in annual GDP per capita growth rate, depending on their estimation methods. However, none of the personal income tax rate measures was found to have any significant influence on the growth rate. An empirical study by Katz *et al.,* 1983, also indicated that the top personal marginal income tax rate had no significant influence on growth.

Growth studies from sub-national governments

While most of the empirical literature on the relationship between taxation and growth has focused on a cross-section of countries, some studies have used data from sub-national governments. Most of these studies have used data from US states, and to the best of our knowledge, no empirical study has examined the impact of tax rates on the growth of Canadian provinces.[4] Consequently, the literature surveyed in this section focuses exclusively on studies of the economic growth of US states.

Helms, 1985, analyzed the effects of fiscal policy on 48 US states for the period 1965 to 1979. In order to take the government's budget constraint into account, the author includes all the fiscal variables with the exception of state and local governments' transfer payments. The results of the study suggest that an increase in property taxes and other taxes to finance transfer payments reduced growth. If used to finance productive public services, on the other hand, taxes have a positive impact on economic activity. Using a similar approach, Miller and Russek, 1997, also found evidence that distortionary taxation affect growth adversely.

4 Some studies estimate growth regressions using data from Canadian provinces in relation to other issues. See for example, Coulombe and Lee, 1995; Coulombe and Tremblay, 2001; and Coulombe, 2003. However, none of these studies deals with the relationship between taxation and growth.

Employing a similar methodology as in Koester and Kormendi, 1989, Mullen and Williams, 1994, analyzed the effects of taxes on economic performance of US states over the period 1969 to 1986. They found that higher marginal tax rates depress output growth. This negative relationship between marginal tax rate and growth was also found to be robust across different periods, control variables, and the use of alternative marginal tax rate measures. Their analysis also showed that tax rates reduce productivity growth. A similar empirical study by Becsi, 1996, also revealed that a state's marginal tax rate relative to other states was negatively related to relative state growth. Holcombe and Lacombe, 2004, also found that states that increased their income tax rates relative to those of their neighbours had slower economic growth.

Empirical studies on taxation and growth often seek to identify the channels through which taxation affects growth. In a similar quest for the transmission channels, Yamarik, 2000, examined the effects of taxes on growth, productivity, private investment, and labour growth using cross-sectional data from US states. The tax measures employed in their study were both aggregate and overall effective average and marginal tax rates. The effective marginal tax rates were generated using Koester and Kormendi's 1989 approach. In all of their regressions, the effect of the overall effective marginal tax rate was insignificant. The marginal tax rate with respect to personal income and the overall average tax rate were found to have a strong negative effect on growth and investment. Tomljanovich, 2004, also found that changes in a state's overall effective average and marginal tax rates affected growth negatively in the short-run, but not in the long-run.

In sum, the majority of empirical studies from a cross section of countries and US states show that distortionary taxes impede growth. Many Canadian commentators also emphatically argue that high tax rates are adversely affecting the country's economic performance and have called for tax cuts (see, for example, Kesselman, 1995; McKenzie, 2000b; Clemens, *et al*., 2002; and Chen and Mintz, 2003). Tax rates can affect growth through their effects on productivity or investment. Thus, following the literature on taxation and growth, we will investigate these issues using data from Canadian provinces.

Tax rates and government revenue studies

Most of the literature on the impact of tax rate changes and government tax receipts focuses on the response of taxable income to changes in the tax rate (see, for example, Feldstein, 1995; Sillamaa and Veall, 2001; Gruber and Saez, 2002; and Kopczuk, 2005). The objective in our paper is to estimate directly the impact of tax rates on tax revenue, rather than the indirect effect of tax rates through the effect on tax bases. Consequently, we will only summarize below studies that examine the relationship between tax rates and tax revenue.

A policy issue that is of particular importance to policy makers who embark on tax reform is the response of tax revenue to changes in the tax rates. Tax rate cuts affect the economy in many ways. Revenue estimations that do not take into account the macroeconomic feedback effects of tax cuts are more likely to overestimate the revenue loss from tax rate reduction.[5] A number of studies have analyzed the impact of tax cuts on government revenue by considering the possible growth effects of tax cuts. Using an endogenous growth model framework, Ireland, 1994; Pecorino, 1995; Bruce and Turnovsky, 1999; and Agell and Persson, 2001, examined whether tax rate cuts are completely

5 This is commonly referred to as static scoring in the literature.

self-financing. While the results of Ireland, 1994, and Pecorino, 1995, indicate that tax rate cuts are self-financing, Bruce and Turnovsky, 1999, and Agell and Persson, 2001, cast doubt on that possibility.

Recently, Mankiw and Weinzierl, 2006; Leeper and Yang, 2006; and Ferede, 2007, used the neoclassical growth model to explore how tax rate cuts affect tax revenue. Their results suggest that that even if tax cuts do not completely finance themselves, the fall in tax revenue is much less than what can be obtained through static revenue estimation, which assumes that tax bases are unaffected by tax rate changes. For example, using parameter values consistent with the US economy, Mankiw and Weinzierl, 2006, found that, in the long-run, one-half of a capital tax cut pays for itself.

Dynamic analysis of the revenue effects of tax cuts is theoretically very appealing, but difficult to estimate empirically. As a result, to our knowledge, there are no econometric studies of the dynamic revenue effects of tax rate changes. Most of the empirical literature on tax rates and tax revenue are static by their very nature. Furthermore, empirical studies usually focus on just one type of tax revenue. For example, while Hsing, 1996, estimated personal income tax revenue, Klassen and Shackelford, 1998; Devereux, 2006; and Clausing, 2007, studied corporate tax revenue.

Using aggregate US data, Hsing, 1996, estimated the impact of average personal income tax rates on personal income tax revenue. The estimated results indicated that there was a bell-shaped relationship between the tax rate and tax revenue—i.e., the so-called Laffer curve—and the revenue maximizing tax rate was in the range of 32.67 to 35.21 percent.

Devereux, 2006, has developed a theoretical framework for estimating the non-linear relationship between the corporate income tax (CIT) rate and corporate income tax revenues, i.e., when the CIT rate is low, increasing the rate raises CIT revenues; but when the CIT rate is high, increasing the tax rate reduces CIT revenues because of the shrinkage of the CIT base. (The CIT base may decline because corporate profits may be transferred to other jurisdictions in response to differences in tax rates, and in the long-run, reduced corporate investment may reduce the CIT base.) Devereux estimated the relationship between tax rates and tax revenue using data from OECD countries. His empirical results lend support to the existence of a non-linear relationship between corporate tax rates and revenue. The results were, however, not very robust to the inclusion of various controlling variables.

Using data from US states and Canadian provinces, Klassen and Shackelford, 1998, also found that there was a non-linear relationship between the corporate tax revenue and tax rate. They estimated the corporate tax revenue to GDP ratio on the tax rate, its square, and other controlling variables. Their regression results indicated that a state or province's CIT revenues are maximized at a CIT rate of about 11 percent. Using a similar regression framework, Clausing, 2007, estimated the determinants of corporate tax revenue for a panel of OECD countries. Her empirical results also indicated that there is indeed a non-linear relationship between the corporate tax revenue and tax rate. The results implied that the revenue-maximizing corporate tax rate at the national level was about 33 percent.

3. Estimation and Empirical Results

This section first describes the evolution of the key variables of interest and the data sources. It then turns to model specification and estimation of growth and investment regressions. In this section, the principal objectives of the empirical analysis are twofold. First, we investigate whether corporate and personal income tax rates affect the per capita GDP growth rate. Having found a statistically significant relationship between tax rates and provincial economic growth rates, we then proceed to explore the transmission channels through which the tax rates influence growth. Second, we analyze the response of provincial tax revenues to changes in various tax rates by estimating regression equations for total tax revenue on tax rates and other control variables. We pay particular attention to the effects of CIT rates on corporate income tax revenues because this has become a focus of intense discussion both in the media and among researchers.

Data description and sources

The main sources of our dataset are Statistics Canada database (CANSIM) and Finances of the Nation (formerly National Finances), published by the Canadian Tax Foundation. Our data on statutory corporate tax rates, top personal income tax rates, and sales tax rates come from various issues of *Finances of the Nation.* Tax revenue figures prior to 1989 were obtained from Statistics Canada, *Public Finance Historical data*, 1965/66-1991/92, catalogue no. 68-512, while data from 1989 onwards were from CANSIM. Similarly, data on GDP at current prices, unemployment rates, corporate profits, population, the export price index of major exporting commodities, and US growth rates were obtained from CANSIM. Data on GDP and private investment (in 1997 constant prices) were obtained from Statistics Canada, *Provincial Economic Accounts.*[6] Appendix 1 gives a brief description of the data and definitions of the variables used in our empirical analysis.

Table 1 shows the profile of Canadian provinces and presents the key variables of interest for the initial, final, and the whole sample period. We also include year 2001 to enable an easier comparison between pre- and post-tax reform periods in BC.

In addition to the federal government, Canadian provinces impose taxes on income generated in their respective jurisdictions. Both the CIT and top marginal PIT rates show modest variations over the period under consideration. In general, Quebec has the lowest CIT rate, but the highest marginal top PIT rate.[7] British Columbia and Manitoba had the highest CIT rate in 1977. In fact, before the tax reform in 2001, BC's CIT rate was the second highest in the country. The 2001 tax reform reduced the province's CIT rate from 16.5 percent to just 12 percent in 2006. This made the province the jurisdiction with the third lowest CIT rate behind Quebec and Alberta. Before the tax reform, BC had the second highest top marginal PIT rate. Again, the 2001 tax reform that reduced the top PIT rate by 5 percentage points put the province second from bottom, next to Alberta.

6 The data on GDP and private investment were kindly supplied by The Fraser Institute.

7 Quebec residents, however, receive a refundable tax abatement of 16.5 percent of the basic federal tax when they calculate their federal tax payable.

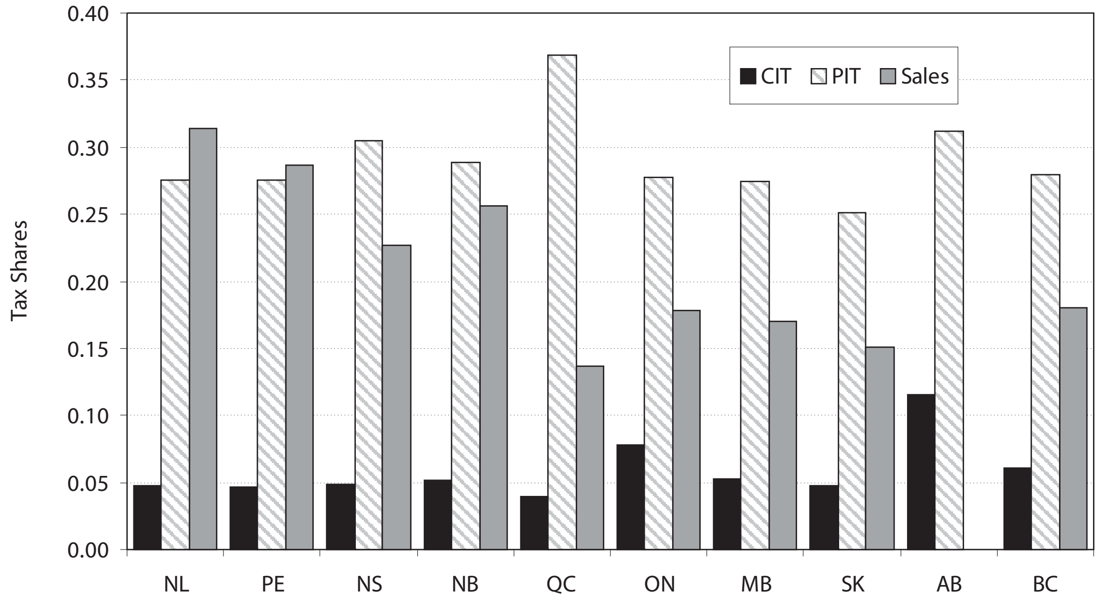
Table 1: Profile of Canadian Provinces, 1977-2006

	NL	PE	NS	NB	QC	ON	MB	SK	AB	BC
Annual average real GDP growth rate (%)[a]										
1977-2001	2.289	2.732	2.411	2.313	2.026	2.763	2.025	2.731	3.92	2.564
1977-06	2.668	2.71	2.294	2.337	2.027	2.707	2.062	2.617	3.98	2.736
Annual average real GDP per capita growth rate (%)[a]										
1977-2001	2.608	2.213	1.992	2.014	1.466	1.421	1.611	2.503	2.117	0.716
1977-06	3.013	2.233	1.938	2.09	1.448	1.374	1.641	2.478	2.147	1.012
Per capita GDP (in 1997 dollars)										
1977	12,491	12,951	15,448	15,523	20,486	25,736	19,227	16,554	23,749	25,816
2001	23,976	22,521	25,419	25,680	29,556	36,710	28,760	30,949	40,321	30,875
2006	30,841	25,303	27,626	29,063	31,633	38,869	31,460	34,801	45,225	34,971
Provincial statutory CIT rate (%)										
1977	14.00	10.00	12.00	12.00	12.00	12.00	15.00	14.00	11.00	15.00
2001	14.00	16.00	16.00	16.00	9.04	14.00	17.00	17.00	13.50	16.50
2006	14.00	16.00	16.00	12.00	9.90	14.00	14.00	14.00	10.00	12.00
1977-06	15.05	13.67	15.13	15.03	8.59	14.65	16.23	15.90	13.15	15.23
Provincial statutory top marginal PIT rate (%)[c]										
1977	24.73	21.50	22.58	23.51	28.00	18.92	28.90	27.67	16.56	19.78
2001	19.64	18.37	18.34	17.84	24.50	17.41	17.40	16.00	10.00	19.70[b]
2006	19.64	18.37	19.25	17.84	24.00	17.41	17.40	15.00	10.00	14.70
1977-06	20.77	18.97	19.57	19.49	27.46	18.29	18.69	18.62	13.82	18.25
Tax revenue to GDP ratio (%)										
1977	14.03	11.63	13.34	12.72	17.23	11.28	14.62	12.93	7.63	12.82
2001	13.85	15.24	14.71	14.11	20.66	15.78	16.83	18.15	8.72	14.36
2006	10.58	15.93	16.25	14.34	19.57	15.44	15.00	15.03	7.30	12.69
1977-06	14.66	13.82	14.24	14.11	18.78	14.27	15.35	14.42	8.76	13.51

[a]Calculated as log difference between the initial and last periods divided by the number of years.
[b] BC's top PIT rate was 19.7% prior to July 1, 2001 but the rate was reduced to 16.7% after July 1, 2001.
[c]The PIT rate includes applicable surtaxes. Note also that Quebec residents also receive a refundable tax abatement of 16.5 percent of basic federal tax which reduces their federal tax liability.
Source: See Appendix 1; calculation by the authors.

