Government debt spillovers and creditworthiness in a federation

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Abstract. Estimates are presented for the impact of debt accumulation by the central and subcentral governments of a federation on the creditworthiness of other federation member governments. The estimates, calculated using an ordered probit model and Canadian provincial data, indicate that debt accumulation by the central government has reduced the creditworthiness of indebted provincial governments. Interprovincial debt accumulation effects are negative but relatively small, except for the debt of the largest province, which has a strong positive effect on the creditworthiness of the other provinces. These findings may have implications for other federations and associated jurisdictions, such as the European Union. JEL Classification: H63, F36

Les effets de retombée de la dette gouvernementale et la cote de crédit dans une fédération. On calcule l'impact de l'accumulation de la dette par les gouvernements fédéral et subfédéraux dans une fédération sur la cote de crédit des autres gouvernements de la fédération. Ces calibrations, à l'aide d'un modèle probit en utilisant les données provinciales canadiennes, montrent que l'accumulation de la dette par le gouvernement central a réduit la cote de crédit des gouvernements provinciaux endettés. Les effets trans-provinciaux de l'accumulation de la dette sont négatifs mais relativement faibles, sauf dans le cas de la province la plus grande, laquelle a un fort effet sur la cote de crédit des autres provinces. Ces résultats peuvent avoir des implications pour d'autres fédérations comme l'Union Européenne.

1. Introduction

The expansion of the economic and monetary union in Europe, as well as proposals to transfer more fiscal powers to subcentral governments in, for example, the United

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Kingdom, Spain, France, Italy, Russia, South Africa, the United States, and Canada, have raised numerous questions with respect to the functioning of federal systems. There exists an extensive theoretical and empirical public finance literature that examines interjurisdictional effects of subcentral and central government expenditure and revenue collection programs. In contrast, there is relatively little analysis of the extent to which debt accumulation by the central and subcentral governments of a federation affect the perceived creditworthiness or costs of borrowing of other governments in the federation.[1]

Debt accumulation by one member of a federation may reduce the creditworthiness of other federation governments if there exist implicit or explicit interjurisdictional bailout provisions, interdependent revenue sources, the risk of monetary accommodation, or imperfect information-induced contagion effects. On the other hand, debt accumulation by one government in a federation may improve the perceived creditworthiness of other federation member governments if the cost of information gathering leads lenders to make interjurisdictional yardstick comparisons of fiscal behaviour.

The purpose of the analysis that follows is to evaluate the impact of debt accumulation by individual governments in a federation on the creditworthiness of other members of the federation. Interjurisdictional debt spillover effects on creditworthiness could have important policy and welfare implications for federations as well as for groups of associated countries, such as the European Union and the European Monetary Union (EMU). For example, if the debt accumulation of one government in a federation reduces the creditworthiness of other member governments, bond yields paid by all members of the federation could rise. Furthermore, if each government in the federation takes into account only the interests of its own residents when determining the size of its debt, individual jurisdictions may choose a suboptimal level of debt from the perspective of the federation as a whole. Some observers argue that the 3 per cent deficit-GDP and 60 per cent debt-GDP ratios required for membership in the EMU are meant to prevent these types of suboptimal debt-level choices by member states (Bovenberg, Kremers, and Masson 1991, 375).

The existence of intergovernment debt spillover effects may also have important implications for the success of 'market-based fiscal discipline' as an alternative to binding budget rules for the control of member government borrowing in the EMU (Bishop, Damrau, and Miller 1989). Market discipline encourages fiscal restraint by causing a widening of the differential between the market yields paid by fiscally

1 Government debt accumulation in a federation may have an impact on factors other than creditworthiness, but this issue also has received little attention in the literature. Two exceptions are Beetsma and Uhlig (1999) and Bruce (1995). Beetsma and Uhlig (1999) develop a theoretical model in which inflation spillovers arise because members of a currency union fail to fully internalize the inflationary consequences of their debt policies. Bruce (1995) shows that subcentral government debt accumulation has an interjurisdictional welfare effect because the benefit of subcentral government debt is concentrated on current residents, while, with free migration across jurisdictions, the future cost of this debt is spread across the population of the whole federation.

imprudent and fiscally prudent debtors.[2] For the market to send the correct signal, the yield on government debt should reflect the fiscal policy stance of the borrowing government alone. That is, there should be no 'spillover,' 'contagion,' or 'externality' effects of the debt of one government on the creditworthiness and yields paid by other governments. If markets view subcentral governments in a federation as linked, the yields paid by one government may be affected by the fiscal actions of other governments in the federation. This would reduce the impact of market discipline on the less fiscally prudent members of the federation and impose costs on the federation's more prudent members. As a result, market discipline may not induce the optimal policy response from the standpoint of the federation as a whole.

