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Government debt spillovers in a monetary union

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Abstract

This paper presents estimates of the impact of debt issued by one government in a monetary union on the yields of the bonds issued by other governments in the union. These debt spillovers may occur if there is a risk of monetary accommodation, implicit or explicit inter-jurisdictional bailout provisions, or interdependent revenues. The analysis empirically distinguishes between two channels through which debt spillovers may affect bond yields: currency depreciation risk and default risk. Data on the yields of individual Canadian provincial government bonds for the period 1983–2005 are employed. No evidence is found of debt spillovers between provinces, but a one percentage point increase in the central government's debt to GDP ratio raises the yield on provincial government bonds by 4.2 basis points—2.9 basis points by increasing the expected depreciation rate of the Canadian dollar and 1.3 basis points by raising the risk of provincial government default. These results imply that a rise in the Canadian central government debt to GDP ratio from 0.25 to 0.58, equivalent to the rise that occurred between 1983 and 1995, would lead to an increase in provincial government bond yields of approximately 140 basis points.

JEL classification: F33; F36; F42; H63

Keywords: Bond yields; Asset returns; Government debt; Government default risk; Spillovers

1. Introduction

The creation of the European Monetary Union (EMU) and proposals to establish currency unions in Asia, Africa and the Americas have generated increased interest in the role of fiscal arrangements and fiscal institutions in federations and monetary unions. One issue that has been of particular interest is the role of government debt "spillovers"—the impact of debt accumulation

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by one government in a federation or currency union on the yields of the bonds issued by other member governments. These debt spillovers may arise if there is a risk of monetary accommodation, implicit or explicit inter-jurisdictional bailout provisions, or interdependent revenues. For example, as noted in the theoretical studies of Bergin (2000), Canzoneri, Cumby, and Diba (2001), and Chari and Kehoe (2003), the incentives inherent in currency unions can lead individual governments to choose a higher level of debt than is optimal from the perspective of the union as a whole. Chari and Kehoe (2003) show that there is a time inconsistency problem in monetary policy if the monetary authority cannot commit, because it has an incentive to inflate away nominal debt when member states' debt levels are high. As individual fiscal authorities take account only of the costs of inflation to their own residents, each fiscal authority issues too much debt.[1]

When intergovernmental debt spillovers exist, the yields on the bonds issued by one government in a monetary union will rise with the debt accumulation of other governments in the union. Despite the possibility of this pecuniary externality from debt accumulation, few empirical studies attempt to verify the presence of debt spillovers or determine their magnitude.[2] Evidence that indirectly supports the existence of debt spillovers in the EMU is reported in Bernoth, von Hagen, & Schuknecht (2004). They show that EMU membership reduces the effect of own-country debt accumulation on interest rates, a result they view as being consistent with markets anticipating fiscal support for EMU countries in financial distress. Using data for Canada, Landon and Smith (2000) find that central government debt accumulation reduces the creditworthiness of indebted provincial governments, but the focus of their study is on credit ratings, so the findings cannot be used to quantify the cost of spillovers in terms of bond yields.[3]

The purpose of the current analysis is to contribute to an understanding of the link between debt accumulation, spillovers and bond yields. Specifically, using data for Canada, estimates are presented of the impact on individual provincial government bond yields of debt accumulation by the provincial governments in aggregate and the federal government. While much of the interest in the relationship between government debt and bond yields has focused on the European Union, several features of the Canadian case facilitate the analysis of debt spillovers. For example, provincial governments in Canada exert considerable fiscal independence and there are no federal government or constitutional restrictions on provincial government borrowing. Debt to GDP ratios vary significantly across provinces and across time (from a low of −0.22 to a high of 0.51 between 1983 and 2005), and provincial government debt is often sizable (see Appendix A; Table A2) so the risk of provincial government default is not trivial.[4] As well, aggregate provincial government

[1] Devereux (1993) emphasizes this type of spillover effect in the Canadian context. Some observers argue that the deficit to GDP and debt to GDP limits imposed on members of the European Monetary Union are meant to prevent sub-optimal debt level choices by member states (Bovenberg, Kremers, & Masson, 1991; p. 375). These rules remain in place, but on 20 March 2005 the European Council introduced changes to the enforcement of the debt and deficit rules to allow longer adjustment times and more exceptions (European Union, 2005). See Feldstein (2005) for a discussion of the new enforcement guidelines.

[2] While there is relatively little research on government debt spillover effects, numerous studies investigate whether a rise in *own-country* debt increases *own-country* bond yields. See, for example, Alesina, De Broeck, Prati, and Tabellini (1992), Codogno, Favero, and Missale (2003), Ardagna, Caselli, and Lane (2004), and Chinn and Frankel (2004) for cross-country studies. Laubach (2003) and Engen and Hubbard (2005) are recent US studies.

[3] In other work on spillovers, Gande and Parsley (2005) identify a spillover from a sovereign debt credit rating change for one country onto interest rate spreads in other countries. However, their focus is on the link implied by international trade and capital flows, rather than government debt accumulation. Giuliodori and Beetsma (2004) use a vector autoregressive model to analyze spillover effects of fiscal shocks on trade in Europe, but do not examine the impact on interest rates.

[4] In 1993, the Saskatchewan government was on the brink of declaring bankruptcy (Roberts, 1997). One provincial government defaulted in 1936, but eventually received federal support (Ascah, 1999).

expenditures (equal to more than 20% of GDP) are larger than those of the federal government (approximately 16% of GDP). Since Canada is a single nation state, comparable and consistent output and government debt data are available and institutions are more similar than would be the case for a cross-section of countries.[5] Furthermore, the market for Canadian provincial government bonds has considerable size and liquidity (Kahn & Gulrajani, 1993).[6] Finally, financial markets in Canada are relatively free and open, and there are few restrictions on the mobility of capital across provincial or international boundaries.

Using a panel of annual yield data for individual provincial bonds over the period 1983–2005, this study finds that debt accumulation by the federal government of Canada has a significant spillover effect on the yields of bonds issued by Canadian provincial governments. A one percentage point increase in the federal government's debt to GDP ratio is predicted to raise the yield on provincial government bonds by 4.2 basis points—2.9 basis points from an increase in the expected depreciation rate of the Canadian dollar and 1.3 basis points from a rise in the risk of provincial government default. Between 1983 and 1995, the federal government debt to GDP ratio increased from 0.25 to 0.58. According to the estimates presented below, an increase of this magnitude would raise provincial government bond yields by approximately 140 basis points.

In contrast to the significant impact of central government debt on provincial government bond yields, aggregate provincial government debt accumulation is not found to have a statistically significant effect on the yields of the bonds issued by individual provinces. A possible explanation for the different impact on yields of federal and provincial government debt is that, in Canada, since the federal government has exclusive responsibility for monetary policy, financial markets believe that only federal government debt accumulation will lead to inflation-inducing monetization. As well, the federal government, but not the provinces, may be viewed as a potential source of bailout funds for a province in financial difficulty. One implication of the absence of evidence of provincial government debt spillover effects is that spillovers do not provide a rationale for the imposition of restrictions on provincial (sub-central) government debt accumulation.