The ratio of total tax revenue to GDP in the provinces has also shown some variations over the sample period. Quebec, Manitoba, and Ontario have the largest total tax revenue relative to their respective GDPs. Alberta has the lowest ratio of total tax revenue to GDP, indicating that this province is relatively less dependent on tax revenue because of its natural resource revenues. BC has the second lowest ratio of total tax revenue to GDP. The data also reveal that corporate tax revenue accounts for only a small share of total tax revenue in all provinces. Figure 1 shows the share of CIT, PIT, and sales tax revenue in total tax revenue in the period 1972 to 2006. Alberta is more reliant on the corporate income

Figure 1: Average Corporate, Personal Income, and General Sales Tax Revenue Shares, 1972-2006



Source: Statistics Canada, *Public Finance Historical Data 1965/66-1991/92* and *CANSIM* table no. 385-0001; calculation by the authors.

tax than other provinces because it does not levy a provincial sales tax. The share of CIT in BC's total tax revenue is the third highest in the country. This share has been relatively stable over time.

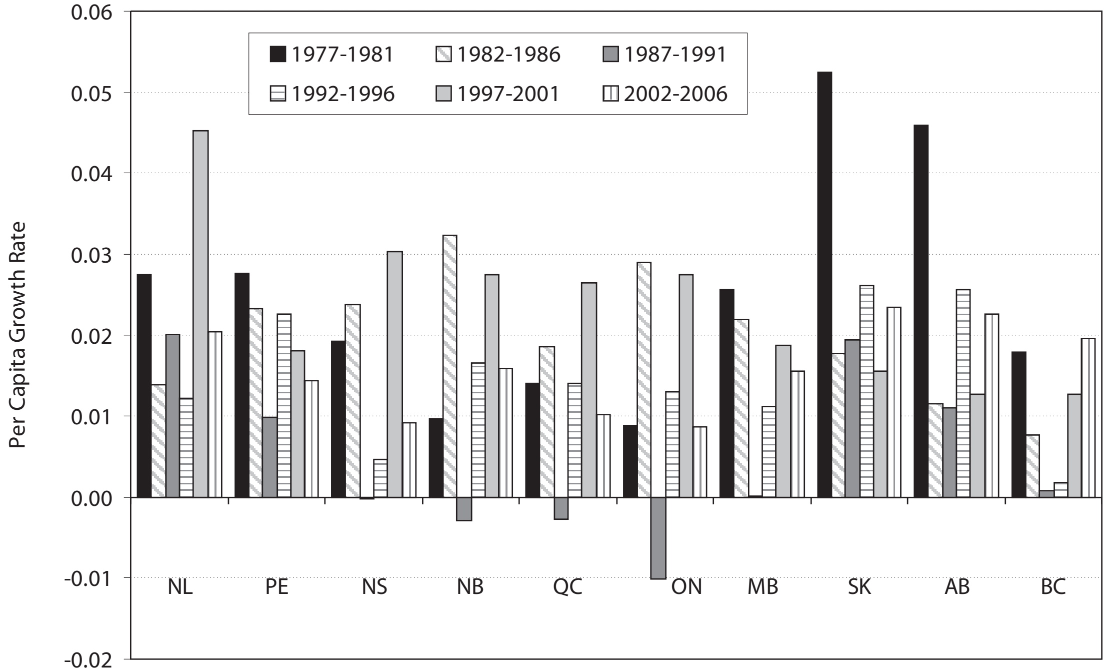
The Canadian provincial data reveal that over the period under investigation, the growth performance of provinces generally exhibited an upward trend. In real GDP terms, the energy sector-driven Alberta economy had the highest growth rate. In per capita GDP growth terms, Newfoundland, PEI, and Saskatchewan also performed impressively.[8]

From 1977 to 2006, British Columbia had one of the lowest per capita growth rates. As figure 2 shows, this is mainly due to its dismal performance between 1982 and 1996. Between 1997 and 2001, its per capita growth rate was also the lowest among the provinces. Only after 2001 was its performance above average performance. The growth rate of the BC economy between 2002 and 2006 was exceeded only by the growth rates of Newfoundland, Saskatchewan, and Alberta. This relatively better performance coincided with the introduction of the province's incentive-based tax reform, which reduced the CIT rate to the third lowest among the provinces. (After the reform, only Quebec and Alberta had lower rates.) Thus, it is extremely important to determine whether BC's tax cuts were responsible for the higher rate of economic growth.

In the following section, we explore the link between taxation and growth using panel data from 10 Canadian provinces for the period 1977 to 2006. To smooth out short-term fluctuations in economic

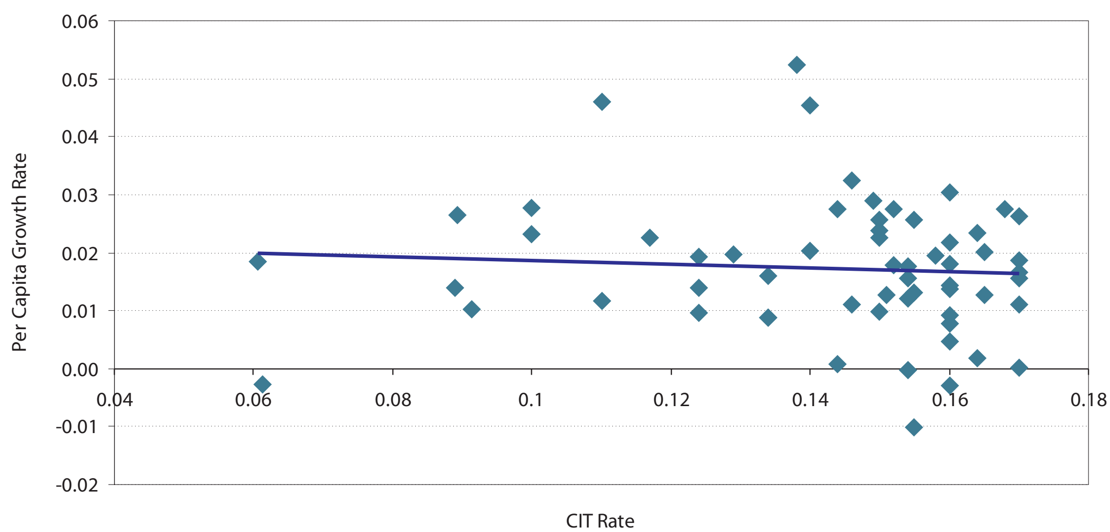
8 Even though Alberta showed the highest GDP growth rate in per capita terms, it ranks fourth. This is because of population migration into the province. Newfoundland and Saskatchewan, on the other hand, saw a decline in their population. This contributes to a rise in the GDP per capita growth in these provinces.

Figure 2: Provincial Average per capita GDP Growth Rates, 1977-2006



Source: Statistics Canada, *Provincial Economics Accounts*; calculation by authors.

Figure 3: Per capita GDP Growth Rates versus Corporate Tax Rates



Note: The variable on the horizontal axis is the average corporate tax rate for 1977-1981, 1982-1986, 1987-1991, 1992-1996, 1997-2001, and 2002-2006.

Table 2a: Summary Statistics for Growth Regressions, 1977-2006

Variables	Mean	Std Dev	Minimum	Maximum
GDP per capita growth rate	0.0173	0.0115	-0.0100	0.0524
Initial GDP per capita (1997 dollars)	23,884	6,186	12,491	40,408
Population growth rate	0.0072	0.0089	-0.0139	0.0418
Government consumption to GDP ratio	0.2988	0.0555	0.1728	0.4159
Export price growth rate	-0.0052	0.0747	-0.1911	0.1909
US GDP growth rate	0.0314	0.0033	0.0255	0.0351
Top corporate tax rate	0.1426	0.0264	0.0605	0.1700
Top personal tax rate	0.1939	0.0404	0.1000	0.3200
Private investment to GDP ratio	0.1753	0.0441	0.1199	0.3340

Notes: The number of observations is 60. Variables are in decimals.

Table 2b: Summary Statistics for Revenue Regressions, 1972-2006

Variables	Mean	Std Dev	Minimum	Maximum
Total tax revenue/GDP)	0.1383	0.0280	0.0606	0.2084
Personal income tax revenue/GDP	0.0408	0.0127	0.0148	0.0793
Corporate income tax revenue/GDP	0.0077	0.0027	0.0020	0.0171
Corporate tax rate	0.1390	0.0268	0.0550	0.1700
Top personal income tax rate	0.1925	0.0413	0.1000	0.3300
Sales tax rate	0.0720	0.0299	0.0000	0.1200
Federal CIT rate	0.3202	0.0530	0.2212	0.4060
Federal PIT rate	0.3386	0.0712	0.2422	0.4700
Corporate profit/GDP	0.0968	0.0427	0.0278	0.3106
Nominal GDP (million dollars)	65,034	98,592	286	556,282

Notes: The number of observations is 350. Variables in decimals.

activity, we use six five-year periods: 1977 to 1981, 1982 to 1986, 1987 to 1991, 1992 to 1996, 1997 to 2001, and 2002 to 2006, yielding 60 observations for estimation.

Figure 3 provides a graphical description of the relationship between the average per capita GDP growth rate and the verage statutory corporate income tax rate (CIT) from 1977 to 2006. The figure suggests a negative partial correlation between the two variables. The basic statistics for the key variables in the growth regression are shown in tables 2a and 2b.

Taxation and economic growth

In this section, we examine the effects of tax rates on the economic growth rate. Our analysis uses annual data from the 10 Canadian provinces over the period 1977 to 2006. Following Padovano and Galli, 2002, and Lee and Gordon, 2005, our empirical growth specification is based on a standard growth model augmented with corporate and personal income tax rates. The basic specification for our growth regression takes the following form:

$$\Delta ln\ y_{it}=\alpha_0+\alpha_1 ln\ y_{it-1}+\alpha_2 CIT_{it}+\alpha_3 PIT_{it}+\alpha_4 POP_{it}+\alpha_5 US_t+\alpha_6 TOT_{it}+\alpha_7 GOV_{it}+\eta_i+\lambda_t+\varepsilon_{it}, \qquad (1)$$

where Δ is the difference operator, *ln* denotes natural logarithm, y_{it} is real GDP per capita, $\Delta ln\ y_{it}$ is the per capita GDP growth rate, *CIT* is the top statutory corporate tax rate, *PIT* is the top personal income tax rate, *POP* is population growth rate, *US* is the US growth rate, *TOT* is the growth rate of terms of trade, *GOV* is government expenditure to GDP ratio, and ε_{it} is the error term. The time-invariant unobserved province-specific effects are captured by η_i . The λ_t, represents province-invariant time dummies.

The dependent variable, $\Delta ln\ y_{it}$, is the annualized average growth rate of real GDP per capita over the period 1977 to 1981, 1982 to 1986, 1987 to 1991, 1992 to 1996, 1997 to 2001, and 2002 to 2006. As is common in the economic growth literature, we use five year period averages to smooth out short term business cycle. To test for conditional convergence of provincial growth rate, we include $ln\ y_{it-1}$, the log of real capita GDP at the beginning of each period. That is, we use the per capita GDP in 1977, 1982, 1987, 1992, 1997, and 2002. If Canadian provinces' growth rates converge overtime we expect α_1 to be negative. This variable is endogenous and we use one period lagged values of the variable as an instrument. That is, the value of 1972 is used for 1977, 1977 for 1982, and so on.