The existing literature on the relationship between interjurisdictional debt spillovers and creditworthiness or borrowing costs is extremely limited.[3] Lindert and Morton (1989) and Eichengreen (1989) describe cases in which the *default* of one country has affected its neighbour's credit terms. Capeci (1991) includes a variable for 'other county debt' – the debt per capita of other debt issuers in a county – in an equation describing a sample of U.S. municipal credit ratings. The parameter associated with this variable, which Capeci finds to be statistically insignificant, could be interpreted as a measure of debt spillover effects between subcounty jurisdictions (although Capeci does not suggest this interpretation).

The analysis that follows uses pooled cross-section time-series data for Canadian provinces to empirically assess the extent to which the debt accumulation of one government in a federation affects the creditworthiness of other members of the federation. Canadian data are well suited to an analysis of this type for several reasons. First, provincial governments in Canada exert considerable fiscal independence and there are no constitutional restrictions on provincial government borrowing. The presence of borrowing restrictions would limit the extent of debt spillovers and make the potential importance of these spillovers difficult to identify empirically. Second, debt-GDP ratios vary significantly across provinces and across time (from a low of -0.251 to a high of 0.533 between 1974 and 1997). Third, an advantage of employing data for regional governments within a single nation state, as opposed to data for a cross section of countries, is that comparable and consistent output and government debt data are available and institutions are likely to be more similar across jurisdictions. As well, there is no explicit guarantee by other provin-

2 Tanzi (1992) and Lane (1993) argue that the experience of many countries suggests that governments may not respond to higher borrowing costs with a reduction in borrowing as the market discipline hypothesis suggests. On the other hand, Capeci (1994) and Metcalf (1993) show that the bond supplies of U.S. state and local governments exhibit considerable price sensitivity, which is consistent with the market-based fiscal discipline hypothesis.

3 Spillover effects have, however, been considered in other contexts. For example, Eichengreen, Rose, and Wyplosz (1996) find a speculative attack on a currency elsewhere in the world is associated with an increase in the probability of a domestic currency crisis. As well, contagion or externality effects have been examined in markets for private goods: the automobile and pharmaceutical industries by Jarrell and Peltzman (1985); airlines by Borenstein and Zimmerman (1988); banking by Park (1991), Cooperman, Lee, and Wolfe (1992), and Calomiris and Mason (1997); and bankruptcy by Lang and Stulz (1992).

cial governments or the Canadian central government of provincial government debt (one provincial government was permitted to default in 1936, although it did eventually receive federal support; see Bishop, Damrau, and Miller 1989). 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, both of which are conditions that Lane (1993) notes are required for market discipline to work effectively.

In the next section, arguments are provided that link the level of debt issued by one government in a federation to the creditworthiness of the other members of the federation. In section 3 we present the empirical methodology, while the data and empirical specification are described in section 4. The empirical results are discussed in section 5, the importance of debt spillover effects is illustrated in section 6, and concluding remarks are given in section 7. The results of the empirical analysis indicate that an increase in the debt of the central government leads to a fall in the creditworthiness of indebted provincial (subcentral) governments. Interprovincial debt accumulation effects are negative, although small, except for the debt of the largest province (Ontario), which has a strong positive effect on the creditworthiness of the other provinces.

2. Creditworthiness and the spillover effects of government debt

In this section, five explanations are given for the existence of a link between the level of debt issued by one government in a federation and the creditworthiness of the other members of the federation. The rationales for these explanations include the existence of implicit or explicit bailout provisions, the potential for monetary accommodation, the interdependence of government revenues, and imperfect information in credit markets.

2.1. Bailout by other members of a federation

Suppose lenders expect that a borrower, if it has difficulty meeting its debt repayment obligations, will have these obligations covered by a third party. In this case, the creditworthiness of the borrower reflects the ability to pay of the guarantor, while the creditworthiness of the guarantor depends on the magnitude of the debts it has guaranteed. In a federation, if lenders expect that the individual jurisdictions of the federation will be supported by the financial resources of the entire federation – so that the debt of one member becomes, to some extent, the debt of all – the creditworthiness of each member government will depend on the debt obligations of the entire federation.

The expectation of bailout has two consequences for government creditworthiness. First, an increase in the debt of the central government, or any subcentral government, increases the implicit liability of the whole federation and, thereby, reduces the creditworthiness of all governments in the federation. (Similarly, a decrease in the debt of the central government, or a subcentral government, improves the creditworthiness of all governments in the federation.) Second, a debt reduction or debt increase by an individual government in a federation should not affect the government's own creditworthiness by as much as it would if there was no bailout expectation. This follows because, with the expectation of a bailout, an individual government's perceived creditworthiness depends not only on its own debt, but also on the debt of all other governments in the federation.