The outline of the paper is as follows. The next section presents arguments for a link between the debt issued by one government in a monetary union and the yields on the bonds issued by the other governments in the union. In Section 3, the empirical specification is developed, while the data are described in Section 4. Results are presented in Section 5 and concluding remarks are given in Section 6.

2. Potential causes of government debt spillovers

The issue of government debt spillovers is closely related to the large literature on the impact of own-government debt on own-government borrowing costs.[7] As noted by Alesina et al. (1992),

[5] Lemmen and Goodhart (1999; p. 92) argue that "future research efforts should rely on the comparison of federal and provincial debt yields within existing federal states" since studies that use cross-country data provide a less "clean" comparison, due to different country-specific factors that may confound the estimated default risk measure. Obstfeld (1992) also recognizes this advantage of data for a single country.

[6] In 2003, for example, the outstanding stock of Canadian provincial government bonds was C$ 258 billion. See Statistics Canada, Cansim database, series V151582.

[7] Recent studies for the US include Canzoneri et al. (2001), Laubach (2003), and Engen and Hubbard (2005). For studies of subcentral governments within a federation or currency union, such as the US, Canada and the European Union, see Lane (1993), Goldstein and Woglom (1992), Bayoumi, Goldstein, and Woglom (1995), Poterba and Reuben (2001), Lemmen (1999) and Booth, Georgopoulos, and Hejazi (2006). Cross-country studies include Alesina et al. (1992), Codogno et al. (2003), Ardagna et al. (2004), Bernoth et al. (2004), and Chinn and Frankel (2004).

own-government debt accumulation can affect own-government borrowing costs by altering two types of risk: default risk and devaluation risk. Since governments with larger debt levels are less likely to be able to meet their required interest and principal payments, debt accumulation raises the risk of default. The risk of a currency depreciation also increases with own-debt accumulation if high debt countries are more likely to "inflate away" their domestic currency-denominated debt (Sargent & Wallace, 1981; Woodford, 2001).[8]

In contrast to the effects of own-debt accumulation, debt spillovers occur when the debt accumulation of one government causes a change in the default risk or devaluation risk associated with *another* government in a federation or currency union and this, in turn, raises the borrowing costs of the other government. This section presents several explanations for why such a change may occur. These explanations relate to the possibility of monetary accommodation, the existence of implicit or explicit bailout provisions, and the interdependence of government revenues.

If a government has control of monetary policy, it can meet its domestic currency debt obligations by monetizing its debt. The greater the risk of debt monetization, the higher the yields on all debt denominated in domestic currency, both debt issued by the monetizing government as well as debt issued by other domestic governments, due to the increased risk of inflation and currency depreciation. The size of the debt of the government in control of monetary policy is likely to be an important determinant of the risk of monetization since, with a larger debt, governments may be viewed as being more inclined to use an inflation tax. In the context of a federation, this means that, if the central government has control of monetary policy, increases in the magnitude of central government debt will raise the risk of monetary accommodation and increase the yields on all debt instruments denominated in the federation's currency. As a result, central government debt accumulation will spill over onto the yields of sub-central government debt.

It seems likely that the market will view the probability of monetization to be higher the greater is the accumulated debt of the government in control of monetary policy. However, if there are implicit or explicit bailout provisions in a federation or currency union, the market may believe that monetary accommodation could be used to reduce the real value of the debt of individual member governments, as an alternative to an outright bailout, even if these governments do not directly control monetary policy (Lemmen & Goodhart, 1999; McKinnon, 1995). As well, if a government or group of governments experience financial distress, pressure may be put on the central bank to keep interest rates low, in order to minimize the costs of a financial crisis, and this could eventually lead to inflation and a currency depreciation. Thus, the market may view the risk of monetary accommodation to be greater the larger is the debt of the member governments of a federation, both those with and those without direct control of monetary policy.[9]

Even in the absence of monetary accommodation, the existence of implicit or explicit bailout provisions can lead to debt spillovers. This follows because the interest rate demanded by lenders will reflect the ability to pay of the government(s) that is (are) likely to provide the bailout. That is, the risk premium incorporated by the market in bond yields of borrowing governments will

[8] Sargent and Wallace (1981) and Woodford (2001) argue that, if a government's budget constraint is to hold in present value terms, the government's approach to debt accumulation and fiscal solvency can limit the options open to the central bank, even if the central bank has been granted legal independence. If the monetary authority is to have the functional independence necessary to achieve price stability, the government must ensure fiscal solvency for any potential path of the price level.

[9] Lemmen and Goodhart (1999; p. 81) note that, although the Maastricht Treaty does not allocate a lender of last resort role to the European System of Central Banks, it is yet to be determined how financial crises would be detected, monitored and resolved. They also point out that the Maastricht Treaty's "no-bailout" provision may be at odds with other functions of the ECB, such as the smooth functioning of the payments system.

depend, to some extent, on the debt obligations of the guarantor government. If lenders expect that the individual jurisdictions of the federation will be supported by the financial resources of the whole federation the yields on the debt of individual members will depend on the debt obligations of the entire federation. If the guarantor is the central government only, the yields on sub-central government debt will depend on the central government's debt commitments, as these will determine the ability of the central government to fulfill its guarantor role.

Revenue interdependence is an additional explanation for why the accumulation of government debt in one region may affect the bond yields of other jurisdictions. Interdependent revenues exist to the extent that the economies of the members of a federation are interconnected—as a result of trade and financial flows, for example. Excess debt accumulation that causes a fiscal crisis in one jurisdiction may adversely affect output and incomes in other jurisdictions. This would decrease the tax revenues generated in the affected jurisdictions and inhibit the ability of the governments of these jurisdictions to meet their debt service obligations. Further, if the central government's debt grows, the market may perceive an increase in the likelihood of a cut in transfers to sub-central governments and, therefore, an increase in the probability that lower-level governments will have difficulty meeting their debt obligations.