Theoretical growth models indicate that marginal tax rates affect economic growth.[9] However, due to lack of data on marginal tax rate, many empirical studies have used overall average tax rates and effective marginal tax rates (see, for example, Koester and Kormendi, 1989; Mullen and Williams, 1994; Yamarik, 2000; Padovano and Galli, 2002; and Tomljanovich, 2004). The marginal tax rates are usually generated as a regression coefficient of tax revenue on a constant and its base.

Our investigation of the link between taxation and growth uses data on statutory corporate tax rates and top personal income tax rates as in Lee and Gordon, 2005. Since the marginal PIT rates change with income brackets, it is problematic to use personal income tax rates in empirical analysis (see Myles, 2000). Previous studies used weighted average statutory personal income tax rates (Easterly and Rebelo, 1993), effective average personal income tax rates (Mendoza *et al.*, 1997), and statutory top personal income tax rates (Lee and Gordon, 2005; Katz *et al.*, 1983). None of the above measures precisely captures the effects of the personal income tax rate on the growth rate. Easterly and Rebelo's 1993 approach, although theoretically interesting, requires information on income distribution and all the tax rates. Due to lack of data on income distribution, this approach is not feasible. Furthermore, as Katz *et al.*, 1983, explained, the top marginal statutory PIT rate seems relatively more appealing

9 See, for example, Padovano and Galli, 2002, who argued that empirical tests of the relationship between taxation and growth should use marginal tax rates, not average tax rate.

because this rate affects the high income group that has the most income and the highest propensity to invest. This implies that the top PIT rate affects this group's incentive to invest and ultimately adversely affects growth. Thus, due to the aforementioned reasons, we use the statutory top PIT rate in our analysis. The tax rate variables enter the growth equation as an average for the corresponding five-year period. That is, we use the average values for 1977 to 1981, 1982 to 1986, and so on.

The US is Canada's largest trading partner. Changes in the US growth rate will have a significant impact on the volume of goods and services that most Canadian firms can export. To capture the potential effects of changes in the US economy on Canadian provincial growth rates, we included the US GDP growth rate in our regressions. A higher US growth rate increases the demand for Canadian products, and this stimulates the Canadian growth rate. Thus, we expect the US growth rate to positively affect provincial growth rates.

In the empirical growth literature, an increase in the terms of trade, defined as the ratio of export price index to import price index, is commonly found to have a significant positive effect on growth (see Barro and Sala-i-Martin, 2004). International trade plays an important role in growth and employment in the Canadian provinces (Coulombe, 2003). Hence, it would be also interesting to see how changes in terms of trade influence Canadian provincial growth rates. Unfortunately, complete provincial data on export and import prices prior to 1981 are unavailable. In their absence, we have used the commodity price index of major exporting commodities to capture the effects of changes in the terms of trade.

The economies of most Canadian provinces are driven by some key sectors. For example, to a large extent the performance of Alberta's economy depends on the energy sector; British Columbia depends on its forestry sector; Ontario on its manufacturing industry (especially autos and related sectors), and so on. The performance of these key sectors in turn depends on the international demand for, and the prices of, various commodities. An increase in the price of a province's principal export commodities usually results in an expansion of that sector, and through other industrial linkages creates a boom in the entire provincial economy. Thus we have used the growth rate of the export price of a province's key commodity as one of the control variables. From the perspective of a provincial economy, increases in the export prices of its key commodities should increase per capita GDP growth and we expect the coefficient of export price to be positive.

Since province-specific export price data for the various commodities were unavailable, we used national figures. Thus the definition of the *TOT* variable that we have adopted is the growth rate of the export price index of major export commodities (net of the national inflation rate).[10] For each province, we used the export price of its major export. For Newfoundland, we have used the price of fish for the period 1977 to 1996 and the price of crude petroleum for 1997 to 2006. For Alberta, we have used the price of crude petroleum. For Prince Edward Island and Nova Scotia, the price of fish. For Saskatchewan and Manitoba, the price of wheat. For British Columbia and New Brunswick, the price of lumber. For Ontario, the price of motor and motor parts; and for Quebec, we used the price of manufactured goods.

10 A subtle problem with using the growth rate of the export price of major commodities is the difficulty of disentangling the effects of increases in domestic prices and foreign prices, as this variable may increase due to changes in both domestic and foreign prices. To circumvent this problem, we have subtracted the national inflation rate from the export price growth rate.

Table 3: Growth Regressions, 1977-2006
Dependent Variable: average growth rate of GDP per capita for the 5-year periods, 1977-2006

Estimation method	OLS	OLS	Robust	Fixed Effect	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.32**	0.06	0.35***		0.48***	0.49***	0.35***	0.39***
	(2.35)	(0.49)	(5.31)		(3.10)	(2.89)	(2.80)	(3.33)
Corporate marginal tax rate	-0.108**	-0.086*	-0.119***	-0.136*	-0.172***	-0.198**	-0.099*	-0.134**
	(-2.06)	(-1.97)	(-2.98)	(-1.79)	(-3.06)	(-2.28)	(-1.88)	(-2.14)
Top Personal marginal tax rate	-0.047	-0.083**	-0.065**	0.031	-0.07**	-0.121**		
	(-1.40)	(-2.05)	(-2.29)	(0.53)	(-2.20)	(-2.06)		
Log of initial GDP per capita	-0.027**	-0.006	-0.03**	-0.02	-0.04***	-0.04***	-0.03***	-0.034***
	(-2.48)	(-0.59)	(-5.62)	(-1.35)	(-3.12)	(-2.96)	(-3.05)	(-3.50)
Population growth rate	-0.46*	-0.61***	-0.42***	-0.24	-1.13***	-1.09***	-0.98***	-1.14**
	(-1.84)	(-3.46)	(-3.01)	(-0.66)	(-3.30)	(-2.71)	(-3.08)	(-2.56)
Export price growth rate	0.05**		0.04***	0.04*	0.06***	0.05***	0.04**	0.06***
	(2.36)		(3.15)	(1.75)	(2.63)	(2.55)	(2.48)	(3.13)
US growth rate	1.26***	1.83***	1.43***	1.29***	1.10***	1.21***	1.13***	1.05***
	(3.36)	(4.87)	(5.29)	(3.33)	(2.96)	(3.12)	(3.26)	(2.69)
Terms of trade		0.06*						
		(1.68)						
Government expenditure to GDP ratio	-0.124*	-0.03	-0.136***	-0.103*	-0.225***	-0.207***	-0.180***	-0.204***
	(-1.93)	(-0.52)	(-4.44)	(-1.95)	(-3.00)	(-2.60)	(-2.76)	(-2.74)
Investment to GDP ratio							0.074**	0.106**
							(1.95)	(2.45)
Observations	60	50	60	60	60	60	60	50
Adj.R-Squared	0.37	0.49	0.39	0.39	0.30	0.30	0.36	0.36

The figures in parentheses are t-ratios calculated from robust standard errors.
*, **, and *** show that coefficients are significant at 10%, 5%, and 1% significance levels respectively.

Many previous growth studies at both national and sub-national levels have found that population growth and government expenditure are important determinants of growth (see, for example, Barro, 1997; Bleaney *et al*., 2001; Holcombe and Lacombe, 2004; and Miller and Russek, 1997). In our regression model, we expect the coefficient of the ratio of government consumption expenditure to GDP to be negative. On the other hand, the expected sign of population growth rate is ambiguous. The coefficient may be negative (due to the direct effect of population growth on per capita GDP), or positive (because of an expansion in market size).

Investment in human capital is important cause of economic growth in many endogenous growth models. In the empirical growth literature, human capital is usually measured by primary or secondary school enrolment rates or some measure of educational attainment, and it is often found to have a positive impact on economic growth. However, due to lack of complete panel data on human capital for the Canadian provinces, we were not able to include this variable in the growth regressions.

As Fischer, 1993, has argued, economic variables such as taxes affect growth through changes in the level of investment per worker and/or the productivity of a given amount of investment per worker. For example, Baldacci *et al*., 2004, found that private investment and productivity levels are the main channels through which fiscal policy affects growth in both high- and low-income countries. Similarly, using data from US states, Mullen and Williams, 1994, and Yamarik, 2000, found that taxes indeed affected both productivity and investment. Consequently, our basic specification of the growth model in equation 1 does not include investment as one of the control variables.[11] We have adopted this specification because, if we control for the level of investment, any impact of taxes on growth is restricted to its effect on productivity. However, in other regressions that are reported later, we include the investment to GDP ratio in order to identify the transmission channels.

Our statistical analysis, which is based on data from 1977 to 2006 for the 10 Canadian provinces, is presented in table 3. Since the dataset covers 6 five-year periods and 10 provinces, the total number of observations is 60. We first report the Ordinary Least Squares (OLS) estimation of the baseline model. We regressed the average GDP per capita growth rate on the control variables (the log of initial GDP per capita, population growth rate, export price growth rate, US growth rate, and government expenditure to GDP ratio) and the tax rates.

Column 1 in table 3 shows that all the control variables have the expected signs and are statistically significant. In all the growth regressions, we also tried to include fixed provincial effects and time dummies, but they are found to be insignificant both individually and jointly and were dropped from the regressions. The key variables of interest, the statutory corporate marginal tax rate and the top marginal personal income tax rate, have, as expected, negative coefficients, but only the former is statistically significant at the 5 percent level. The point estimate of the coefficient of the corporate income tax rate implies that a 10 percentage point reduction in the tax rate is associated with a 1.08 percentage point increase in the growth rate of GDP per capita. The point estimate of the coefficient of the corporate marginal tax rate is well within the range of estimates found by Lee and Gordon, 2005, in their study of the effects of corporate and personal income taxes on growth rates of a cross-section of countries.[12]

As explained previously, we used the national export price growth rate (less the national inflation rate) of the main export commodities as a proxy for changes in the terms of trade. We also experimented by including terms of trade as an additional explanatory variable as in Barro and Sala-i-Martin, 2004. The results are shown in column 2 where the terms of trade variable is the growth rate of the ratio of export prices to import prices. Since export and import price data by province are not available prior to 1981, the number of observations was reduced to 50 when we used this terms of trade variable. Note that despite the fall in the number of observations, the tax rate variables are negative and highly significant. This shows that the statistical significance of the tax rate variables does not depend on the use of the

11 Lee and Gordon, 2005, also ignored investment and used similar specifications. This issue will be discussed further when we later estimate the effects of tax rates on investment.

12 Lee and Gordon, 2005, found that the top personal income tax rate is insignificant.

growth rate of the price of the major export commodities. Thus, we used this variable as a proxy for terms of trade to expand the number of observations and maximize degrees of freedom.

It is well known that the coefficient estimates of ordinary least squares are sensitive to the presence of outliers in the data. To check the robustness of our results to outliers, in column 3 we used the Least Absolute Deviation (LAD) estimation method, which is less sensitive to the presence of influential observations. All the variables have the expected sign and are statistically significant. Comparing columns 1 and 3, one also sees that the point estimates of the coefficient of the tax rates are slightly higher. Moreover, the personal income tax rate is now statistically significant. In column 4, we used the Fixed Effects estimation method. Now the personal income tax rate is insignificant, while the corporate income tax rate is still negative and significant with a numerical value very close to that which we obtained under OLS. This shows that the relationship between the corporate tax rate and the GDP per capita growth rate is robust.

The econometric model is a dynamic panel as it includes the log of initial per capita GDP. Moreover, some of the other explanatory variables may be endogenous. In such cases, the appropriate econometric technique is to use the Instrumental Variable (IV) estimation method.[13] In column 5, we employed the IV estimation method to account for the potential endogeneity problems of some of the explanatory variables. There is ample evidence from the empirical growth literature that initial GDP per capita, population growth rate, and government expenditure may be endogenous (see, for example, Barro and Sala-i-Martin, 2004). Thus, we treat these variables as endogenous and used their respective one-period lagged values as instruments. The IV estimation results show that both the corporate and personal income tax rates are negative and statistically significant, suggesting that higher tax rates are related to a lower growth rate.

The regression results show that the point estimates of the coefficients of the corporate tax rate are generally higher than those of the top personal income tax rate, implying that the former has a greater impact on the provincial growth rate than the latter. In a closed economy, higher PIT and CIT rates reduce both saving and investment and hence the growth rate. However, in an open economy, the PIT rate is less important due to international capital mobility. This is because in an open economy, investment can also be financed using external capital inflows, even when a higher PIT rate reduces domestic saving.[14] Thus a higher PIT rate, even though it reduces domestic saving, does not affect investment and growth that much. A higher CIT rate in an open economy, on the other hand, reduces investment, increases capital outflow, and as a result has a relatively stronger negative effect on the growth rate.

So far we have assumed that tax rates are exogenous. However, as explained in Lee and Gordon, 2005, tax rates may be endogenous. A growing economy can afford to reduce tax rates, while governments may be forced to raise taxes when their economies decline and their tax bases contract. If tax rates are endogenous, the point estimates of the coefficients of the tax rates may be biased. To overcome this potential endogeneity problem, we treated the tax rates as endogenous and instrumented with their

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13 For a dynamic growth model, System General Method of Moments (GMM) is a preferable method of estimation. However, given our sample size (small individual and time dimensions), it is not feasible to use system GMM.