Perhaps anticipating the possibility of bailout-related debt spillover effects, the European Union included an explicit no-bailout clause (Article 104b) in the Maastricht Treaty (De Grauwe 1997). According to Wyplosz (1997, 14), however, 'Germany has argued that the no-bailout clause cannot be fully credible, that any rule can always be circumvented.' Furthermore, Bovenberg, Kremers, and Masson (1991) suggest that the EMU, by eliminating currency risk, will encourage residents to invest in debt instruments issued by other member governments. This will increase the exposure of their own residents to the financial difficulties of other member governments and raise the pressure on governments to bail out an EMU member in financial distress.[4] As a consequence, even in the presence of an explicit no-bailout clause, lenders may expect there to be some possibility of bailout and, thus, debt accumulation may have a significant interjurisdictional impact on creditworthiness.

2.2. Monetary accommodation

Debt accumulation may increase the market's perception of the risk of monetary accommodation and, therefore, of inflation and devaluation. As a result, in a monetary union, increased debt accumulation by one government (particularly the central government, which is generally the government in control of monetary policy) may cause the creditworthiness of all governments in the federation to fall and borrowing costs to rise.

2.3. Interdependent revenues

To the extent that the economies of the members of a federation are interdependent – as a result of trade flows, for example – a fiscal crisis that reduces income in one jurisdiction is likely to reduce incomes in other jurisdictions as well. This may decrease tax revenues and, thereby, the ability of other governments in the federation to meet their debt service obligations. Hence, since a larger debt increases the probability of a fiscal crisis, a government's creditworthiness should depend on the debt levels of all other governments in the federation.

The larger is the central government's debt, the greater is the likelihood that a negative shock will lead it to cut transfers to lower-level governments. A cut in transfers increases the probability that a lower-level government will have difficulty

4 The experience of another federation, the United States, appears to contradict this view, since the default of a number of American states in the 1840s did not lead the federal government to bail out debtholders resident in non-defaulting states. According to English (1996), however, in many cases debt held by out-of-state residents was held in Europe, chiefly London, rather than by residents of other American states. As well, English (1996) notes that the small relative size of the United States government in the pre-Civil-War era provided much less scope for intervention than governments would have today.

meeting its debt obligations. Thus, an increase in central government debt is likely to lead to a reduction in the creditworthiness of subcentral governments.

2.4. Information effects: information contagion

Lane (1993) and Ter-Minassian and Craig (1997) note that, in the absence of complete information, lenders may perceive that the debt-servicing difficulties of one borrower signal impending problems with similar borrowers. This type of information contagion may be stronger for the members of a federation or a currency union, since creditors may view these jurisdictions as sharing many characteristics. Thus, if one government in a federation raises its debt level and, thereby, increases its probability of default, lenders may view this as a signal that other member governments will do the same. As a result, the perceived probability of default for all governments in the federation may rise and their perceived creditworthiness fall.

The information contagion effect described here is similar to the concept of collective reputation presented in Tirole (1996), where consumers predict a firm's quality using information on the quality of the goods produced by similar firms. Although he also does not explicitly address the issue of debt contagion, Shiller (1995) develops a model, consistent with information contagion effects, in which the reaction of one market to new information provides a signal to agents in other markets.

2.5. Information effects: yardstick comparisons

If information is costly to acquire, lenders may not know whether a borrower's fiscal behaviour is reasonable, in the sense of ensuring that the borrower will meet its financial obligations. For example, lenders may have imperfect knowledge of the debt-GDP ratio that yields a given probability of repayment for a particular type of borrower. As a result, lenders may evaluate the fiscal performance of a borrower using the performance of a similar borrower or group of borrowers, for whom they have more information, as a 'yardstick' or benchmark. Lenders would then penalize or reward borrowers to the extent that they diverge from this benchmark.[5]

If lenders use yardstick comparisons, a government's perceived creditworthiness would depend on the debt accumulation of the governments with which it is deemed to be comparable. Since the members of a federation or a currency union are likely to be viewed as similar, yardstick comparisons would cause the creditworthiness of the federation's members to be interdependent. In contrast to the information contagion effect described above, whereby an increase in the debt of one government leads to a *decrease* in the perceived creditworthiness of governments in similar

5 Empirical evidence on the use of yardstick comparisons in a different context is provided by Case (1993) and Besley and Case (1995), who find that voters employ yardstick comparisons to evaluate the performance of U.S. state governors. Shleifer (1985) discusses the use of yardstick comparisons for the case of a regulated monopoly when the regulator has incomplete information on a firm's operating costs. Under Shleifer's regulatory scheme, the regulator uses the costs of comparable firms to infer a firm's attainable cost level.

circumstances, with yardstick comparisons, an increase in the debt of one government *enhances* the *relative* creditworthiness of comparable governments.