3. Specification of the empirical model

This section describes the derivation of an estimable model of provincial government bond yields that incorporates inter-government debt spillover effects. Suppose provincial (subcentral) government bonds are purchased in a competitive financial market by risk-neutral lenders. The relationship between the expected return on a domestic currency-denominated provincial government bond issued by province i, r^i, and the yield on a default risk-free domestic currency-denominated national (central) government bond, r^{C}, can be expressed as:

$$(1 + r_m^i)(1 - \rho_m^i) = (1 + r_m^{\mathrm{C}}), \tag{1}$$

where ρ_m^i is the probability of default by province i between the current period and period m, and the subscript "m" represents maturity length. The central government bond is default risk-free since the central government has control of monetary policy and so can always repay its domestic currency debt.[10]

In addition to provincial and central government bonds, investors can hold foreign bonds that are denominated in foreign currency. The difference between the returns on domestic and foreign bonds involves exchange rate risk, since the value of the exchange rate when the bonds mature is uncertain. Given risk-neutral investors, the yield on a central government default risk-free domestic currency government bond must equal the expected yield on a foreign currency default risk-free bond when returns are converted to a common currency:

$$1 + r_m^{\mathrm{C}} = (1 + r_m^{\mathrm{f}})\frac{S_m^{\mathrm{e}}}{S}, \tag{2}$$

where r_m^{C} is the yield on a domestic central government bond with m periods to maturity, r_m^{f} the yield on a foreign currency bond, S the current value of the exchange rate (the domestic currency

[10] If provincial and national government bond markets differ in terms of liquidity, the yield on provincial bonds will differ from the yield on national bonds as a result of a provincial government bond market-specific liquidity premium, as well as a default premium, both of which would then be incorporated in ρ_m^i. See Booth et al. (2006).

price of one unit of foreign currency), S_m^e the expected value of the exchange rate when the bonds mature in m periods, and there are assumed to be negligible transactions costs and no restrictions on foreign ownership.

Taking log approximations of Eqs. (1) and (2) and rearranging yields:

$$r_m^i = r_m^C + \rho_m^i, \tag{3}$$

$$r_m^C = r_m^f + \varepsilon_m, \tag{4}$$

where ε_m is the expected log change in the exchange rate (the expected rate of currency depreciation) between the current period and period m, so $\varepsilon_m \equiv [\ln(S_m^e) - \ln(S)]$.[11]

The probability of default, ρ^i in Eq. (3), is determined by government debt spillover factors that increase the likelihood of default by province i, as well as by non-spillover factors that affect the province's probability of default. Thus, the default risk in period t of a bond issued by province i with maturity m can be expressed as:

$$\rho_{m,t}^i = \alpha_Z Z_t + \alpha_X X_t^i + \alpha_W W_t^\rho, \tag{5}$$

where Z is a vector of spillover variables that depend on the debt levels of the other provinces and the central government,[12] X^i a vector of factors specific to province i that may affect the risk of default, and W^ρ is a vector of non-spillover factors, not specific to province i, that may affect the province's probability of default.

Changes in the anticipated future value of the exchange rate, ε_m in Eq. (4), may also depend on central and sub-central government debt levels because an increase in debt accumulation by these governments may raise the risk of a monetary expansion. As a result, ε_m is specified to depend on the spillover factors, Z, as well as on non-spillover factors, denoted W^ε, that affect the expected rate of currency depreciation:

$$\varepsilon_{m,t} = \beta_Z Z_t + \beta_W W_t^\varepsilon \tag{6}$$

Using Eq. (4) to substitute for r_m^C in Eq. (3) yields:

$$r_m^i = r_m^f + \rho_m^i + \varepsilon_m. \tag{3'}$$

Rearranging Eqs. (3) and (3′), and using Eqs. (5) and (6) to substitute for ρ_m^i and ε_m, gives:

$$r_{m,t}^i - r_{m,t}^C = \alpha_Z Z_t + \alpha_X X_t^i + \alpha_W W_t^\rho, \tag{7}$$

$$r_{m,t}^i - r_{m,t}^f = \alpha_Z Z_t + \alpha_X X_t^i + \alpha_W W_t^\rho + \beta_Z Z_t + \beta_W W_t^\varepsilon. \tag{8}$$

[11] If investors are risk averse, factors representing the variance of expected returns would also enter Eqs. (3) and (4). See, for example, the portfolio balance models of Solnik (1974) and Glassman and Riddick (1996) and, for the specific case of sovereign debt risk, see Bernoth et al. (2004). Although Eqs. (1) and (2) are specified in terms of nominal returns, if real returns are used, Eqs. (3) and (4) are unchanged. To see this, note that the real return anticipated on an investment in a provincial government bond that matures in m periods is given by: $1 + r_m^{i,\text{real}} = (1 + r_m^i)/(1 + \pi_m^e)$ so, using (1), the real return on a province i bond is: $1 + r_m^{i,\text{real}} = ((1 + r_m^C)/(1 - \rho_m^i))(1/(1 + \pi_m^e))$, where π_m^e is the rate of inflation anticipated between the current period and period m. Similarly, the real return on a Canadian government bond is given by: $1 + r_m^{C,\text{real}} = ((1 + r_m^f)[S_m^e/S])(1/(1 + \pi_m^e))$. Taking logs of these latter two expressions, rearranging and noting that $r_m^i = r_m^{i,\text{real}} + \pi_m^e$ and $r_m^C = r_m^{C,\text{real}} + \pi_m^e$, yields Eqs. (3) and (4).

[12] The debt, rather than the deficit, is employed following the arguments of Engen and Hubbard (2005; pp. 106–107). They note that it is the *stock* of government debt that is relevant to explain the *level* of the interest rate, while the *change* in the interest rate is related to the *change* in government debt (the deficit).

Estimates of the vectors of parameters α_Z and β_Z in Eqs. (7) and (8) can be used to determine the significance and magnitude of spillover effects on bond yields. The parameters in α_Z represent the impact of the spillover variables on the probability of default (ρ_m^i), while the parameters in β_Z reflect the impact of the spillover variables on the expected rate of currency depreciation (ε_m).

By specifying the dependent variables in Eqs. (7) and (8) as yield differentials for bonds of the same maturity, it is possible to eliminate factors that may affect yields on all bonds. Estimation using a yield differential is standard in studies of own-government debt effects, such as Alesina et al. (1992), Favero, Giavazzi, and Spaventa (1997), Lemmen and Goodhart (1999), Codogno et al. (2003), Ardagna et al. (2004), and Bernoth et al. (2004).

4. Empirical implementation and data

In order to estimate Eqs. (7) and (8), data are required for the bond yields (r^i, r^C, r^f), the spillover variables (Z), and the non-spillover variables (X^i, W^ρ, W^ε). Data on the yields of individual provincial government bonds, published by the *Financial Post Corporation*, are used to represent the provincial government bond yield variable, r^i. While bond yield data are generally available for several outstanding bonds at any one time for each province, the yield on only one bond for each province is used because the yields on the different bonds issued by a province are highly correlated.[13] However, since the data for a single bond did not span the entire length of the sample for any province (as bonds matured during the sample), the time series for r^i for each province incorporates the yields of several bonds. Bonds were chosen, from those available, in order to minimize the number of different bonds used for each province. Table A1 in Appendix A gives a complete list of the individual bonds employed. The results are not sensitive to this selection procedure since the values of the parameters estimated using a completely different sample of bonds for each province are very similar to those reported for the original sample.[14]

While individual bond yields are available at a monthly frequency, only one observation per year is utilized in the empirical analysis as data on the stock of provincial government debt are available only at an annual frequency—as of fiscal year-end 31 March. To avoid possible endogeneity between the level of provincial debt and provincial government bond yields, the bond yield observation employed is the observation for the last business day in April, the first yield observation available following 31 March. The average time to maturity of the bonds in the sample is 10.7 years, while the average issue amount is approximately C$ 250 million. The Appendix provides detailed notes on the bond yield data, as well as descriptions and sources for all the other data.