14 See Mintz, 1996, and the references contained therein for a detailed discussion of this issue.

one-period lagged values in column 6. The weighted average tax rates of other provinces, weighted by the inverse of the distance between their provincial capital cities, were also used as instruments. The coefficient estimates of the tax rate variables using the IV technique were still statistically significant with point estimates of the coefficients slightly close to the ones obtained under robust estimation.

As previously noted, many researchers use average tax rates, instead of marginal tax rates, in their growth regressions (see Koester and Kormendi, 1989; Mullen and Williams, 1994; and Yamarik, 2000). Thus, we also experimented with both average total tax rates and separate average tax rates for corporate and personal income tax. However, these variables do not seem to have a significant effect on growth and were omitted from the reported results. Padovano and Galli, 2002, also found a similar result for a sample of 25 industrialized countries, including Canada.

So far we have not controlled for the level of investment. Thus, the reported negative relationship between tax rates and provincial growth is through their influences on both productivity and investment levels. However, it is important to identify the transmission channels through which the tax rates affect growth. To accomplish this, in column 7 we included the ratio of private investment to GDP as an additional explanatory variable. As commonly used in the growth literature, we treat this variable as endogenous and instrumented with lagged values of the variable (see, for example, Barro and Sala-i-Martin, 2004). That is, the average investment to GDP ratio over the preceding five years 1972 to 1976, 1977 to 1981, and so on, are used as instruments. Once we control for investment, any remaining effect of tax rates on growth must be through their influence on productivity (see Fisher, 1993; and Baldacci *et al*., 2004).[15] When we control for private investment, both the corporate and personal income tax rates are negative, but only the former is statistically significant. This suggests that the main channel through which the top personal income tax rate affects growth is through its effect on the level of investment. In column 7 we re-estimated the model after dropping the personal income tax rate and these results show that the corporate tax rate is still negative and significant. Private investment is found to have a positive and statistically significant effect on per capita growth. The log of initial per capita GDP is negative and significant. Note that the point estimate of the coefficient of the log of initial per capita income shows the rate of conditional convergence among Canadian provinces. That is, holding other explanatory variables constant, those provinces which start with a lower GDP per person grow faster relative to those with high initial GDP per person.

The period under investigation includes the time of tax reform for British Columbia. As described above, the British Columbia government introduced an income tax cut in 2001. To evaluate the possible growth effects of the tax reform, it is appropriate to first concentrate the analysis on the period prior to the reform. Thus, in column 8, we estimate the growth regression in the period 1977 to 2001. This reduces the number of observations to 50. However, the estimated result is generally consistent with what we have found previously. More specifically, a higher corporate tax rate is associated with a lower per capita GDP growth rate. The numerical magnitude of the point estimates of the corporate tax rate and private investments are higher than that we found in column 7. Our analysis of the effect of tax reform on British Columbia's growth will be conducted based on the estimated results reported in column 8.

15 Lee and Gordon, 2005 also provided a similar argument in relation to human capital and tax rates.

In general, the estimated regression results suggest that higher corporate and personal income tax rates are associated with a lower per capita GDP growth rate. The negative impacts of the tax rates on growth are robust to the estimation method employed and the time period considered. In addition, corporate income tax rate increases seem to have greater negative growth effects than personal income tax rate increases. A higher corporate tax rate is related to a lower growth rate through its effects on both productivity and private investment. The main transmission channel for the effect of the top personal income tax rate on the growth rate, however, is only through its effects on private investment. In order to better understand the main transmission channel through which tax rates affect growth, we explore the effects of tax rates on investment in the next section.

Taxation and investment

The growth regression results from the previous section show that tax rates are negatively related to economic growth. An important issue related to the tax-growth link is identifying the channels through which the tax rates affect growth. Column 7 in table 3 shows the impact of taxes on growth through their effect on productivity, while the effect of taxes on investment is ignored, i.e., investment is held constant. We now proceed to empirically explore the other main transmission channel through which taxes can affect growth: investment. To accomplish this, following Cohen, 1993; Barro, 1991, 1997; and Baldacci *et al.,* 2004, we estimate a structural equation of investment using the right hand side variables of the growth regression as explanatory variables.

Tax rates can reduce investment through their effects on the supply of funds for investment or their impact on the user cost of capital and thus the incentive to invest (see Hulten, 1984; Hubbard, 1998; and Feldstein, 2006).[16] For instance, McKenzie and Thompson, 1997, indicated that over the period 1971 to 1996, the user cost of capital in Canada was higher than that in the US partly because of higher Canadian tax rates. To fully explore how tax rates and provincial growth rates are related, it is important to run a separate regression of investment on the tax rates and other control variables. This enables us to identify the channels through which corporate and personal income tax rates affect economic growth. Ideally, an analysis of the response of investment to tax rate changes would be best performed using disaggregated data on investment by sector to capture the potential differential effects of tax rates on investment levels in different sectors (see Mintz, 1996). However, since our principal objective is to identify the channels through which tax rates affect the growth rate, we have focused on aggregate private investment. Furthermore, as Mintz, 1996, and Chen and Mintz, 2003, explained, the marginal effective tax rate (METR) includes not only the statutory tax rate, but also provisions for tax credits and deduction of relevant expenses. Thus, the METR, which incorporates all of these factors, is a better measure of the impact of corporate taxes on investment. Nevertheless, due to lack of data for most of the sample period, we used the statutory corporate income tax rate.[17]

16 Mintz, 1996, also provided a survey of the literature on the effects of corporate taxation on investment.

17 Chen and Mintz, 2006 developed a combined federal/provincial effective corporate tax rate on capital for the period 1997 to 2006. However, for our panel data analysis, the data set does not provide enough observations for estimation.

Table 4: Investment Regressions, 1977-2006
Dependent variable: average private investment to GDP ratio

Estimation method	OLS	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)
Constant	0.94**	1.45***	1.42***	1.33***	1.30***
	(2.15)	(3.68)	(3.54)	(2.76)	(2.76)
Corporate marginal tax rate	-0.509**	-0.568**	-0.576**	-0.687**	-0.537*
	(-1.97)	(-2.40)	(-2.42)	(-2.27)	(-1.67)
Top Personal marginal tax rate	-0.517***	-0.581***	-0.596***	-0.844***	-0.710***
	(-2.77)	(-3.35)	(-3.55)	(-3.40)	(-2.77)
Log of initial GDP per capita	-0.04	-0.09***	-0.09***	-0.075***	-0.078**
	(-1.26)	(-2.67)	(-2.63)	(-1.97)	(-2.10)
Population growth rate	-0.84	-1.17	-1.13	-1.08	-0.64
	(-0.92)	(-1.51)	(-1.45)	(-1.28)	(-0.60)
Export price growth rate	0.15	0.16**	0.15**	0.15**	0.12
	(1.61)	(2.01)	(2.02)	(2.00)	(1.45)
US growth rate	-0.53	-0.79			
	(-0.38)	(-0.61)			
Government expenditure to GDP ratio	-0.40*	-0.56***	-0.56***	-0.44**	-0.40*
	(-1.77)	(-2.89)	(-2.86)	(-2.03)	(-1.76)
Observations	60	60	60	60	50
Adj.R-Squared	0.26	0.24	0.25	0.25	0.10

The figures in parentheses are t-ratios calculated from robust standard errors.
*, **, and *** show that coefficients are significant at 10%, 5%, and 1% significance levels respectively.

The investment regression equation is specified as:

$$INV_{it}=\beta_0+\beta_1 ln\ y_{it-1}+\beta_2 CIT_{it}+ \beta_3 PIT_{it} + \beta_4 POP_{it}+\beta_5 US_t+\beta_6 TOT_{it}+ \beta_7 GOV_{it} + \eta_i + \lambda_t + \varepsilon_{it} \quad (2)$$

where *INV* is private investment to GDP ratio, and the other variables are as defined before. The dependent variable is the ratio of average gross private investment to GDP over the five year periods 1977 to 1981, 1982 to 1986, 1987 to 1991, 1992 to 1996, 1997 to 2001, and 2002 to 2006. Basically, we used the same model as the growth regressions of the previous section except that now the dependent variable is the investment to GDP ratio. The estimated coefficients from the above regression show the indirect effects of tax rates on the growth rate through their impact on the level of investment. The direct effects of tax rates on growth through the productivity channel are shown through the growth regressions that control for investment.[18] The results of the investment regressions are shown in table 4.

18 For a similar approach of isolating direct and indirect effects on growth, see Knight, *et al.*, 1996. For a theoretical explanation of why tax rates may affect growth with or without controlling investment, see Easterly *et al.*, 1992.

The empirical results indicate that, as expected, the tax rates have a negative and statistically significant relationship with investment. The baseline OLS estimates of the investment equation are given in column 1. All the fiscal policy variables are statistically significant with their expected signs. In column 2, we treated the initial GDP per capita as an endogenous variable and we used a one period lagged value of the variable as an instrument. Now only the US growth rate is insignificant, and this variable does not seem to add any explanatory power to the model. Thus, in column 3, we dropped this variable from our estimation and now all the variables are significant with their respective expected signs. It indicates that a 10 percentage point reduction in the corporate marginal tax rate is associated with a 5.76 percentage point increase in the ratio of private investment to GDP. Similarly, a 10 percentage point cut in the top personal income tax rate is related to a 5.96 percentage point rise in the ratio of private investment to GDP. Thus, the investment regression results show that the negative relationship between the tax rates and growth rate, which we have found previously, works through the investment channel, i.e., that investment is one of the transmission channels in the tax-growth link.

In column 4, we also treated the tax rates as endogenous variables using lagged values of the variables as instruments. Again, the tax rates have the expected negative sign and are statistically significant. The numerical magnitudes, however, are relatively higher. Finally, in column 5, we re-estimated the investment model over the period 1977 to 2001 to focus on the period before the tax reform in British Columbia. This is our preferred investment regression and will be used later in the last section. The estimated result is generally similar to the ones we obtained previously. The point estimates of the tax rates are slightly lower now. Moreover, the export price growth rate is insignificant. In summary, our analysis of Canadian provincial growth rates indicates that corporate and personal income tax cuts encourage private investment and thus spur provincial economic growth.

Tax rates and tax revenue

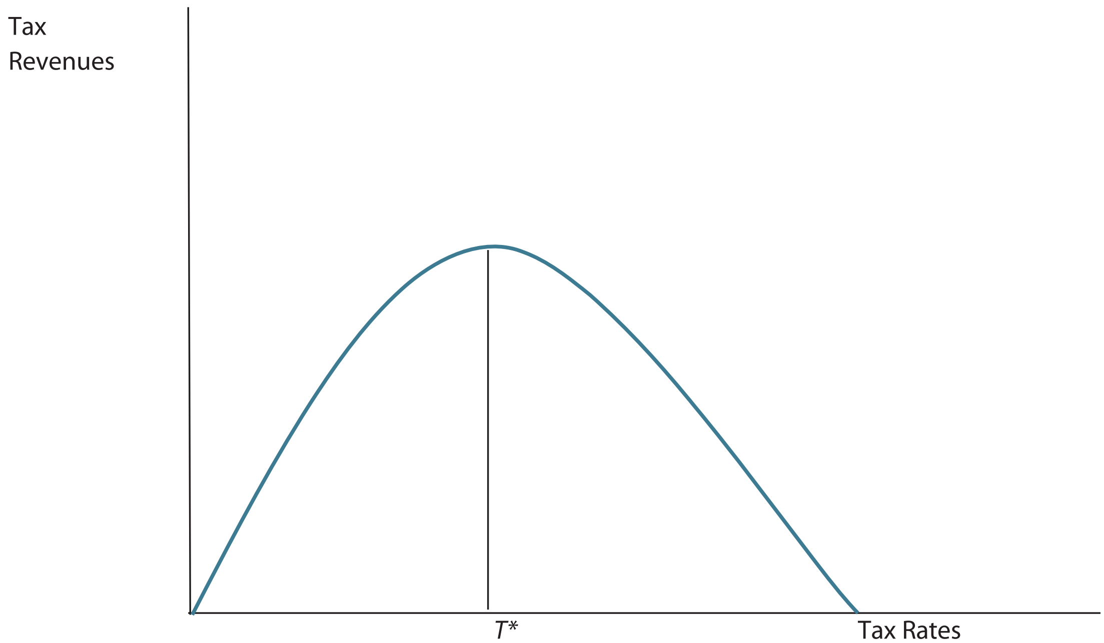
The amount of tax revenue that a provincial government collects depends on both its tax rates and its tax bases. In particular, the effects of tax rate changes on governments' tax receipts depend on how responsive the tax base is to a change in the tax rate. When governments cut tax rates, tax revenue may increase, decrease, or remain constant depending on the tax rate elasticity of the tax base.[19] In this section, we explore the relationship between tax rates and tax revenue. We begin by estimating the impacts of statutory corporate and top personal income tax rates on corporate tax revenue and personal income tax revenue, respectively. We then turn to an analysis of the effects of various tax rates on total provincial tax revenue.