2.6. Summary: creditworthiness and debt accumulation in a federation
The bailout, interdependent revenues and information contagion rationales discussed above imply that the creditworthiness of each subcentral government in a federation falls with an increase in the debt of other subcentral governments in the federation. In contrast, if lenders use yardstick comparisons, an increase in the debt of one subcentral government causes the creditworthiness of other subcentral governments in the federation to rise. Thus, the net effect of subcentral government debt on the creditworthiness of other subcentral governments in a federation is positive if the yardstick comparison effect dominates the bailout, revenue interdependence, and contagion effects; negative if the reverse is true; and zero if the two effects are equally balanced in magnitude or if none of these factors is a significant determinant of creditworthiness. In contrast, the impact of central government debt accumulation on subcentral government creditworthiness is predicted to be unambiguously negative, owing to the bailout, revenue independence, and monetary accommodation rationales given above.

3. The empirical methodology

3.1. Measures of government creditworthiness
To investigate the magnitude of government debt spillovers on creditworthiness, we need a measure of subcentral government creditworthiness. Government bond yields provide one indicator of creditworthiness. This measure is not practicable, however, because sufficient comparable data on the yields of individual subcentral government bonds, including Canadian provincial (subcentral) government bonds,[6] are not available. The approach taken here is to use data on a direct measure of creditworthiness: credit ratings. A number of studies have examined the impact of own-government debt (and other factors) on a government's credit rating. These include Liu and Thakor (1984), Feder and Uy (1985), Capeci (1991), Lee (1993), Uyar and Escarraz (1995), Haque et al. (1996), Cantor and Packer (1996), Cheung (1996), and Badu and Daniels (1997). One advantage of credit ratings data is that they are readily available. A second advantage is that, for country-level data, credit ratings tend to be highly correlated with bond yields (Cantor and Packer 1996).

3.2. An empirical model of creditworthiness and credit ratings
To examine the relationship between debt spillovers and creditworthiness using credit ratings data, it is necessary to specify an empirical model that relates gov-

6 The situation is similar in the United States, where Bayoumi, Goldstein, and Woglom (1995) note that market yields on most state general obligation bonds are not readily available since these bonds are not actively traded.

ernment debt to creditworthiness and creditworthiness to credit ratings. To begin, let the continuous random variable, y_k^*, represent the creditworthiness of a jurisdiction at a point in time determined by a credit-rating agency (so k identifies observations that differ either by jurisdiction or time period). This measure of creditworthiness, which is observed only by the rating agency, is a linear function of a vector of observable (by everyone) variables that are associated with interjurisdictional debt spillovers, S_k; a vector of observable variables that are *not* associated with interjurisdictional debt spillovers, X_k; and an unobservable (by everyone but the credit-rating agency) variable, ϵ_k:

$$y_k^* = S_k'\psi + X_k'\beta + \epsilon_k, \tag{1}$$

where

$$E(\epsilon_k | S_k, X_k) = 0, \qquad E(\epsilon_k \epsilon_i) = 0 \ \forall \ k \neq i, \qquad \epsilon_k \sim N(0, \sigma_k^2), \qquad k = 1, \ldots, n,$$

and ψ and β are vectors of constant parameters. The elements of the vector ψ determine the magnitude of the impact of the spillover variables on creditworthiness.

The variance of ϵ_k depends on a vector of observable variables, Z_k:

$$\sigma_k^2 = [\exp(Z_k'\alpha)]^2, \tag{2}$$

where α is a vector of parameters. This variance is constant (and equal to one) if all the elements of the vector α are zero.

The creditworthiness equation, equation (1), cannot be estimated directly because the creditworthiness index, y_k^*, is not observable. One method of proceeding is to note that the credit-rating agency maps the continuous variable y_k^* into one of m observable credit ratings, y_k, as follows:

$$y_k = \begin{cases} R_0 & \text{if } -\infty < y_k^* \leq 0 \\ R_1 & \text{if } 0 < y_k^* \leq \gamma_1 \\ \vdots & \vdots \\ R_{m-2} & \text{if } \gamma_{m-3} < y_k^* \leq \gamma_{m-2} \\ R_{m-1} & \text{if } \gamma_{m-2} < y_k^* < \infty, \end{cases} \tag{3}$$

where m is a finite integer equal to the discrete number of credit-rating categories used by the credit-rating agency. The highest credit rating is represented by R_{m-1} (thus a larger value of the creditworthiness index corresponds to a higher credit rating), while the γ_i parameters represent the levels of the creditworthiness index that act as partitions between credit rating categories ($0 < \gamma_1 < \ldots < \gamma_{m-3} < \gamma_{m-2}$).