The central government bond yield, r_m^C, is represented by the yield on a Government of Canada bond of maturity length m. Given the open financial markets in Canada and the US, and the large size of the US bond market, the natural choice for the return on the alternative foreign bond, r_m^f, is the yield on a US Treasury bond with maturity m.

[13] It is not possible to use a "benchmark" bond or a bond index since these are not available for bonds issued by individual provincial governments. Further, the two yields that form the dependent variables in Eqs. (7) and (8) are matched by maturity, and this would be impossible with an index.

[14] In this case, due to the unavailability of data on more than one bond for some provinces for some years, the estimates are obtained using only 203 observations.

4.1. The spillover explanatory variables, Z

Two spillover variables are employed: the federal government's debt to GDP ratio, denoted FEDDEBT, and the aggregate debt to GDP ratio of the provinces, denoted PROVDEBT.[15] (Selected observations for these two debt variables are presented in Table A2 of Appendix A.) The use of PROVDEBT implies that the relevant sub-central government debt spillover variable is the *aggregate* level of provincial borrowing and that, as it relates to spillovers, a dollar of debt is treated the same no matter which provincial government is the issuer. An alternative provincial government debt measure is total provincial debt less the debt of province *i*. However, since the estimating equations both include province *i*'s debt to GDP ratio as a separate explanatory variable, the use of this alternative debt measure would not be substantially different to the specification employed.[16]

4.2. Non-spillover explanatory variables

To determine the magnitude of debt spillover effects on provincial government bond yields, it is necessary to control for the non-spillover factors (X^i, W^ρ, W^ε) that may also affect yields through their impact on default risk or the expected change in the exchange rate. Control variables were chosen to represent these effects in a parsimonious fashion and to be consistent with the literature that examines (non-spillover) debt effects on yields.

4.2.1. Province-specific non-spillover explanatory variables, X^i

Own-government debt exposure and regional income are among the most frequently employed variables used to explain government bond yields (Alesina et al., 1992; Bayoumi et al., 1995; Cantor & Packer, 1996; Edwards, 1984; Eichengreen & Mody, 1998). Each province's own-government debt exposure is represented by its debt to GDP ratio, OWNDEBT^i.[17] Two variables are used to represent the determinants of regional incomes: the change in provincial real GDP, ΔY^i, and federal government transfers to province *i* as a share of the province's total revenues, TRANSFERS^i. A jurisdiction with growing income is likely to have more revenue flexibility,

[15] Government debt is defined as financial assets minus total direct liabilities, excluding the liabilities of government employee pension plans. Employee pension liabilities are not included in the debt measure because they are likely to be of a different nature than other direct government liabilities. For example, it may be easier for a government to renege on these commitments than to renege on their bond liabilities. In addition, the employee pension liabilities of the provincial governments may not have been measured as accurately as other government liabilities, since these liabilities were either not assessed or assessed only periodically during much of the sample period. The definition of debt employed here also does not include the liabilities of the Canada and Quebec pension plans, because they are not direct government liabilities; nor does it include guaranteed liabilities (such as the liabilities of government enterprises) since these are conditional liabilities. As reported in Section 5, incorporating guaranteed liabilities in the debt definition has little impact on the results.

[16] As noted below, the results are essentially unchanged if this alternative debt measure is employed.

[17] Six provincial governments have introduced legislative restrictions to control debt accumulation. While there is some evidence that strong tax and expenditure limits have had an impact on borrowing in US states (Bayoumi et al., 1995; Poterba and Reuben, 2001), similar results do not appear to hold for state *debt* limits. Also, Millar (1997; pp. 6–7) notes that, with the exception of Alberta, "...none of the acts seems to clearly restrict the ability of governments to create new debt" and the provincial governments "could amend, or even repeal this anti-deficit legislation if compliance becomes particularly costly".

so faster growth should reduce yields.[18] A province that is more dependent on federal transfers is likely to be more vulnerable to a unilateral reduction in these transfers. The TRANSFERS^i variable may also reflect the revenue raising capacity of a province, as those provinces with poor revenue raising capacity tend to receive the largest transfers. For similar reasons, this variable may proxy the general long run economic health of a province. As a result, higher values for TRANSFERS^i should be associated with higher yields.

To account for effects that differ across bonds, but are constant through time, the vector X^i also includes a dummy variable for each bond.[19] Because bonds are issued by only one province, the set of bond fixed effects is perfectly co-linear with a set of province fixed effects and, thus, the bond fixed effects also control for the social, political, economic and institutional characteristics that are specific to a province, but constant over time.[20]

4.2.2. Additional non-spillover explanatory variables, W^ρ and W^ε

The elements of the vectors W^ρ and W^ε represent non-spillover non-province specific factors that, respectively, determine common movements in provincial bond risk premia and changes in the expected rate of currency depreciation. Studies that examine long term bond rates typically include controls for monetary policy,[21] as changes in monetary policy may cause movements in bond yields by altering both the risk of default and the expected rate of currency depreciation. To capture the relative tightness of Canadian and US monetary policy, W^ρ and W^ε both include the policy rate differential $r^{\text{BankR}} - r^{\text{FFR}}$, where r^{BankR} is the Bank of Canada's Bank rate, used to capture the stance of Canadian monetary policy, and r^{FFR} is the US Federal funds rate. The policy rate differential is included in the vector W^ε since a relative rise in the Canadian monetary policy rate would be expected to lead to an increase in Canadian bond rates relative to comparable US rates. The differential is included in the vector W^ρ as relatively tighter Canadian monetary policy conditions may raise expectations of provincial government default risk by reducing the availability of credit or raising the debt service burden of borrowers in Canadian currency.

As shown in numerous empirical studies (Meese & Rogoff, 1983, for example), it is difficult to identify factors that can accurately forecast future exchange rate movements. For this reason, factors that may determine expected changes in exchange rates (ε) are also difficult to identify. However, literature reviews by Taylor and Taylor (2004), and Rogoff (1996), conclude that, over the longer term, purchasing power parity may provide some guidance for predictions of exchange rate movements. This implies that the inflation differential is a likely determinant of long-term expected changes in exchange rates. To capture this effect, the differentials between the Canadian and US inflation rates over each of the two previous years, $\pi^{\text{Can}} - \pi^{\text{US}}$ and $\pi^{\text{Can}}_{-1} - \pi^{\text{US}}_{-1}$, respectively, are included in the vector W^ε.[22] Higher values of these variables are expected to

[18] Alesina et al. (1992) find strong and very robust evidence that government bond yields are affected by the level of economic activity in all of the 12 OECD countries they consider.

[19] As noted above, bond liquidity may have an impact on bond yields. If the liquidity of a particular bond depends on the amount of the bond issued, the bond fixed effects will represent the bond-specific liquidity effect as well.