Corporate tax revenue regressions

Corporations can easily move their profits across jurisdictions in response to changes in profitability and tax incentives. As a result, jurisdictions may compete over tax rates to attract business investment, which helps increase economic activities and expand employment opportunities in their respective

19 See, for example, Gruber and Saez, 2002, and the references contained therein for studies of the elasticity of taxable income with respect to the marginal income tax rates in the United States.

Figure 4: Corporate Tax Rates and Corporate Tax Revenues



jurisdiction. The effect of corporate tax rates on corporate tax revenues has attracted a lot of attention recently (see, for example, Klassen and Shackelford, 1998; Jog and Tang, 2001; Auerbach, 2007; Devereux and Klemm, 2004; Devereux, 2006; and Clausing, 2007). Thus, in this section, we focus specifically on the impact of the corporate income tax (CIT) rate on corporate tax revenue.

As discussed in Klassen and Shackelford, 1998; Devereux, 2006; and Clausing, 2007, corporate tax rates may have a non-linear effect on corporate tax revenue. When the corporate tax rate is low, it is likely that an increase in the CIT rate will increase corporate tax revenue. However, when the corporate tax rate exceeds some critical value, corporations will have a strong incentive to shift their profits to other jurisdictions. The possibility of profit-shifting, tax avoidance, and reduced incentives to invest at a higher corporate tax rate can result in lower corporate tax revenue when the CIT rate is above the critical value. In other words, the Laffer curve for corporate income tax revenue may have a negatively sloped section beyond some critical value such as τ^* (see figure 4). Tax rate increases beyond τ^* will reduce CIT revenues because of the decline in the CIT base.

Thus, to investigate the relationship between corporate tax rates and corporate tax revenue, we assume that the tax revenue takes the following exponential function form:

$$R = X^{a}\left(\tau^{\alpha} \cdot e^{\beta \cdot \tau^{\gamma}}\right) \quad (3a)$$

Log-linearizing the above, we obtain an equivalent expression as:

$$ln\ (R) = a.\ ln\ (X) + \alpha.\ ln\ (\tau) + \beta.\ \tau^{\gamma} \quad (3b)$$

Table 5: Corporate Tax Revenue Regressions, 1972-2006
Dependent variable: ln (corporate tax revenue) = ln (T_{it})

Estimation method	**OLS** (1)	**IV** (2)	**IV** (3)	**IV** (4)	**IV** (5)
Ln (GDP_{it})	1.094***	1.093***	1.110***	1.040***	1.109***
	(0.010)	(0.010)	(0.010)	(0.015)	(0.010)
Ln(CIT)	0.303***	0.297***	4.140***	3.711***	2.346***
	(0.112)	(0.114)	(0.437)	(0.506)	(0.256)
Corporate tax rate (CIT)			-32.92***	-27.285***	
			(3.785)	(4.444)	
Corporate tax rate squared (CIT^2)					-71.091***
					(8.79)
Other provinces CIT rate				3.515*	
				(2.028)	
Federal CIT rate				-1.067*	
				(0.634)	
Unemployment rate				-0.025***	
				(0.005)	
US corporate tax rate				0.010	
				(0.635)	
SYS				0.238***	
				(0.05)	
Constant	-5.266***	-5.27***	6.802***	5.532***	0.080
	(0.262)	(0.262)	(1.380)	(1.617)	(0.671)
Revenue maximizing tax rate (%)			12.58***	13.60***	12.84***
			(0.002)	(0.005)	(0.002)
Observations	350	340	340	340	340
Adj.R-Squared	0.96	0.96	0.97	0.97	0.97

Significance levels are indicated by * for 10%, ** for 5%, and *** for 1%. Robust standard errors in parentheses.

where R is the tax revenue, X is an exogenous variable that affects the tax base, τ is the tax rate. We appended an error term and estimated equation (3b). Devereux, 2006, provided a theoretical explanation and estimated this form of regression equation for the corporate tax but with $\gamma = 1$. We experimented with different values of γ. We use the general statutory corporate tax rate in each province.[20] If there is a Laffer curve-like relationship between the corporate tax rate and corporate tax revenue, as in figure 4, we expect α. to be positive and β to be negative. From equation 3b, if the coefficients have the

20 For Quebec we use the corporate tax rate that is applicable to "eligible business income" rather than the higher rate that is applicable to non-active corporate income. However, the result does not change much if one uses the highest rate that is applicable for the non-active income.

expected sign, the implied revenue-maximizing corporate tax rate can be calculated as $\tau_{max} = \left(\frac{\alpha}{-\beta\gamma} \right)^{\frac{1}{\gamma}}$.

Table 5 shows the results of the corporate tax revenue regressions on the tax rate and other control variables. We first run a regression of the log of corporate tax revenue on the log of corporate tax rate and GDP.

Column 1 shows that as expected, the coefficients of the corporate tax rate and GDP are significant. In column 1, we treated the corporate tax rate and GDP as exogenous; however, these variables may be endogenous and in this case the coefficient estimates will be biased. For example, provinces that have difficulty raising revenue may impose higher rates, leading to a spurious negative relationship between tax rates and tax revenues. To account for the possible endogeniety of tax rates and GDP, we used an IV estimation method treating the tax rate and GDP as endogenous variables. We used the one-period lagged values of the variables as instruments. As indicated in column 2, the variables are still significant with their expected signs.

So far, we have assumed that $\gamma = 0$ and examined the simple linear relationship between corporate tax rate and tax revenue. However, as the previous empirical studies by Klassen and Shackelford, 1998; Devereux, 2006; and Clausing, 2007, have shown, the relationship between the corporate tax rate and tax revenue may be non-linear. To explore this possibility, we estimate equation 3b with $\gamma = 1$ as in Devereux, 2006. The regression results reported in column 3 indicate that there is a non-linear relationship between the corporate tax rate and tax revenue. The implied revenue maximizing tax rate is 12.58 percent. This shows that a reduction in the provincial CIT rate will result in lower or higher provincial corporate income tax revenue depending on whether the initial tax rate is below or above 12.58 percent.

Since capital is mobile, CIT revenues depend not only on a government's tax rate but also on the tax rates charged by other governments (Devereux, 2006). Furthermore, sub-national governments' tax revenues generally depend not only on the tax rates prevailing in the jurisdiction, but also on the tax rates imposed at the national level by the federal government and other provinces.[21] That is, we need to take into account the possibility of vertical and horizontal fiscal externality (see Dahlby, 1996; 2000a, on the horizontal and vertical tax externalities in federations). To capture the effect of vertical externalities explicitly, we include the federal statutory corporate income tax rate as an explanatory variable. A higher federal statutory corporate tax rate may reduce the corporate tax base for the provinces and thereby adversely affect provincial CIT revenues. Thus we expect the coefficient of the federal tax rate to be negative.

One notable feature of businesses operating in multi-jurisdiction environments is that they tend to shift their income across jurisdictions in response to any difference in tax rates and incentives among the different provinces. For example, using data from Canadian provinces and US states, Klassen and Shackelford, 1998, found evidence that firms shift their income to those jurisdictions with favourable corporate tax rates. Mintz and Smart, 2004, also showed that firms operating in different provinces can shift their income through various tax planning strategies. As the authors indicated, the effects of such

21 See also Hayashi and Boadway, 2001, on the relationship between federal and provincial tax rates.

income shifting on government tax revenue and elasticities depend on the corporate allocation formula.[22] Their analysis suggests that the response of taxable income (and hence government revenue) to provincial tax rate changes is lower for companies that allocate income compared to similar companies that do not.

Thus, the amount of corporate tax revenue that a province can collect is influenced by other provinces' tax rates due to the potential benefit of profit-shifting across jurisdictions by corporations. Since we did not have data to separate the effects of tax rates on tax revenue based on business size and the allocation formula, we used total provincial corporate tax revenue (see Mintz and Smart, 2004, for different elasticities for businesses that differ in size and corporate allocation formulas). In order to capture the possible effects of a horizontal fiscal externality, we included as an additional variable the weighted average corporate tax rate of other provinces, weighted by the GDP of the provinces. We use this variable to account for the incentive to shift profits across provinces. If a province has a high corporate tax rate (relative to other provinces), other things remaining constant, then firms will have an incentive to shift their income to low tax jurisdictions. That is, an increase in the corporate tax rates of other provinces should have a positive impact on a specific province's corporate tax revenue. Thus, if there is evidence of a horizontal fiscal externality, we expect the coefficient of the "tax rate of other provinces" to be positive.

The literature on corporate taxation also shows that corporate tax revenue responds to differences in tax rates across countries. Thus, in an open economy such as Canada's, profit shifting would be done not only across provinces but also internationally. The incentives to shift profits across countries for the most part depend on combined federal and provincial statutory rates. Since we are interested in the possibility of profit shifting across provinces we need to include federal and foreign statutory CIT rates as control variables. For Canada, the largest share of its foreign direct investment inflow and outflow is with the US. Thus, the US corporate tax rate may have a direct impact on Canadian provinces' corporate tax revenue (see, for instance, Jog and Tang, 2001), and in our estimation we must include it. An increase in the US corporate tax rate encourages capital inflow into Canada and increases Canadian corporate tax revenue. So we expect the US tax rate to be positive. Furthermore, in the Canadian tax system, Alberta, Quebec, and Ontario administer their own corporate taxes, while the federal government collects corporate income taxes on behalf of other provinces. In our estimation, we capture these differences in the corporate tax collection system among the provinces by including a dummy variable (*SYS)* that takes a value of one for Alberta, Quebec, and Ontario, and zero otherwise.

Column 4 shows the regression result of the corporate tax revenue on the corporate tax rate, controlling for the federal corporate tax rate, the weighted average corporate tax rate of other provinces, the US corporate tax rate, and a dummy variable that reflects differences in the corporate tax collection system in the Canadian provinces. As expected, the coefficient of the federal tax rate is negative and significant, providing empirical support for the hypothesis of a negative vertical tax externality between the federal government and the provinces. Similarly, there is evidence of horizontal tax externality as indicated by a positive and significant coefficient of the tax rate of other provinces. Moreover, the regression result also suggests that indeed, provincial corporate tax rates do affect cor-

22 If a corporation operates in more than one province, the allocation of its taxable income among the provinces is conducted based on a statutory allocation formula (see, for example, Mintz and Smart, 2004, for the details).

porate tax revenue non-linearly. The implied CIT revenue-maximizing tax rate is 13.60 percent, and it is statistically significant. This result is comparable to the 11 percent revenue maximizing corporate tax rate that Klassen and Shackelford, 1998, obtained for Canadian provinces and US states. For a sample of OECD countries, including Canada, Mintz, 2007, also found that the tax revenue-maximizing corporate tax rate is 28 percent. Over the sample period 1972 to 2006, the average top statutory corporate tax rate was about 13.90 percent. Thus, the implied revenue maximizing corporate tax rate is slightly below the average value.

In BC, the statutory corporate tax rate was 16.5 percent in 2001 before the introduction of the tax reform. The tax reform reduced the corporate tax rate from 16.5 percent to 13.5 percent in 2002; it was then further reduced to 12 percent in 2005. The new rate is slightly below the implied CIT revenue-maximizing rate obtained from the coefficient estimates in column 5. Thus, other things remaining constant, we expect that a further reduction in the corporate tax rate will reduce the corporate tax revenue slightly.

To check the robustness of the relationship between corporate tax rates and revenue further, we also estimated equation 3b with $\gamma = 2$ in column 5. The coefficients of the tax rates are once again statistically significant, with a slightly lower implied revenue-maximizing tax rate. We also employed an alternative quadratic specification similar to the one used in Klassen and Shackelford, 1998; Clausing, 2007; and Devereux, 2006. We ran a regression of the ratio of corporate tax revenue to GDP on the corporate tax rate, its square, and other conditioning variables. The results are reported in Appendix 2. The results also support the hypothesis that the corporate tax rate affects corporate tax revenue non-linearly. In sum, the non-linear relationship between the provincial CIT rates and CIT revenues is quite robust to the estimation method and the conditioning variables used.

Personal income tax revenue regressions

To investigate the impact of personal income tax rates on personal income tax revenue, we assume an exponential revenue function, as in the previous section. Specifically, we ran a regression of the logarithm of personal income tax revenue on the top personal income tax rate and other conditioning variables. The estimation results are reported in table 6.

Column 1 shows the OLS estimation results of personal income tax revenue on the tax rate and GDP. Both the tax rate and GDP are positive and significant. The results indicate that an increase in GDP and the top personal income tax rate increase personal income tax revenue. One may expect the top personal income tax rate to affect revenues non-linearly. We check for the possible existence of a non-linear relationship between the income tax rate and tax revenue in column 2. The result suggests that there is a non-linear relationship between the top personal income tax rate and the personal income tax revenue.[23]

23 However, in subsequent regressions, the non-linear relationship between personal income tax revenue and the top marginal tax rate disappeared, indicating that the non-linear association is not robust to the inclusion of other control variables and estimation methods.