The probability that y_k will equal a particular credit rating, R_j, given S_k, X_k, and Z_k, is

$$
\begin{aligned}
&P(y_k = R_j, j = 0, \ldots, m-1 \mid S_k, X_k, Z_k) \\
&= \begin{cases} P(S_k'\psi + X_k'\beta + \epsilon_k \leq \gamma_j \mid S_k, X_k, Z_k) & \text{for } j = 0 \\ P(\gamma_{j-1} < S_k'\psi + X_k'\beta + \epsilon_k \leq \gamma_j \mid S_k, X_k, Z_k) & \text{for } 1 \leq j \leq m-2 \\ P(\gamma_{j-1} < S_k'\psi + X_k'\beta + \epsilon_k \mid S_k, X_k, Z_k) & \text{for } j = m-1 \end{cases} \\
&= \begin{cases} P(\epsilon_k \leq \gamma_j - S_k'\psi - X_k'\beta \mid S_k, X_k, Z_k) & \text{for } j = 0 \\ P(\gamma_{j-1} - S_k'\psi - X_k'\beta < \epsilon_k \leq \gamma_j - S_k'\psi - X_k'\beta \mid S_k, X_k, Z_k) & \\ & \text{for } 1 \leq j \leq m-2 \\ P(\gamma_{j-1} - S_k'\psi - X_k'\beta < \epsilon_k \mid S_k, X_k, Z_k) & \text{for } j = m-1 \end{cases} \\
&= \begin{cases} \Phi\left(\dfrac{\gamma_j - S_k'\psi - X_k'\beta}{\sigma_k}\right) & \text{for } j = 0 \\ \Phi\left(\dfrac{\gamma_j - S_k'\psi - X_k'\beta}{\sigma_k}\right) - \Phi\left(\dfrac{\gamma_{j-1} - S_k'\psi - X_k'\beta}{\sigma_k}\right) & \\ & \text{for } 1 \leq j \leq m-2 \\ 1 - \Phi\left(\dfrac{\gamma_{j-1} - S_k'\psi - X_k'\beta}{\sigma_k}\right) & \text{for } j = m-1. \end{cases}
\end{aligned} \tag{4}
$$

where $\Phi(\cdot)$ is the standard normal cumulative density function and γ_0 equals zero.

Equation (4) takes the form of the standard ordered probit model. For n observations on the credit rating variable, y_k, the likelihood function associated with this model is

$$
\mathcal{L} = \prod_{k=1}^{n} \left(\left(1 - \Phi\left(\frac{\gamma_{m-2} - S_k'\psi - X_k'\beta}{\sigma_k} \right) \right)^{D_{m-1,k}} \prod_{j=1}^{m-2} \left(\Phi\left(\frac{\gamma_j - S_k'\psi - X_k'\beta}{\sigma_k} \right) - \Phi\left(\frac{\gamma_{j-1} - S_k'\psi - X_k'\beta}{\sigma_k} \right) \right)^{D_{jk}} \left(\Phi\left(\frac{-S_k'\psi - X_k'\beta}{\sigma_k} \right) \right)^{D_{0k}} \right),
$$

where D_{ik} is an indicator variable that takes on a value of one if the credit rating for observation k is R_i and a value of zero otherwise. This form of the likelihood function takes into account both the discrete nature of credit ratings as well as their natural ordering, and its parameters, including the vector of spillover parameters ψ, can be estimated given data on y_k, S_k, X_k, and Z_k.[7]

7 Discussions of the ordered probit model and the properties of ordered probit estimates are provided in Hausman, Lo, and MacKinlay (1992), McKelvey and Zavoina (1975), Becker and Kennedy (1992), Davidson and MacKinnon (1993), and Greene (1997). Several authors use ordinary least squares to estimate credit rating equations (Lee 1993; Cantor and Packer 1996), even though

4. The data and empirical specification

4.1. The data

Annual data from 1974 to 1997 for nine Canadian provinces are used to estimate the parameters of the model. Although there are ten Canadian provinces, Prince Edward Island is not rated by Standard and Poor's, the source of the credit rating data used here.[8] The sample begins in 1974, because in this year Standard and Poor's began using pluses and minuses to augment its Canadian provincial government credit ratings.

A rating agency can change a jurisdiction's credit rating at any time, but provincial output and government spending data are available only on an annual basis. In order to combine these annual economic data with the continuous credit ratings data, the empirical analysis uses credit ratings at the end of each year. By this date, the previous fiscal year's results were available, and, for every year of the sample, the budgets for the current fiscal year of all nine provinces had been released (while not all budgets had been released by the end of November). Since end-of-year credit ratings are employed, all the other variables used in the empirical analysis were specified so that they could have been observed by the credit rating agency at the end of the year. (Appendix A provides a detailed description of the data and data sources.)

The twenty-four years of data for the nine provinces yield a sample of 216 observations covering eight different credit-rating categories. As can be seen from table 1A in appendix A, these observations are spread relatively uniformly across the eight credit rating categories. During the sample period, there were thirty-five changes in the credit ratings of the nine provinces – twenty-three downgrades and twelve upgrades. While most of the thirty-five changes involved a move of only one category, five changes involved more than one category. In addition, each province had at least three different credit ratings during the period examined.