[20] During the sample period, the Quebec government held a referendum on the question of Quebec sovereignty, which might be expected to affect provincial bond yields. However, Johnson and McIlwraith (1998) find that the referendum had only a transient impact on Quebec and Ontario provincial government bond yields (they examine a 3-month period). Given this transient effect, the referendum is unlikely to have affected the results here since, as noted above, the bond yield data employed in this study are annual and measured at the end of April, while the referendum campaign began on 7 September 1995 (when the referendum question was officially announced) and the vote was held on 30 October 1995.

[21] See Eichengreen and Mody (1998), Arora and Cerisola (2001), Ardagna et al. (2004), and Engen and Hubbard (2005).

[22] Ardagna et al. (2004) also include an inflation variable in their interest rate equation.

raise the yield differential by increasing the expected rate of depreciation (ε). Also included as an element of W^{ε} is the national growth rate, denoted ΔY^{Can}, since stronger national economic growth may reduce the probability of a currency depreciation and, thus, reduce the yield differential.

The bond yield Eqs. (3) and (4), and thus the estimating Eqs. (7) and (8), are specified for bonds with maturity m. To account for maturity differences across bonds, a variable representing the log of the number of months to maturity for the provincial bond, denoted MATURITY, is included in both estimating equations.

5. Empirical results

Eqs. (7) and (8) are estimated jointly using panel data for the ten Canadian provinces over the period 1983–2005.[23] Joint estimation allows for the imposition of the restriction that the vectors of parameters, α_Z, α_X and α_W, are the same in both equations. As well, since the dependent variables in Eqs. (7) and (8) both incorporate r^i, the error terms are likely to be correlated and joint estimation takes this correlation into account.

From the estimates of Eqs. (7) and (8), it is possible to derive estimates of the parameters in Eqs. (5) and (6), the equations that describe the risk of default (ρ^i) and the expected rate of depreciation (ε), respectively. These estimates are reported in Columns I and II of Table 1. The coefficient estimates associated with the control variables have the anticipated signs, the estimates are not rejected by a test for autocorrelation (although in one case at 1% rather than 5%) or a Reset test for model misspecification and omitted variables, and the estimates explain a large proportion of the variation in the yield differential. One result of note in Table 1 is that a province's own-debt to GDP ratio (OWNDEBT^i) has a statistically insignificant impact on its own bond yield. A similar finding is not uncommon in studies that measure the impact of own-debt on own-government bond yields, but which do not consider spillover effects.[24]

The estimates presented in Table 1 show that a rise in the aggregate provincial government debt to GDP ratio (PROVDEBT) has a statistically insignificant impact on the risk premium of provincial government bonds, ρ^i.[25] One implication of this result is that provincial governments are not perceived to be implicit guarantors of the debt issued by other provinces. The insignificant coefficient associated with the aggregate provincial debt variable in the equation for the expected change in the exchange rate, ε, indicates that the market does not expect the federal government to choose a more inflationary policy in response to higher provincial debt levels. As there is no evidence of statistically significant inter-provincial government debt spillovers, debt spillovers

[23] The number of observations used in the empirical analysis is 223 rather than 230 (23 years multiplied by 10 provinces) as, for 7 observations, appropriate provincial government bond yields were not available. See Appendix A. Due to these missing observations, the sample is unbalanced.

[24] Studies that have found no significant relationship between own-government debt and own-government bond yields, or that find a positive relationship only at relatively high levels of debt, include Ford and Laxton (1999), Alesina et al. (1992), and Codogno et al. (2003). For Canada, Lemmen (1999) finds some evidence that higher provincial government debt raises provincial government bond yields, but he uses a fairly short sample period (1992Q3-97Q4). Booth et al. (2006) find a significant effect of debt and deficit levels on the spread between provincial and Government of Canada bonds. None of these studies examine spillovers.

[25] The negative sign of this coefficient may represent a provincial government bond market-specific liquidity effect. Booth et al. (2006) suggest that an increase in provincial debt, by raising the quantity of bonds in the market, may increase liquidity and, thus, reduce the yield spread.

Table 1
Government debt spillover effects

Explanatory variables	ρ^i Equation (Eq. (5))	ε Equation (Eq. (6))	Sum of the ρ^i and ε coefficients
Spillover variables: Z			
FEDDEBT	0.0131* (3.58)	0.0294* (8.74)	0.0425* (8.28)
PROVDEBT	−0.0261 (1.90)	0.0055 (0.49)	−0.0206 (1.14)
Non-spillover variables: X^i, W^ρ and W^ε			
OWNDEBT^i	0.0060 (1.16)		
ΔY^i	−0.0171* (2.64)		
TRANSFERS^i	0.0227* (4.11)		
$r^{\text{BankR}} - r^{\text{FFR}}$	0.0706* (5.25)	0.4295* (19.48)	0.5001* (21.83)
$\pi^{\text{Can}} - \pi^{\text{US}}$		0.0922* (3.47)	
$\pi^{\text{Can}}_{-1} - \pi^{\text{US}}_{-1}$		0.0116 (0.37)	
ΔY^{Can}		−0.0324* (2.43)	
MATURITY	0.0012* (2.93)	−0.0017* (4.23)	−0.0005 (0.85)

	Eq. (7)	Eq. (8)
R^2	0.690	0.796
AR1 test (t-statistic)[a]	1.98[b]	0.89[c]
Reset test (t-statistic)[d]	1.56[e]	0.78[e]

Notes: Estimates of the individual bond fixed effects are not reported to conserve space. There are 223 observations. The number in brackets to the right of each coefficient estimate is the absolute value of the heteroskedasticity corrected t-statistic.

[a] AR1 test methodology: Estimate Eqs. (7) and (8) separately using OLS. Regress the residuals from each of these equations on the lagged residuals and the explanatory variables of the model. The test statistic is the t-statistic on the lagged residual. (See Davidson and MacKinnon, 1993; p. 358).

[b] Cannot reject the hypothesis of no serial correlation at 1%, but reject at 5%.

[c] Cannot reject the hypothesis of no serial correlation at 5%.

[d] Reset test methodology: Estimate Eqs. (7) and (8) jointly. Add the squared predicted values for each dependent variable to the model as explanatory variables and re-estimate. Test if either squared predicted value is individually significant (t-statistic).

[e] Cannot reject the hypothesis of no misspecification at 5%.

* The estimated coefficient is significant using a 95% confidence interval.

cannot be used as a rationale to justify restrictions on provincial government debt accumulation.[26] Such fiscal rules have been proposed as an alternative to market-based fiscal discipline when the possibility of spillovers exists (Bergin, 2000; Canzoneri et al., 2001; Chari & Kehoe, 2003; Devereux, 1993; European Commission, 2002).[27]

In contrast to the results for provincial government debt, as can be seen from Table 1, a rise in the federal government debt to GDP ratio (FEDDEBT) has a significant effect on both the expected rate of currency depreciation, ε, and the risk of default, ρ^i. The significant positive coefficient

[26] This does not imply that fiscal rules could not help to meet objectives other than the prevention of government debt spillovers. For example, Fatás and Mihov (2006) consider the circumstances under which fiscal rules in US states could reduce macroeconomic volatility.