Table 6: Personal Income Tax Revenue and Tax Rate, 1972- 2006
Dependent variable: log of personal income tax revenue

	OLS (1)	OLS (2)	OLS (3)	IV (4)	IV (5)
Log of PIT rate	0.826*** (0.057)	1.504*** (0.305)	0.830** (0.037)	0.854*** (0.041)	0.899*** (0.056)
PIT rate		-3.450** (1.46)			
Other provinces PIT rate			-0.581 (0.40)		
Federal PIT rate			-3.190*** (0.148)	-3.193*** (0.142)	-2.737*** (0.213)
Dummy88					0.076*** (0.024)
Log of GDP	1.082*** (0.008)	1.087*** (0.008)	1.009*** (0.005)	1.006*** (0.004)	1.008*** (0.004)
Constant	-2.696*** (0.104)	-0.954*** (0.762)	-0.759*** (0.118)	-0.806*** (0.108)	-0.940*** (0.109)
Observations	350	350	350	340	340
Adj.R-Squared	0.979	0.979	0.993	0.993	0.993

Significance levels are indicated by * for 10%, ** for 5%, and *** for 1%. Robust, standard errors in parentheses.

In column 3, we included the federal top marginal income tax rate and the weighted average, weighted by the provinces' GDP, and the top personal income tax rate of other provinces to check for possible vertical and horizontal tax externality. We expect the coefficient of the federal income tax rate to be negative and other provinces' income tax rates to be positive. The estimation results show that, as expected, the federal income tax rate is negative and significant. However, the average of other the provinces' personal income tax rates has the unexpected sign and is statistically insignificant. Consequently, we dropped this variable in our subsequent estimations. The same result continues to hold in column 4 when we treat the personal income tax rate and GDP as endogenous variables using their respective one-period lagged values as instruments.

In Canada, tax reforms at both the provincial and federal levels are quite common. However, as Sillamaa and Veall, 2001, have correctly noted, the personal income tax reform of 1988 was quite extensive. Since such a reform may have a direct impact on provincial personal income tax revenue, we capture the effect of this reform by using a dummy variable that equals 1 from 1988 onwards and zero otherwise. The regression results are reported in column 5. The dummy variable is positive and significant, suggesting that the base-broadening tax reform of 1988 increased provincial personal income tax receipts. All the other variables have the expected signs and are statistically significant. The upshot of our estimation result is that reducing the top personal income tax rate reduces personal income tax revenue.[24] In addition, as in the case of corporate taxation, we find empirical evidence that is consistent with negative vertical tax externalities.

Total tax revenue regressions

We now turn to examining the impact of tax rate changes on total government tax revenue. The total tax revenue regression takes the following log-linear form:

$$ln\,(TR_{it}) = \theta_1 + \theta_2\, ln\,(GDP_{it}) + \theta_3 ln\,(CIT_{it}) + \theta_4\, ln\,(PIT_{it}) + \theta_5\, ln\,(PST_{it}) + \beta' X + u_{it} \quad (4)$$

where *TR* is total tax revenue (which is obtained as the sum of income, consumption, property and related, and other tax revenues), *GDP* is provincial Gross Domestic Product, *CIT* is provincial statutory corporate tax rate, *PIT* is provincial top marginal income tax rate, *PST* is provincial sales tax rate, and *X* is a vector of other variables, u_{it} is the error term. We expect the coefficients of the tax rates and GDP all to be positive. The coefficients of the tax rates indicate the elasticity of total tax revenue with respect to the various tax rates. Thus, the above log-linear regression specification allows us to estimate the tax revenue elasticities directly. Due to this advantage, such empirical specification is common in the literature (see, for instance, Friedlaender *et al.*, 1973; Hsing, 1996; and Devereux, 2006).

Our regression results of total tax revenue on tax rates and various control variables are reported in table 7.

Column 1 reports the basic OLS estimates of the regression of the log of total provincial tax revenue on just the province's tax rates, based on annual data for the 10 provinces from 1972 to 2006. The coefficients for all three tax rates are positive and highly significant, suggesting that tax rate cuts reduce total tax revenue. In order to see whether the tax rates have a non-linear effect on tax revenue, we also experimented by including the level of tax rates. However, these variables were insignificant and dropped from the regression.

The tax revenues that a provincial government generates also depend on the tax policies of other provinces and on federal tax policies. Due to the relatively free mobility of capital across jurisdictions, a tax rate increase in one province can affect the amount of tax revenue in another province, creating a horizontal tax externality. To check for the possibility of horizontal and vertical tax externalities in corporate taxation, we included both the federal corporate income tax rate and the provincial tax rates in the revenue regressions. We expect the coefficient of the federal tax rate to be negative due to the possibility of a vertical fiscal externality. To capture the effect of tax rates in other provinces, we included the weighted average of corporate income tax rates in other provinces, weighted by the GDP of the provinces. For the reasons explained above, we expect the coefficient on the tax rate of other provinces' to

24 This is essentially a static revenue effect of the top personal income tax rate. Since this revenue estimation does not take into account the effect of a lower top personal income tax rate on GDP and the relevant tax base, the predicted fall in personal income tax revenue following a cut in top personal income tax rate may be overstated.

Table 7: Total Tax Revenue Regressions, 1972-2006
Dependent variable: Natural logarithm of total tax revenue[a]

Estimation method	**(1)** OLS	**(2)** IV	**(3)** IV	**(4)** IV	**(5)** IV
Constant	-3.90***	-4.62***	-3.04***	-2.75***	-2.76***
	(0.128)	(0.332)	(0.386)	(0.356)	(0.356)
Ln (GDP)	1.052***	1.035***	1.022***	1.012***	1.012***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln (CIT)	0.072**	0.058**	0.040*	0.042*	0.042*
	(0.031)	(0.026)	(0.023)	(0.024)	(0.023)
ln (PIT)	0.253***	0.256***	0.252***	0.264***	0.270***
	(0.038)	(0.050)	(0.046)	(0.043)	(0.042)
ln (sales tax rate)[b]	0.224***	0.210***	0.195***	0.206***	0.205***
	(0.015)	(0.014)	(0.013)	(0.013)	(0.012)
Ln(other provinces CIT)		0.729***	0.394***	0.397***	0.402***
		(0.087)	(0.102)	(0.095)	(0.096)
Ln(Federal CIT)		-0.268***	-0.041	0.026	
		(0.048)	(0.051)	(0.052)	
ln (Federal PIT)			-0.365***	-0.484***	-0.465***
			(0.052)	(0.060)	(0.043)
Unemployment rate				-0.008***	-0.008***
				(0.002)	(0.002)
Observations	350	340	340	340	340
Adj.R-Squared	0.99	0.996	0.997	0.997	0.997

Robust standard errors in parentheses.
Significance levels are indicated by * for 10%, ** for 5%, and *** for 1%.
[a]Total tax revenue is the sum of income, consumption, property and related, and other tax revenue.
[b]This variable is defined as *ln* (variable + 1).

be positive. We also treated GDP and the CIT and PIT rates as endogenous using their respective one period lagged values as instruments.

These results are reported in column 2. As expected, the federal corporate income tax rate is negative and statistically significant, consistent with other empirical studies indicating vertical tax externalities in a federation. The coefficient of the CIT rate in other provinces is positive and statistically significant, consistent with the presence of a horizontal fiscal externality. We also included the personal income tax rates in other provinces from other regressions that are not shown. However, this variable was insignificant and therefore we dropped it from our estimation. In summary, the regression results in column 2 lend strong empirical support to the notion that there are significant vertical and horizontal corporate income tax externalities in the Canadian federation.

In column 3 we included the federal top PIT rate. Now the federal CIT rate becomes insignificant while the federal PIT rate is statistically significant with the expected negative sign. The estimated results are, however, quite robust for all the other variables. To capture the effects of the business cycle on tax receipts, in column 4 we also include the provincial unemployment rate as an additional control variable. Again, all the coefficients with the exception of the federal CIT rate are statistically significant. The point estimates of the coefficients of the tax rates show that the personal income tax rate has the highest impact on tax revenue, followed by the sales tax rate. Note also that since we use the top personal income tax rate, the regression result overestimates the impact of personal tax rates on total tax revenue.

Finally, we dropped the insignificant federal CIT rate and re-estimated the model. The regression results are reported in column 5. All the variables maintain their expected signs and are statistically significant. Note in particular that the coefficient estimates of the PIT rate, CIT rate, and sales rate did not change much after the exclusion of the federal PIT rate.

4. Simulating the Effects of the 2001 BC Tax Cuts on Growth and Output

Our econometric results indicate that higher CIT rates are associated with lower investment and slower growth rates. Lower PIT rates are also associated with higher investment, which also leads to faster growth. One implication of these results is that a pro-growth fiscal policy may involve a reduction in the tax rates to raise the level of investment and spur growth. In this section, we attempt to gauge the magnitude of the growth effects of the CIT and PIT rate cuts in BC in 2001 based on the econometric estimates in tables 3 and 4.

We have seen that tax rates affect growth directly through higher productivity and indirectly through higher investment. Thus, in order to capture these direct and indirect effects of tax rate cuts on growth, we will use both the growth and investment regression results. More specifically, we will use the point estimates of our preferred growth regression from column 8 of table 3 and the investment regression from column 5 of table 4.

The growth effects of the CIT rate cut

Let α_{CIT}, and α_{INV} denote the coefficients of the corporate tax rate and investment in the growth regression, and let β_{CIT} and β_Y denote the coefficients of the corporate tax rate and log of the initial GDP per capita in the investment regression. The impact of a change in the statutory corporate marginal tax rate on the growth rate *j* years after the tax cut, g_{t+j}, can be calculated as:[25]

$$\Delta g_{t+j} = \left(1+\alpha_Y + \alpha_{INV} + \beta_Y\right)^j \left[\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right]\Delta CIT \qquad (5)$$

The expression in square brackets indicates how a change in the CIT rate directly affects the current growth rate (α_{CIT}) and indirectly affects it through its effect on the investment rate ($\alpha_{INV}\beta_{CIT}$). The expression in the round brackets indicates that the effect of the tax rate change diminishes over time because $0 < 1 + \alpha_Y + \alpha_{INV}\beta_Y < 1$. In other words, the growth impact of the CIT rate cut diminishes over time because of the conditional convergence effect. Recall that our model has the characteristic of the neo-classical growth model that fiscal policy only has a temporary effect on the growth rate, although (as we will see) the "temporary" effect occurs over a very long period of time.

Our computations are based on the values of the coefficients in column 8 of table 3 and column 5 of table 4, assuming a 4.5 percentage point reduction in the CIT rate. It was assumed that, in the absence of the CIT cut, the BC economy would grow at an average annual rate of 1.275 percent.[26] The solid line in figure 5 shows the simulated growth rate with the 2001 CIT rate cut, compared to the base line growth rate of 1.275 percent, the dashed line. Given our parameter estimates, it takes almost 100 years

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25 See Appendix 3 for the derivation of this equation.

26 This is BC's average real per capita GDP growth rate over the period 1997 to 2001, the five-year period prior to the tax cut. In Appendix 5, we experiment with alternative baseline growth rates.