The analysis of the impact of debt and debt spillovers on government credit ratings requires data on the level of government debt. In this study, 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 used here because they are likely to be of a different nature than other direct government liabilities. For example, since government bonds are not issued against these liabilities, it may be easier for a government to renege on these commitments than to renege on their bond liabilities. In addition, the employee

credit ratings are naturally discrete. Ordinary least squares estimation treats differences between rating levels as cardinal, yields estimates of marginal effects, which are difficult to interpret when the dependent variable is discrete, and also entails distributional assumptions (to facilitate inference), which are inappropriate when the dependent variable is discrete (see McKelvey and Zavoina 1975; Hausman, Lo and MacKinlay 1992; Greene 1997).

8 Using data for U.S. municipalities, Moon and Stotsky (1993) find some differences in the economic determinants of Standard and Poor's and Moody's credit ratings, but they note that there is a high and significant correlation between the two sets of ratings.

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.

4.2. The spillover variables

The impact of the debt accumulation of other governments on a jurisdiction's creditworthiness is captured by the term $S_k'\psi$ in equation (1). Following the discussion in section 2, the vector S_k should include variables that represent the debt exposure of governments (both central and subcentral) other than the government of the jurisdiction for which observation k applies. The debt exposure of the federal government is represented in the vector S_k by the federal government's debt-GDP ratio, FEDDEBT.

The impact of federal government debt on provincial creditworthiness, through the central government's bailout role, is likely to be more significant the larger a province's debt and is likely to be relatively unimportant for provinces with positive net wealth. To capture this effect, the federal debt variable (FEDDEBT) is interacted with the provincial debt to GDP ratio, DEBT, to create an additional explanatory variable, DEBTFEDDEBT, that is set equal to zero for observations in which provincial government net wealth is positive.

In order to maintain a parsimonious specification for the estimating equation, a single aggregate variable, DEBTAGG, is used to represent the debt exposure of the other provinces. This variable is the weighted average of the debt-GDP ratios of all the provinces, other than the province associated with observation k, with the weights given by each province's share of total GDP. This weighting scheme is equivalent to summing the debts of the other provinces and dividing the sum by total GDP.[9]

The provinces of Ontario and Quebec are much larger than the other seven provinces – Ontario accounts for 40 per cent of national GDP and Quebec for 22 per cent. Given the importance of the two largest provinces in the national economy, the debt of these provinces could have a different impact than the debt of the smaller provinces on the creditworthiness of the remaining provinces. To allow for this

9 The empirical conclusions generally are unaffected if the debts of the other provinces are weighted equally or if they are weighted by the square of their share of GDP. The definition of DEBTAGG implicitly assumes that the effect of one province's debt (adjusted for its share of GDP) on each of the other provinces is the same for all eight of the other provinces. An alternative approach would be to assume that debt spillover effects extend only to 'neighbours' – provinces located in the same region or with similar income levels. This is similar to the idea of neighbourhood effects raised in Case (1993) and Besley and Case (1995) and might be appropriate if there exist regional revenue interdependencies or if provinces from the same regions, or with similar income levels, are grouped by credit-rating agencies. Preliminary estimates indicated, however, that these neighbourhood effects were statistically insignificant determinants of creditworthiness.

possibility, variables representing the debt-GDP ratios (weighted by their share of GDP) of Ontario, DEBTONT, and Quebec, DEBTQUE, were included separately in the vector S_k. So that these variables capture only the effects of Ontario and Quebec debt on the *other* provinces, the variable DEBTONT takes a value of zero for those observations associated with Ontario, while DEBTQUE takes a value of zero for those observations associated with Quebec. (The effect of the debt levels of Ontario and Quebec on their own creditworthiness comes through the variable DEBT, which is described below.)

The spillover variables described above imply that the debt spillover component of the creditworthiness equation, $S_k'\psi$, takes the form

$$S_k'\psi = \psi_1 FEDDEBT_k + \psi_2 DEBTFEDDEBT_k + \psi_3 DEBTAGG_k + \psi_4 DEBTONT_k + \psi_5 DEBTQUE_k. \quad (5)$$

4.3. The non-spillover explanatory variables

To determine the magnitude of debt spillover effects on creditworthiness, it is necessary to control for non-spillover factors (the elements of the vector X_k) that may lead to interjurisdictional differences in creditworthiness.[10] In theoretical discussions, the identification of the non-spillover variables that determine creditworthiness or default risk follow two main approaches. The first focuses on the debt service capacity of a government. In this approach, default occurs because of unexpected changes in economic circumstances that make it impossible for a government to service its debt (Sachs 1981; Frenkel and Razin 1996). Variables that would be expected to capture changes in the probability of future insolvency include factors that influence government expenditures and revenues, as well as the level of government debt.