[27] Market discipline encourages fiscal restraint by causing a widening of the differential between the market yields paid by fiscally imprudent and fiscally prudent debtors. For the market to send the correct signal, the yield on government debt should reflect the fiscal policy stance of the borrowing government alone, and there should be no "spillover" or "externality" effects of the debt of one government on the yields paid by other governments. Bishop, Damrau, and Miller (1989), for example, argue that market discipline is an effective alternative to budget rules for the EMU.

associated with the federal debt variable in the exchange rate depreciation (ε) equation implies that the market believes the federal government, through its control of monetary policy, may use inflation to reduce the real value of its own-debt. The significant effect of federal debt on the provincial government debt risk premium (ρ^i) is consistent with the federal government being in a weaker position to provide bailout funds to the provinces, or more likely to cut inter-governmental transfers, as its debt rises. Further, the significant effect of the federal debt on the provincial debt risk premium implies that a rise in the federal government debt to GDP ratio has a greater impact on provincial government bond yields than on federal government yields (since federal yields rise only due to the increase in the expected rate of currency depreciation, while provincial bond yields rise as a result of changes in both the risk premium and the expected rate of depreciation).

The coefficients associated with the federal debt variable, FEDDEBT, in columns I and II of Table 1 indicate that the largest component of the impact on bond yields of federal government debt accumulation is through the expected change in the exchange rate, ε. Through this channel, a one percentage point increase in the federal government's debt to GDP ratio increases the yield on provincial government bonds by 0.0294 percentage points. A similar increase in the federal debt would raise the default risk premium on provincial bonds, ρ^i, by only 0.0131 percentage points. One reason why default risk may be relatively small is the potentially high costs associated with default (loss of borrower reputation, possible financial sector instability or crisis). Alesina et al. (1992; p. 431) note that, in OECD countries, the costs of default are likely to greatly outweigh the benefits, even for highly indebted countries, so the default premium is likely to be small. The larger impact of federal debt accumulation on depreciation risk is consistent with the literature on the impact of own-debt on own-yields. These studies find currency depreciation risk to be large relative to default risk.[28]

According to the results in Table 1, taking depreciation and default risk together, a one percentage point rise in the federal government's debt to GDP ratio is predicted to increase the yield on provincial government bonds by 4.25 basis points. Given that movements in Canadian federal government debt levels have often been substantial, federal debt accumulation may have had a large impact on provincial bond yields. For example, from 1983 to 1995 the federal government debt to GDP ratio rose from 0.248 to 0.583. Based on the coefficient estimates in Table 1, an increase of this magnitude would lead to a rise in provincial bond yields of 142 basis points (equivalent to 17% of the average provincial bond yield in the sample for 1995). Similarly, a decline in the federal government debt to GDP ratio, equivalent to the fall from 0.583 in 1995 to 0.305 in 2005, is predicted to cause provincial bond yields to fall by 118 basis points. For provinces with a considerable burden of outstanding debt, a portion of which must be rolled over every year, a yield decline of 118 basis points could represent significant savings (slightly more than US$ 2 billion per year if the yield decline is applied to total 2005 provincial net debt).

While the benefit to the provinces from a reduction in federal debt, in terms of lower debt servicing costs, is considerable, back-of-the-envelope calculations indicate that the provinces would prefer a direct US$ 1 transfer from the federal government to a US$ 1 cut in the federal

[28] See the study by Giovannini and Piga (1994) for Italy, and the studies for European countries by Favero et al. (1997) and Codogno et al. (2003). Also Ardagna et al. (2004) do not find a significant effect of the government debt to GDP ratio or the primary deficit to GDP ratio on the 10-year government bond yield over a swap contract with the same maturity and currency of denomination (a dependent variable that allows for government default risk but excludes currency risk). However, their fiscal policy variables have a significant effect on interest rate spreads relative to German rates. Ardagna et al. (2004; p. 13) note that "These results may suggest that the impact of fiscal policy on interest rates is not likely to be via default risk directly, but could be through expected inflation . . .".

debt. In 2005, a US$ 10 billion decline in federal government debt would have reduced the federal debt to GDP ratio by 0.77 percentage points, a decline which, given the estimates in Table 1, is predicted to cause a fall in provincial bond yields of 3.3 basis points. If this decline applied to all outstanding provincial government net debt, provincial debt interest payments would fall by approximately US$ 61 million per year. With a discount rate of 5%, this saving would be equivalent to US$ 1.2 billion in present value terms. Thus, the value of provincial government interest savings from a reduction in the federal debt is much smaller than the magnitude of the debt reduction that would be required to realize these savings.[29]

The size of the effect of the federal government debt to GDP ratio on provincial government bond yields found here is of similar magnitude to several estimates of the impact of own-debt on own-government bond yields found in studies for other countries (none of which consider spillover effects). For example, Engen and Hubbard (2005) find approximately a 3 basis point rise in long term interest rates in the US following a 1 percentage point increase in the federal government debt to GDP ratio, while Laubach (2003) estimates the impact to be 4–5 basis points. Chinn and Frankel (2004, pp. 20–21) obtain a similar estimate for a sample of European countries.

The estimates of the coefficients associated with the federal government debt to GDP ratio are robust, in terms of magnitude and significance, to a number of variations in the model's specification. While not reported to conserve space, the following alternative specifications were considered. First, the model was augmented by the addition of a variable representing the ratio of provincial government foreign currency debt to total outstanding debt, since the market may view foreign currency debt differently than domestic debt.[30] Second, to capture possible nonlinearities, Eqs. (7) and (8) were re-estimated with various combinations of the three debt variables (FEDDEBT, PROVDEBT, OWNDEBT^i) squared and interacted with one another.[31] Third, since it is possible that negative levels of debt have a different impact on yields than positive debt, the model was re-estimated using only those observations for which the OWNDEBT^i variable is positive. Fourth, the two provincial debt variables (OWNDEBT^i and PROVDEBT) were redefined to include the "guaranteed liabilities" of provincial governments.[32] Fifth, the aggregate PROVDEBT

[29] From the perspective of the provincial governments alone, this calculation may overestimate the difference between the cost and benefit of a reduction in federal debt. Finance Canada reports that transfers to the provinces made up only 26% of federal program spending (21% of all federal spending) in 2004–2005. If a federal debt reduction of US$ 10 billion is implemented through proportional cuts to all types of federal program spending, the direct cost to the provinces would be only $2.6 billion, which is closer to the estimated US$ 1.2 billion gain that would result from the reduction in provincial debt servicing costs.