Figure 5: The Effect of the CIT Rate Cut on the Economic Growth Rate

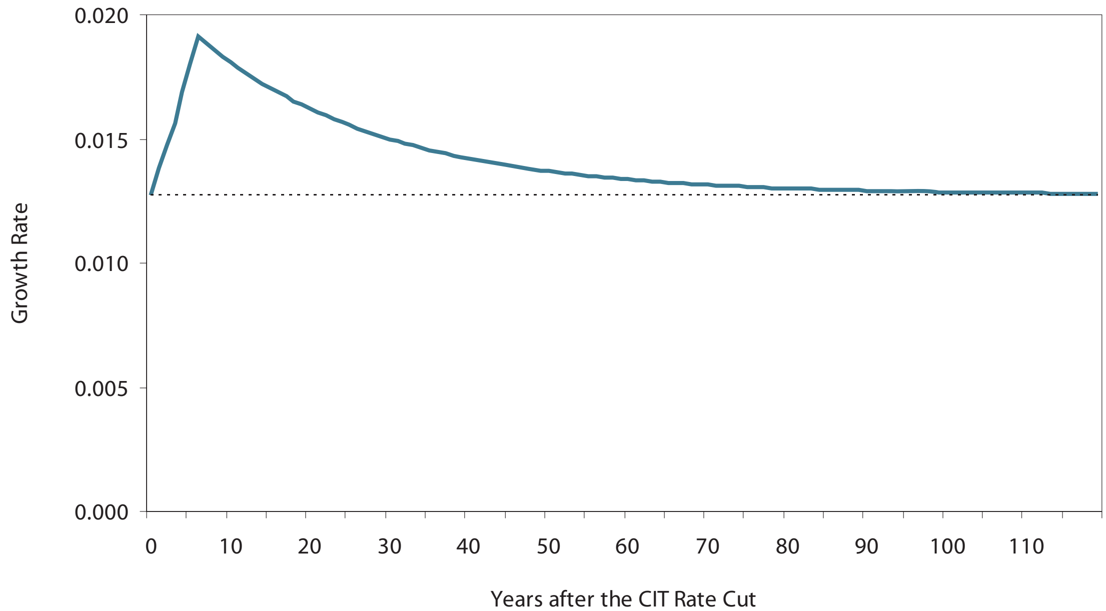
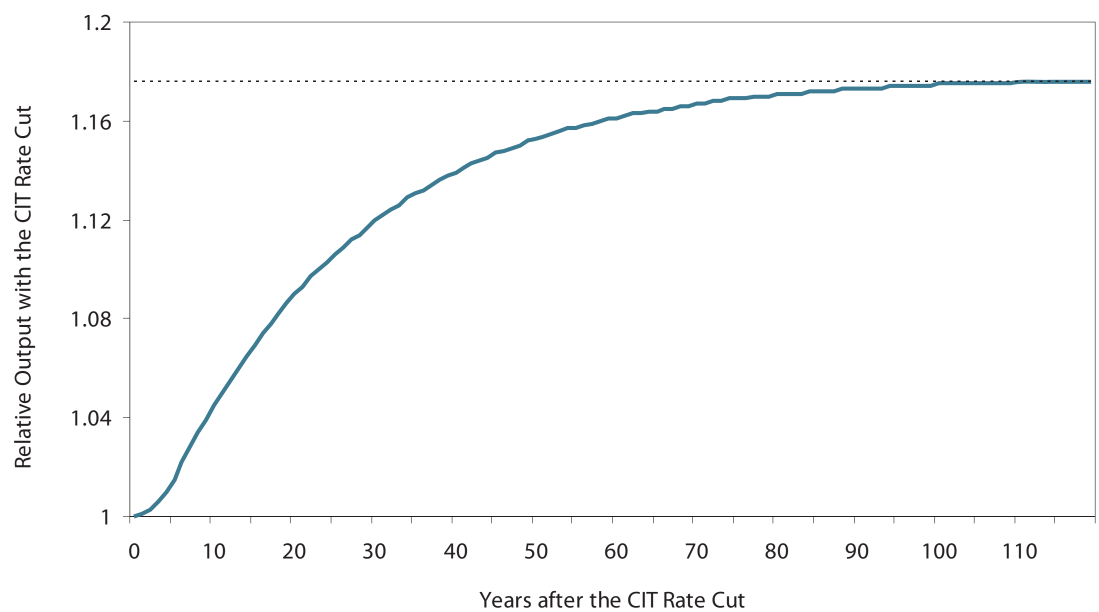
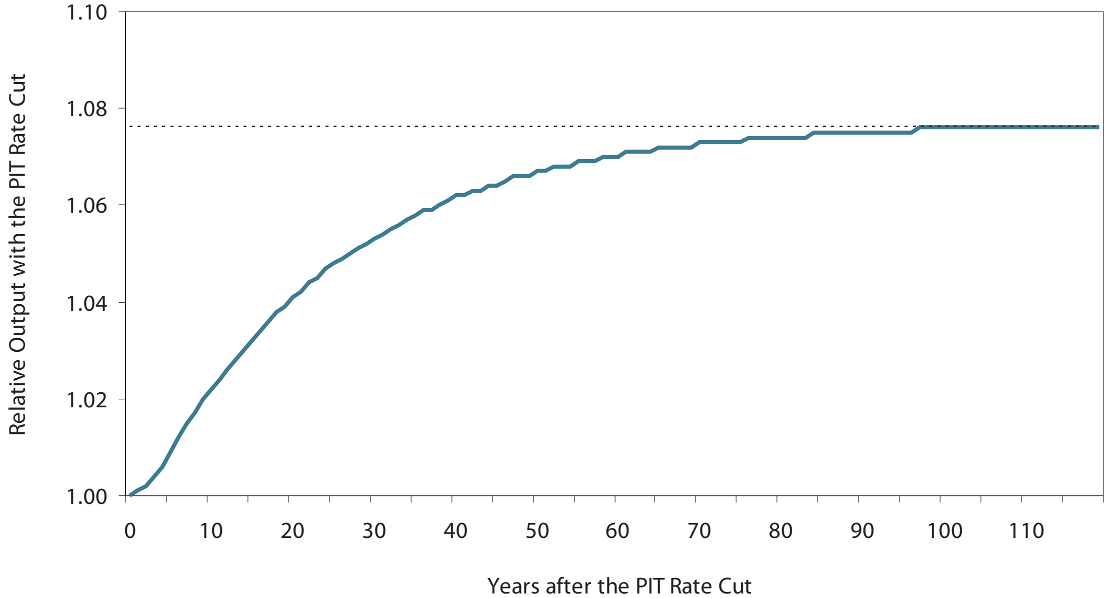


Figure 6: Relative Output with the CIT Rate Cut



for the economy to return to the base line growth rate. Therefore, the growth rate effect of the tax cut is temporary, but long-lasting. Figure 6 shows the output with the CIT rate cut relative to the no-tax-cut output at the 120-year horizon. Our model indicates that in the long run, per capita output would be 17.6 percent higher with the 4.5 percentage point CIT rate cut. The model can be similarly used to get some idea about the effect of the tax rate during the transitional period. For example, in 10 years the per capita output would be about 4 percent higher as a result of the CIT rate cut.

Figure 7: Relative Output with the PIT Rate Cut



Of course, we have to wait a long time to receive some of this increased output. Therefore, a better measure of the effect on total output is the increase in the present value of per capita output that occurs with a CIT rate change. In particular, we can calculate the elasticity of the present value of per capita output with respect to the CIT rate. This elasticity, γ_{CIT}, indicates the percentage reduction in the present value of output from a one percent increase in the CIT rate. Of course, the present value of the increased output depends on the discount rate that is used to calculate the present value of a future income stream, and there is a lot of controversy concerning the appropriate public sector discount rate. Therefore, we have calculated the γ_{CIT} with a low discount rate of 4.0 percent and a high discount rate of 10.0 percent. See Appendix 5 for a sensitivity analysis. For the low discount rate, γ_{CIT} = -0.351 and with the high discount rate, γ_{CIT} = -0.166. These parameters measure, in present value terms, the long-run impact of the CIT rate changes. For example, the $\tilde{a}_{CIT}$ based on the high discount rate implies that a 10 percent reduction in the CIT rate will increase the present value of per capita output by 1.7 percent. The γ parameter is the best way of expressing the long-run output effect of a tax rate change, and as we will show in section 5, it plays an important role in the calculation of the long-run marginal cost of public funds.

The growth effects of the PIT rate cut

We have used a similar procedure to calculate the effects of the 5 percentage point reduction in the PIT rate in BC. Our computations for the PIT rate cut were also based on the values of the coefficients in column 8 of table 3 and column 5 of table 4. Note, however, that α_{PIT} is zero, and that the PIT cut only affects the growth rate through its effect on investment. The solid line in figure 7 shows simulated relative output with the PIT rate cut compared to the output with the base line growth rate of 1.275. Our model indicates that per capita output would be 7.6 percent higher in the long run with the 5 percentage point PIT rate cut.[27] With a 4.0 percent discount rate, γ_{PIT} = -0.169 and with a 10.0 percent discount rate, γ_{PIT} = -0.084. These parameters measure, in present value terms, the long-run impact of the PIT rate changes, and they indicate that the output effect of a CIT rate cut is about two times larger than the output effect of a PIT rate cut.

27 In 10 years, per capita output would be about 2 percent higher as a result of the PIT rate cut.

5. Calculating the Marginal Cost of Public Funds

The true cost of raising a tax rate to taxpayers is not just the direct cost of taxes (i.e., the additional revenue that it generates), but also the loss of output caused by changes in the economic decisions of taxpayers. The Marginal Cost of Public Funds (MCF) measures the loss created by the additional distortion in the allocation of resources when an additional dollar of tax revenue is raised through a tax rate increase. See Dahlby (forthcoming) for a detailed description of the MCF concept and its application in the analysis of tax policies.

In this section, we calculate the MCFs associated with the CIT rate, top PIT rate, and sales tax rate in BC. In Appendix 4, we show that the MCF can be calculated as:

$$MCF_{\tau} = \frac{S_{\tau}}{\rho_{\tau} + \gamma_{\tau}} \tag{6}$$

where S_τ is the share of total tax revenue generated by a tax at rate τ, ρ_τ is the elasticity of total tax revenue with respect to the tax rate τ, holding per capita output constant, and γ_τ is the elasticity of the present value of per capita output with respect to τ. Note in particular that ρ_τ depends on the elasticity of total tax revenue (and not just the responsiveness of the tax revenue generated by a particular tax) because we need to assess the effects of a tax increase on all of the tax bases in assessing the cost of raising revenue from any particular tax source. We will also distinguish between the short-term MCF, where we set $\gamma_\tau = 0$, from the long-run MCF where we include the growth rate effects that are reflected in the γ_τ parameter. Finally, note that if $\rho_\tau + \gamma_\tau < 0$, then the MCF_τ is not well defined because the government is on the negatively-sloped section of its present value revenue Laffer curve. If $\rho_\tau + \gamma_\tau < 0$, a tax rate reduction would increase the present value of the government's tax revenues. Under these circumstances, taxpayers would be better off if the tax rate were cut, and the government would have more revenue to cut other taxes or increase spending on public services. Finally, if the $MCF_\tau < 1$, then a tax increase will generate more revenues than the tax increase "costs" taxpayers. This could occur if, for example, an increase in one tax rate causes taxpayers to shift to other tax bases which generate more tax revenues. For example, a lump-sum tax in the presence of a distortionary wage tax will have an MCF that is less than one if leisure is a normal good, because the lump-sum tax will induce an increase in the supply of labour and an increase in wage tax revenues.

The results of our computations are reported in table 8. The shares of total tax revenues are the 1972 to 2006 averages for the CIT, PIT, and sales tax in BC. The values for ρ_τ are based on the parameter estimates in column 5 of table 7. The γ_τ parameters are based on the calculations of the growth effects of the tax rate changes in Section 4. The calculations indicate that the short-term MCFs for the PIT and the CIT are broadly similar to previous estimates of the MCFs for these taxes using simulation models (see Dahlby, 1996; Sillamaa and Veall, 2001; and Baylor and Beausejour, 2004). However, our computations indicate that the MCF for the PIT is lower than the MCF for the CIT. Our computations also indicate that the MCF for the sales tax is less than one, a result that could arise if a higher sales tax rate leads to increased labour supply.

Since our empirical analysis did not indicate that the sales tax affected the growth rate of the economy either directly or indirectly through the level of investment, the long-term MCF for the sales tax is the

Table 8: The MCFs for Corporate, Personal, and Sales Taxes in BC

	CIT	PIT	Sales Tax
Shares of Total Tax Revenues	0.0603	0.2797	0.1800
MCFs			
Short-Term ($\gamma_\tau = 0$)	1.436	1.036	0.878
Long-Term			
4.0 % Discount Rate	*	2.769	0.878
10.0 % Discount Rate	*	1.504	0.878

* = not applicable

same as the short-term MCF, 0.878. Incorporating the growth rate effects of the tax rate changes increases the MCF for the PIT from 1.036 to 1.504 with a 10 percent public sector discount rate to 2.769 with a 4 percent discount rate. These computations indicate that including the growth rate effects substantially raises our view of the MCF for a PIT. Our computations, therefore, support previous analyses which indicate that it is much more costly to raise revenue through a PIT rate increase than through a sales tax rate increase, and that there are potentially large efficiency gains if a province switches from an income tax to a sales tax (see McKenzie, 2000a; and Dahlby, 2000b).

When the growth rate effects of the CIT are included in the analysis, the MCF does not have a well-defined meaning because a CIT rate reduction would increase the present value of the government's tax revenues. A CIT rate cut would make taxpayers better off and the government would have more funds to spend on public services or cut other taxes. Therefore, our computations provide strong support for cutting corporate income tax rates. Unfortunately, our analysis does not indicate how low the optimal CIT rate for BC is, or indeed whether the optimal CIT rate is zero.

6. Conclusions

This paper examines the impact of tax rates on the economic growth rate using panel data from Canadian provinces over the period 1977 to 2006. Our empirical analysis indicates that higher CIT and PIT rates are associated with lower private investment and slower economic growth. The estimation results appear to be robust to changes in estimation methods and sample period. While the PIT rate affects growth through private investment, the CIT rate seems to influence growth through both private investment and productivity channels. Moreover, the CIT rate tends to have a stronger negative relationship with both private investment and the per capita growth rate. Our empirical estimates suggest that a 10 percentage point cut in the CIT rate is related to a 1 to 2 percentage point increase in the transitional growth rate.

The empirical results are then used to assess the impacts of BC's 2001 tax cuts on the province's output and growth rate. The results indicate that in the long run, with the CIT tax cut, BC's per capita GDP will be about 18 percent higher than it would be in the absence of the tax cut. Equivalently, at a discount rate of 10 percent, the present value of the output gain from the 2001 CIT rate cut is about 53 percent of current output. Qualitatively similar results are also found for the PIT cut, although the total impact of the PIT cut was smaller than the CIT cut. Thus, the small "temporary" increase in the per capita growth rate translates into a significant long run output gain for the province. An important implication of this is that Canadian provincial governments will see higher output and growth gains if they adopt pro-growth tax policies.