A second approach to modelling sovereign default begins with the observation that lenders to a government, unlike lenders to an individual, generally do not have the legal means to seize government assets in the event of default. In this situation, debt repayment occurs if the cost of default, such as the possibility of exclusion from future loans, exceeds the cost of repayment (Eaton and Gersovitz 1981; Eaton, Gersovitz, and Stiglitz 1986; Bulow and Rogoff 1989; Eaton 1996). Indicators of default risk consistent with this approach include factors that increase the benefits and reduce the costs of default. In particular, a larger outstanding debt raises default risk by increasing the benefit of default.

The non-spillover explanatory variables used in the empirical analysis below were chosen to reflect these two views of default risk, as well as to represent the determination of a province's creditworthiness in a parsimonious fashion. The debt exposure of a province, a determinant of both the risk of insolvency and the benefit

10 While Standard and Poor's does issue a guide that identifies variables that have an impact on its credit ratings, the list of relevant factors is too long to be empirically practical, some of the criteria listed are not quantifiable, and the weights placed on the different factors are not provided (Cantor and Packer 1996).

of default, is represented by the province's debt-GDP ratio (DEBT) at the end of the previous fiscal year.

Real GDP per capita, Y, is included as an explanatory variable in the creditworthiness equation because a higher income jurisdiction is likely to have more revenue flexibility (and, thus, a lower probability of insolvency) and may face higher default costs (for example, in terms of lost income opportunities). The use of a per capita income variable and the debt-GDP ratio is standard in the sovereign creditworthiness literature (see Edwards 1984; Bayoumi, Goldstein, and Woglom 1995; Cantor and Packer 1996).

While government employee pension liabilities may be less accurately measured and easier to abrogate than other government direct liabilities, it is possible that these liabilities may, nevertheless, have an impact on government creditworthiness. To examine this possibility, a variable representing the ratio of these liabilities to provincial GDP, PENSION, is included as a non-spillover explanatory variable.

The creditworthiness of a jurisdiction may also depend on social, political, economic or institutional characteristics that are specific to a jurisdiction but are constant over time. To represent these factors, the creditworthiness equation includes dummy variables for eight of the nine provinces – DNF (Newfoundland), DNS (Nova Scotia), DNB (New Brunswick), DQ (Quebec), DM (Manitoba), DS (Saskatchewan), DA (Alberta), and DBC (British Columbia).

Given the discussion above, the non-spillover term $X_k'\beta$ in the creditworthiness equation can be written

$$X_k'\beta = \beta_0 + \beta_1 DEBT_k + \beta_2 Y_k + \beta_3 PENSION_k + \beta_4 DNF_k + \beta_5 DNS_k + \beta_6 DNB_k + \beta_7 DQ_k + \beta_8 DM_k + \beta_9 DS_k + \beta_{10} DA_k + \beta_{11} DBC_k. \quad (6)$$

In order to examine the appropriateness of this parsimonious specification, the model was augmented with seven types of additional explanatory variables that might be expected to affect a province's creditworthiness. Since none of these proved to have statistically significant explanatory power, however, they have not been included in equation (6). Descriptions of these variables, as well as the rationales for including them in the estimating equation, are provided in appendix B, section B2.

4.4. The variance specification

To estimate the parameters of the model described by equation (4), we need to specify the vector of variables Z_k that determine the variance of the creditworthiness index (given by equation (2)). In most empirical applications of the ordered probit model, the variance is assumed to be constant (Hausman, Lo, and MacKinlay 1992 is an exception). Since the data set used here includes observations for nine different jurisdictions, however, it may be inappropriate to impose a variance that is constant across provinces. To allow the variance to differ by province, provincial dummy variables are used as the elements of the vector Z_k.

5. Parameter estimates

Table 1 reports parameter estimates[11] for the creditworthiness model described above, as well as for two versions of the model that restrict the parameters of either the Quebec or the Quebec and Ontario debt spillover variables (DEBTQUE and DEBTONT) to be zero. The general specification appears to be reasonable for all three versions of the model. Many of the parameters are statistically significant, the pseudo-R^2 ranges from 0.592 to 0.613 and, for the specifications of columns II and III, the model correctly predicts just under 70 per cent of the actual credit ratings. The model also predicts relatively well out of sample, as discussed in appendix B, section B3. If all the parameters except the constant, the partition parameters, the variance parameters, and the parameters associated with the provincial dummy variables are restricted to be zero, the psuedo-R^2 falls to 0.32 and a joint test of the zero restrictions is decisively rejected.[12] As well, likelihood ratio tests of the significance of the second, third, and fourth powers of the predicted value of the creditworthiness index ($\hat{y}^*$), as in the standard RESET test, indicate that the linear specification of the creditworthiness equation is not rejected.[13] Additional discussion of the robustness of the estimates, as well as the specification of the variance function, is provided in appendix B.[14]

The estimates in table 1 indicate that per capita income (Y) has a statistically significant positive effect on a province's creditworthiness index (y^*), while a province's own debt-GDP ratio has a negative impact on its creditworthiness, as does the ratio of its own employee pension liabilities to GDP.[15] The negative estimates of the fixed effect parameters, all of which are statistically significant, imply that the eight

11 All estimates were calculated using the LIMDEP 7.0 econometric program.

12 Using the estimates of column II in table 1, the χ^2 test statistic associated with this restriction is 235.5, while the 5 per cent critical value is 14.07 with seven degrees of freedom.