[30] In this case, the estimation period is 1984–2003, due to the more limited availability of the foreign currency debt data. One reason debt issued in foreign currency might not be a significant determinant of domestic currency yields is that, as noted by Wooldridge (1996; p. 25), two of the larger provinces, Ontario and British Columbia, swap virtually all of their foreign currency borrowings into Canadian dollars and, while Alberta held substantial amounts of unhedged U.S. dollar liabilities, revenues from sales of oil and gas to the United States serve as a natural hedge against fluctuations in the exchange rate.

[31] When OWNDEBT^i was squared or interacted with FEDDEBT or PROVDEBT only observations for positive values of OWNDEBT^i were used, which reduced the sample size to 206 observations. To account for the possibility of further nonlinear effects, a variable was included that consists of the ratio of the debt of the three most heavily indebted provinces to their aggregate provincial GDP (on average over the sample period these were Newfoundland, Nova Scotia, New Brunswick). This variable was added as the influence of debt on yields may depend on the distribution of debt across provinces as well as the aggregate level of debt. An increase in the debt of a heavily indebted province, because it is more likely to default, could lead to a larger spillover effect. This variable was insignificant in both equations.

[32] Statistics Canada does not provide data on the guaranteed liabilities of the federal government and only provides data for the provinces to 2003, so the sample had only 203 observations.

variable was modified to exclude the debt of province *i*. Sixth, to account for the possible influence of external sector and terms-of-trade factors, the current account to GDP ratio from the previous year and the year-over-year percentage change in the real commodity price index from the previous month were added separately as explanatory variables. Finally, the PROVDEBT variable was excluded from the estimating equations.[33] None of these alternative specifications alter the conclusions with respect to the sign or significance of the federal government debt coefficient.[34]

6. Conclusions

The results presented above provide evidence of a spillover effect on sub-central government bond yields that arises from central government debt accumulation in the Canadian federation. Specifically, a one percentage point rise in the Canadian federal government debt to GDP ratio leads to a statistically significant increase in provincial government bond yields of approximately 4.2 basis points. Of this increase, approximately 2.9 basis points are due to a rise in the expected rate of currency depreciation and 1.3 basis points are due to an increase in the probability of provincial government default. The significant positive effect of the federal debt on provincial bond yields is consistent with the view that, as the federal government increases its debt, it is in a weaker position to provide assistance to the provinces and, in addition, is more likely to monetize its debt and precipitate a currency depreciation. The estimated spillover effects are not only statistically significant, but may also be important in terms of magnitude as the Canadian federal government's debt to GDP ratio increased by almost 35 percentage points through the 1980s and early 1990s. The estimates appear reasonable as they explain a large proportion of the variation in provincial government bond yields, pass standard specification tests, and the estimated federal government spillover coefficient is robust to several generalizations of the estimating equations.

While the analysis finds a significant effect of central government debt on provincial government bond yields, the spillover effect associated with debt accumulation by the provinces is not statistically significant. One reason for this may be that an important channel for potential spillover effects, monetary accommodation, is available only to the federal government in Canada. The insignificant coefficient associated with aggregate provincial government debt also suggests that the other provinces are not viewed as a potential source of bailout funds for a province in financial difficulty. An implication of the absence of evidence of provincial government debt spillovers is that spillovers cannot be used to rationalize the imposition of limits on provincial government debt accumulation.

One policy implication of the finding that federal government debt has a significant positive impact on provincial government bond yields is that the imposition of restrictions on central government borrowing may be in the interest of sub-central governments. To our knowledge, the welfare effects of restrictions on *central* government debt accumulation in a federation have not

[33] When the estimated parameters are allowed to differ for the inflation targeting period of 1991–2005, the estimated federal debt coefficient does not change significantly. As a further indication of the stability and robustness of the federal government debt effect, Eqs. (7) and (8) were estimated for each province. While the results are similar to those reported above, the province-specific estimates are much less precise as there are a maximum of only 23 observations for each province, and at least sixteen parameters to estimate for each province (more if there are more individual bond fixed effects).

[34] With these variations in the specification, there is also little change in the coefficients associated with the other debt variables. The coefficient on $OWNDEBT^i$ remains insignificant in every case. The coefficients on PROVDEBT remain individually insignificant in almost every case and the sum of the PROVDEBT coefficients is insignificant in every case.

been explored, although a number of studies have suggested the need for limits on *sub-central* government debt accumulation. It is perhaps noteworthy that the European Union imposes a strict ceiling on European Union expenditures (European Commission, 2005).

The results presented above for Canada show that much of the spillover effect on yields from government debt accumulation comes through a rise in the expected rate of currency depreciation, rather than through an increase in the risk of outright default. Therefore, a major source of debt spillovers is the perceived risk of monetary accommodation. As a consequence, in a monetary union, if the market believes that the central bank is independent and will not be pressured by governments with large debts to inflate, yields may be less likely to rise with central government debt accumulation. This is a potential benefit of central bank independence in a monetary union. A related point is that, due to debt spillovers, the control of monetary policy in a monetary union is important when preferences for anti-inflationary policies differ across potential members of the union and the proposed union's central bank is subject to regional political pressures, as in the model of Debrun, Masson, and Pattillo (2005).

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Appendix A. Variable descriptions and data sources

r_m^i is the provincial government bond yield for a bond with m months to maturity. Calculated as the continuous yield, where the continuous yield is the natural log of (1 + yield). Source: *FT Bonds—Canadian Prices*, Toronto, Financial Post, annual 1998–2005, and *Canadian Bond Prices*, Toronto: Financial Post, annual, 1983–1997. Yields are last business day of April closing bid yields.

To ensure comparability across provincial government bonds, bonds were employed only if they had no distinctly individual characteristics other than yield, maturity date and province of issue. Specifically, from the universe of available bond data, provincial government bonds were excluded if:

1. There was no information on the bond's characteristics in *FP Bonds Government* or *Government Bond Record*.
2. The outstanding quantity did not equal the issued quantity.
3. The bond was callable, redeemable, extendable, retractable, defeased or partially defeased, had a sinking fund that did not commence for several years after the issue date, or if the bond had other characteristics (warrants, options, etc.) that could affect the price.
4. There was no information on interest frequency, issue date or issue amount.
5. The bond was not issued in Canadian dollars.
6. The bond did not have a semi-annual coupon with principal paid at maturity.
7. The bond was issued in exchange for another bond.