One concern that policy makers often voice about cutting tax rates is the implication of tax reform for government tax receipts. We have estimated the elasticities of total tax revenue with respect to CIT, top marginal PIT, and sales tax rates. We then use the results from the revenue regressions to calculate the marginal cost of funds for BC. We find that the marginal cost of funds from the PIT and CIT are higher than from the sales tax. In other words, raising revenue through the PIT or the CIT has a higher economic cost than through a sales tax. The study also found an interesting relationship between the corporate tax rate and tax revenues. Our results show that there is a Laffer curve-like relationship between the corporate tax rate and tax revenue. The implication of this is that there is a revenue-maximizing CIT rate beyond which a reduction in the tax rate increases CIT revenue. The simulation analysis conducted for BC also shows that the present value of total tax revenue actually increases when the CIT rate is cut.

Finally, an important contribution of this study is that it fills the gap in empirical literature on taxation and growth in Canada. The revenue estimations and the associated marginal cost of funds calculations included in the analysis also provide a good starting point for future empirical research on static and dynamic revenue effects of tax cuts. This paper can also be extended by using a similar methodology to investigate the effects of taxes on productivity and entrepreneurship in Canada.

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Appendix 1: Definitions of Variables and Data Sources

The data for the study come from various sources.

- Corporate Income tax rate (CIT) is the provincial statutory top marginal corporate income tax rate (general rate). It is obtained from the Canadian Tax Foundation and from *Finances of the Nation* (formerly *National Finances*), various issues.
- Top personal income tax rate (PIT) is the provincial income tax rate of the top income bracket. Source: *Finances of the Nation* (formerly *National Finances*), various issues.
- Sales tax rate is the provincial sales tax (PST). Source: *Finances of the Nation* (formerly *National Finances*), various issues.
- Various other tax revenues include corporate income tax revenue, personal income tax revenue, general sales tax revenue, consumption tax revenue, and other tax revenue. Source: Statistics Canada, *Public Finance Historical Data* 1965/66-1991/92, catalogue no. 68-512 (1972-1988) and *CANSIM* (1989-2006). Note that the tax revenue data are based on Financial Management Services (FMS) for the entire sample period. However, because of the 1997 historical revision by Statistics Canada, the two data series are not directly comparable. Statistics Canada had revised back to fiscal year 1988/1989. Thus, there is a break in the data in 1988. To make the two series comparable, the old FMS data series (unrevised, 1972 to 1988) were converted to new FMS series by multiplying the series by the ratio of the 1989 new series to 1989 old series. That is, the 1988 data on the old FMS basis were converted to the new FMS basis by multiplying the 1988 value on the old basis by the ratio of the 1989 value on the new basis and 1989 value on the old basis.[28]
- Government expenditure to GDP ratio is the total (local and provincial) government expenditures to GDP ratio. Source: Statistics Canada (CANSIM, table 385-0001)
- Gross Domestic Product (GDP) and total private investment in chained 1997 dollars. Sources: For 1981 to 2006, Statistics Canada (CANSIM, table 384-0013). For 1972 to 1980, The Fraser Institute.
- Nominal GDP is Gross Domestic Product (GDP) in current prices. Source: Statistics Canada (CANSIM, table 384-0014 for 1972 to 1988, and table 384-0001 for 1989 to 2006).
- Corporate profit denotes the before-tax total profit of the corporate sector. Source: Statistics Canada (CANSIM, table 384-0014 for 1972 to 1988, and table 384-0001 for 1989 to 2006).
- Population. Source: Statistics Canada (CANSIM, table 051-0001).
- Export price is the export price index of major exporting commodities. Export Paasche price index of major commodities (1992 = 100). For each province we take the export price of its major exporting commodity. That is, for Newfoundland (1997 to 2006) and Alberta, this is the price of crude petroleum; for Prince Edward Island, Newfoundland (1972 to 1996), and Nova Scotia, it is the price of fish; for Saskatchewan and Manitoba, it is the price of wheat; for British Columbia and New Brunswick it is the price of lumber; for Ontario it is the price of motor and motor parts; and for Quebec, it is the price of manufactured goods. Source: CANSIM (table 176-0006 and table 228-0044).
- US growth rate is obtained from US GDP (in chained 2000 dollars). Source: Statistics Canada, (CANSIM II, table 4510010).
- Provincial total unemployment rate: Source: For 1972 to 1975, CANSIM (table 384-0035); for 1976 to 2006, CANSIM (table 282-0002).

28 For a somewhat similar approach of dealing with a data break of this form, see Day and Winer, 2001.

Appendix 2: Corporate Tax Revenue Regressions (Quadratic Specification)

Table A1: Corporate Tax Revenue Regressions (Quadratic Specification), 1972-2006
Dependent variable: Corporate tax revenue to GDP ratio

Estimation method	**OLS**	**IV**	**IV**	**IV**	**IV**
	(1)	(2)	(3)	(4)	(5)
Constant	-0.005***	-0.004**	-0.010*	-0.002	-0.041***
	(-2.58)	(-2.36)	(-1.77)	(-0.97)	(-6.52)
Corporate tax rate	0.192***	0.192***	0.278***	0.101***	0.216***
	(6.52)	(6.08)	(5.07)	(2.76)	(6.99)
Corporate tax rate squared	-0.726***	-0.724***	-1.091***	-0.343**	-0.850***
	(-6.04)	(-5.61)	(-5.05)	(-2.28)	(-6.56)
Corporate profit/GDP				0.03***	
				(4.79)	
Other provinces CIT rate			0.03		
			(1.51)		
Federal CIT rate			-0.010***		
			(-3.56)		
Unemployment					-0.0002***
					(-4.19)
Ln(GDP per capita)					0.004***
					(6.69)
Revenue maximizing tax rate (%)	13.22***	13.23***	12.74***	14.78***	12.69***
	(34.64)	(33.93)	(53.50)	(10.69)	(49.05)
Observations	350	340	340	340	340
Adj.R-Squared	0.06	0.06	0.09	0.09	0.30

Notes
Significance levels are indicated by * for 10%, ** for 5%, and *** for 1%.
T-ratios based on robust standard errors in parentheses.

Appendix 3: Derivation of Equation 5

The growth equation that includes private investment is given as:

$$g_{it} = \Delta ln\ y_{it} = \alpha_Y ln\ y_{it-1} + \alpha_{CIT} CIT_{it} + \alpha_{PIT} PIT_{it} + \alpha_{INV} INV_t + other\ terms + \varepsilon_{it}, \quad (3.1)$$

where $\Delta ln\ y_{it}$ is the per capita GDP growth rate, *ln* denotes natural logarithm, y_{it} is real GDP per capita, *CIT* is the top statutory corporate tax rate, *PIT* is the top personal income tax rate, and INV is the private investment to GDP ratio. The estimated reduced aggregate private investment equation is given as:

$$INV_{it} = \beta_Y ln\ y_{it-1} + \beta_{CIT} CIT_{it} + \beta_{PIT} PIT_{it} + other\ terms + \varepsilon_{it}\ , \quad (3.2)$$

By combining equations 3.1 and 3.2 and rearranging them, we obtain:

$$\ln y_t = \left(1 + \left(\alpha_Y + \alpha_{INV}\beta_Y\right)\right) \ln y_{t-1} + \left(\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right) CIT_t + other\ terms \quad (3.3)$$

Noting that at the initial period $ln\ y_{t-1}$ is predetermined and hence $\Delta \ln y_{t-1} = 0$. Thus, equation 3.3 implies that

$$\Delta \ln y_t = \left(\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right)\Delta CIT \quad (3.4)$$

From equation 2.3, the percentage gain in per capita GDP growth rate (Δg_t) due to a change in the CIT rate is given as:

$$\Delta g_t = \left(\alpha_Y + \alpha_{INV}\beta_Y\right)\Delta \ln y_{t-1} + \left(\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right)\Delta CIT \quad (3.5)$$

Equations 3.4 and 3.5 imply that one year after the CIT cut, the impact on growth rate is

$$\begin{aligned}\Delta g_{t+1} &= \left(\alpha_Y + \alpha_{INV}\beta_Y\right)\Delta \ln y_t + \left(\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right)\Delta CIT \\ &= \left(1 + \alpha_Y + \alpha_{INV}\beta_Y\right)\ \left(\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right)\Delta CIT\end{aligned}$$

For subsequent years, the impact on growth rate can be similarly calculated as:

$$\begin{aligned}\Delta g_{t+2} &= \left(\alpha_Y + \alpha_{INV}\beta_Y\right)\Delta \ln y_{t+1} + \left(\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right)\Delta CIT \\ &= \left(1 + \alpha_Y + \alpha_{INV}\beta_Y\right)^2\ \left(\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right)\Delta CIT\end{aligned}$$

$$\Delta g_{t+3} = \left(1 + \alpha_Y + \alpha_{INV}\beta_Y\right)^3 \left(\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right)\Delta CIT$$

$$\Delta g_{t+j} = \left(1 + \alpha_Y + \alpha_{INV}\beta_Y\right)^j \left(\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right)\Delta CIT$$

Thus, the impact of a change in the statutory corporate marginal tax rate (*CIT*) on the growth rate *j* years after the tax cut, g_{t+j}, can be calculated as:

$$\Delta g_{t+j} = \left(1 + \alpha_{Y} + \alpha_{INV}\beta_{Y}\right)^{j}\left[\alpha_{CIT} + \alpha_{INV}\beta_{CIT}\right]\Delta CIT \qquad (3.6)$$

A similar procedure is followed for the effects of A PIT rate cut. That is, the growth rate effects of changes in the top marginal PIT rate can be derived by using PIT instead of CIT in the above expression.

Appendix 4: Derivation of Equation 6

The present value of a government's total tax revenues can be expressed as:

$$PVR = \frac{R}{Y} PVY$$

where R is current total tax revenues, Y is current output, and PVY is the present value of the current and future output. It is assumed that the economy's effective tax rate (R/Y) will remain constant at current tax rates.

The marginal cost of public funds from raising the tax rate, τ, on one of the tax bases, B, can be expressed as:

$$MCF_{\tau} = \frac{\left(\frac{B}{Y}\right) PVYd_{\tau}}{\left(\frac{dPVR}{d_{\tau}}\right) d_{\tau}}$$

The numerator indicates that the harm that is incurred by taxpayers from a small tax increase dô is proportional to the present value of the tax base. The denominator is the present value of the increase in total revenue from a small tax rate increase. The ratio is the additional harm inflicted on taxpayers in raising an additional dollar of tax revenue. This expression can be simplified as follows:

$$MCF_{\tau} = \frac{\left(\frac{B}{Y}\right) PVY}{\frac{1}{Y}\frac{dR}{d_{\tau}} PVY + \frac{R}{Y}\frac{dPVY}{d_{\tau}}} = \frac{\frac{\tau B}{R}}{\frac{\tau}{R}\frac{dR}{d_{\tau}} + \frac{dPVY}{d_{\tau}}\frac{\tau}{PVY}}$$

Therefore, the MCF for a tax rate increase on one of the government's tax bases can be calculated as:

$$MCF_{\tau} = \frac{S_{\tau}}{\rho_{\tau} + \gamma_{\tau}}$$

where:

$S_{\tau} = \frac{\tau B}{R}$ is the share of total tax revenues for the particular tax base;

$\rho_{\tau} = \frac{\tau}{R}\frac{dR}{\tau}$ is the elasticity of total revenues with respect to the tax rate (holding output constant); and

$\gamma_{\tau} = \frac{\tau}{PVY}\frac{dPVY}{d\tau}$ is the elasticity of the present value of output with respect to the tax rate.

Appendix 5: Sensitivity Analysis

Table A2: Sensitivity Analysis for the Simulation of BC's Tax cut

Effects of tax rate cuts		**Baseline per capita GDP growth rate (in percent)**		
		0.716[a]	1.275[b]	2.0
Increase in long-run per capita output (in percent)	CIT rate cut	17.72	17.61	17.48
	PIT rate cut	7.68	7.63	7.58
Elasticity of the present value of per capita output (γ)	γ_{CIT}	-0.325	-0.351	-0.387
(Discount rate = 4%)	γ_{PIT}	-0.157	-0.169	-0.185
Elasticity of the present value of per capita output (γ)	γ_{CIT}	-0.282	-0.304	-0.336
(Discount rate = 5%)	γ_{PIT}	-0.138	-0.148	-0.162
Elasticity of the present value of per capita output (γ)	γ_{CIT}	-0.157	-0.166	-0.179
(Discount rate = 10%)	γ_{PIT}	-0.080	-0.084	-0.090

[a]BC's average real per capita GDP growth rate for the period 1977-2001.
[b]BC's average real per capita GDP growth rate for the period 1997-2001.

Acknowledgements

We would like to thank Jason Clemens and Niels Veldhuis of The Fraser Institute for their advice and assistance with data. We are also indebted to the three anonymous referees for their comments and suggestions. However, we are solely responsible for the analysis, conclusions, and any remaining errors. This paper was made possible through a generous donation from The Lotte and John Hecht Memorial Foundation and an anonymous donor.

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