Table A1
Provincial bonds included in the sample

Province	Sample years bond used	Maturity date	Coupon (%)
Alberta	1987–1989	18 June 1991	9
	1990–1992	25 February 1993	9.25
	1993–1996	20 August 1997	7
	1997–2002	1 June 2004	6.375
	2003–2005	16 December 2008	5
British Columbia	1984–1992	20 October 1993	12
	1993–2005	19 August 2022	8.75
Manitoba	1983–1986	13 October 1987	13.25
	1987–1994	15 May 1995	11.5
	1995–2005	22 July 2013	8.5
New Brunswick	1983–1987	15 September 1988	5.5
	1988–1992	15 April 1993	10.625
	1993–2005	31 October 2011	10.125
Newfoundland	1983–1987	15 February 1988	7.5
	1988–2005	25 February 2010	9.375
Nova Scotia	1983–1986	30 September 1987	14.25
	1987–1992	1 November 1993	12
	1993–2005	30 January 2022	9.6
Ontario	1983–1985	4 May 1988	10.5
	1986–1988	7 March 1989	11.25
	1991–1995	1 May 1996	10.75
	1996–2005	2 December 2025	8.5
PEI	1983–1991	15 March 1995	9.5
	1992–1996	26 Novermber 1997	11.375
	1997–2005	27 October 2015	8.5
Quebec	1983–1991	22 December 1992	12.75
	1992–2005	10 February 2012	9
Saskatchewan	1983–1986	2 October 1987	9.25
	1987–2002	30 December 2004	9.625
	2003–2005	5 September 2031	6.4

8. The bond had a variable coupon or variable maturity date.
9. The price data listed two bonds with the same coupon and maturity, and so it was not possible to distinguish the bonds.

For each province, the bonds used were those with the longest span of data available. The bonds employed are listed in Table A1. Data were not available for bonds that satisfied the above criteria for all provinces and all periods. Appropriate bond yield data (that is, data that satisfied the nine conditions above) were missing for Alberta (4 years), Ontario (2 years) and British Columbia (1 year). For this reason, the sample is unbalanced and the number of observations is equal to 223 rather than 230.

r_m^C is the Government of Canada bond yield for a bond with m months to maturity. Calculated as the continuous yield, where the continuous yield is the natural log of (1 + yield). The variable r_m^C

Table A2
Provincial and federal government debt/GDP ratios

	1983	1994	2005	Average 1983–2005
FEDDEBT	0.248	0.576	0.305	0.440
PROVDEBT	0.042	0.207	0.145	0.144
$OWNDEBT^i$:				
Alberta	−0.215	0.053	−0.132	−0.086
British Columbia	−0.018	0.054	0.122	0.056
Manitoba	0.120	0.308	0.193	0.217
New Brunswick	0.222	0.282	0.240	0.256
Newfoundland	0.355	0.500	0.312	0.409
Nova Scotia	0.198	0.432	0.370	0.340
Ontario	0.104	0.239	0.209	0.186
PEI	0.156	0.233	0.255	0.210
Quebec	0.094	0.224	0.172	0.181
Saskatchewan	−0.047	0.388	0.165	0.195

is generated as a weighted average of the two closest (in terms of maturity) available Government of Canada yields. The weights are chosen to set the maturity of the Government of Canada bond equal to the maturity of the corresponding provincial bond, with the exception of provincial bonds with maturity equal to 1 month (these were associated with the 1-month Government of Canada bond yield) and bonds with maturity equal to or greater than 10 years (which were associated with the 10-year Government of Canada bond yield). Canadian government bond data are available for 1 month, 3 months, 6 months and 1, 2, 3, 5, and 10 years. (Cansim series numbers: V122529, V122531, V122532, V122533, V122538, V122539, V122540, V122543, respectively.)

r_m^f is the US Treasury bond yield for a bond with m months to maturity. Calculated as the continuous yield, where the continuous yield is the natural log of (1 + yield). The variable r_m^f is generated as a weighted average of the two closest (in terms of maturity) available US Treasury yields. The weights are chosen to set the maturity of the US Treasury bond equal to the maturity of the corresponding provincial bond, with the exception of provincial bonds with maturity equal to or less than 3 months (these were associated with the 3-month US Treasury bond yield) and bonds with maturity equal to or greater than 10 years (which were associated with the 10-year Treasury bond yield). Constant maturity US Treasury bond data are available for maturities of 3 months, 6 months and 1, 2, 3, 5, 7 and 10 years. (US Federal Reserve series numbers: tcm3m, tcm6m, tcm1y, tcm2y, tcm3y, tcm5y, tcm7y, tcm10y, respectively.)

$OWNDEBT^i$ is the province's debt to GDP ratio at the end of the fiscal year (March 31). The data for GDP is from the previous calendar year (as quarterly data is not available by province). Debt is defined as financial assets minus direct liabilities net of liabilities to government employee pension plans. The financial asset data are from Cansim series V151769, V151791, V151724, V151656, V151591, V151636, V151701, V151614, V151678, V151747. The direct liabilities series are: V151776, V151798, V151731, V151663, V151598, V151643, V151708, V151621, V151685, V151754. The liabilities to government pension plans data are from series: V151778, V151800, V151733, V151665, V151600, V151645, V151710, V151623, V151687, V151756. Provincial GDP are from series: V687287, V687299, V687263, V687227, V687191, V687215, V687251, V687203, V687239, V687275.

FEDDEBT is the federal government debt to GDP ratio. Debt is measured as of March 31. GDP is from the previous calendar year to remain consistent with the provincial data. Debt is

measured as financial assets (V151549) minus direct liabilities (V151555) net of liabilities to employee pension plans (V151558). GDP for Canada is given by series V687179.

PROVDEBT is the aggregate debt to GDP ratio for the provinces. The source is the same as for OWNDEBT^i.

$r^{\text{BankR}} - r^{\text{FFR}}$ is the Canadian Bank rate set by the Bank of Canada minus the Federal funds rate of the US Federal Reserve. Cansim series V122530 and V122150, respectively.

$\pi^{\text{Can}} - \pi^{\text{US}}$ is the Canada-US annual inflation differential. The inflation rate is measured from March-to-March. Inflation is calculated using the CPI for both Canada and the US, Cansim series V735319 and V11123, respectively.

$\pi^{\text{Can}}_{-1} - \pi^{\text{US}}_{-1}$ is $\pi^{\text{Can}} - \pi^{\text{US}}$ lagged 1 year.

ΔY^{Can} is the growth rate of real Canadian GDP from the previous year. Derived from Cansim series V3839887.

ΔY^i is the percentage change in real provincial GDP during the previous calendar year. GDP in 1997 constant dollars are from the Cansim series: V3840301, V3840347, V3840209, V3840071, V3839933, V3840025, V3840163, V3839979, V3840117, V3840255.

TRANSFERS^i is the transfers to province i from the federal government during the previous calendar year (as fiscal year data are not available for the entire sample period) divided by total provincial revenues. Transfers are from the Cansim series: V689473, V689496, V689427, V689358, V689289, V689335, V689404, V689312, V689381, V689450. Total revenues are given by the Cansim series: V689466, V689489, V689420, V689351, V689282, V689328, V689397, V689305, V689374, V689443.

MATURITY is the log of months to maturity of the individual provincial bonds. Since bonds can mature on any day of the month, maturity is calculated so that, if a bond matures after the 15th of the month, the month is included as a month to maturity. However, if a bond matures on the 15th or earlier, the month is not counted as a month to maturity. *Source*: Same as for the provincial government bond yield, r^i.

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