13 Pagan and Vella (1989) suggest that a test that augments the vector of explanatory variables with powers of $\hat{y}^*$ also provides a test for normality in the probit model. Another method of examining the importance of the normality assumption is to re-estimate the model assuming that the errors have a logistic distribution. This re-estimation yields ordered logit parameter estimates that lead to the same conclusions as the ordered probit estimates.

14 The estimates in table 1 include only two provincial dummy variables in the variance specification because the other provincial dummy variables were statistically insignificant determinants of the variance. The signs and significance (at the 95 per cent confidence level) of the spillover and non-spillover parameters (except for those of the fixed effects) reported in table 1 are unchanged if the variance is restricted to be one (i.e., if the vector α equals zero).

15 The estimated negative own-debt effect is consistent with numerous empirical studies that have found that either the credit rating of a jurisdiction falls or the yield on its debt rises with the quantity of own debt outstanding. This result has been found both for independent countries (Edwards 1984; Feder and Uy 1985; Ben-Bassat and Gottlieb 1992; Lee 1993; Cantor and Packer 1996) and for subcentral governments in a federation (Liu and Thakor 1984; Capeci 1991; Goldstein and Woglom 1992; Moon and Stotsky 1993; Metcalf 1993; Capeci 1994; Eichengreen and Bayoumi 1994; Bayoumi, Goldstein, and Woglom 1995; Cheung 1996; Mattina and Delorme 1997). Not all empirical studies, however, have found a relationship between credit ratings or bond yields and the level of government debt (Feder and Just 1977; Sachs 1981).

TABLE 1
Parameter estimates with government debt spillover effects

		I	II	III
β_0	: Constant	24.993	23.278	22.590
		(3.26)	(3.35)	(3.22)
β_1	: DEBT	−10.534	−15.226	−15.526
		(2.19)	(3.57)	(3.49)
β_2	: Y	0.4940	0.4922	0.4885
		(3.02)	(2.93)	(2.88)
β_3	: PENSION	−9.166	−12.250	−11.117
		(1.80)	(2.46)	(2.17)
Debt spillover effects				
ψ_1	: FEDDEBT	0.1847	2.438	2.036
		(0.05)	(0.75)	(0.62)
ψ_2	: DEBTFEDDEBT	−58.277	−45.909	−46.951
		(4.10)	(3.31)	(3.33)
ψ_3	: DEBTAGG	3.754	−28.510	−35.621
		(0.58)	(2.30)	(2.59)
ψ_4	: DEBTONT		65.565	63.465
			(3.22)	(2.97)
ψ_5	: DEBTQUE			46.767
				(0.98)
Fixed effects				
β_4	: DNF	−8.372	−8.640	−8.346
		(2.81)	(3.03)	(2.97)
β_5	: DNS	−12.734	−13.969	−13.630
		(3.62)	(4.19)	(4.06)
β_6	: DNB	−3.530	−5.309	−4.942
		(1.78)	(2.74)	(2.56)
β_7	: DQ	−3.298	−6.211	−4.612
		(2.81)	(3.81)	(2.22)
β_8	: DM	−3.754	−6.276	−5.736
		(3.10)	(4.17)	(3.78)
β_9	: DS	−10.712	−12.164	−11.826
		(3.44)	(4.20)	(4.04)
β_{10}	: DA	−7.182	−8.765	−8.408
		(5.20)	(6.52)	(6.08)
β_{11}	: DBC	−3.511	−5.313	−4.946
		(3.80)	(5.12)	(4.58)
Variance parameters				
α_1	: DS	2.111	1.988	1.986
		(4.77)	(4.37)	(4.31)
α_2	: DNB	1.562	1.370	1.406
		(4.24)	(3.64)	(3.73)

continued

TABLE 1 *continued*

	I	II	III
Partition parameters			
γ_1	11.347	9.736	9.889
	(3.90)	(3.57)	(3.58)
γ_2	15.334	13.271	13.413
	(4.06)	(3.81)	(3.76)
γ_3	22.238	19.398	19.660
	(4.17)	(4.06)	(4.01)
γ_4	26.100	23.110	23.537
	(4.24)	(4.11)	(4.08)
γ_5	30.387	28.129	28.322
	(4.39)	(4.37)	(4.33)
γ_6	31.814	29.721	29.921
	(4.53)	(4.55)	(4.50)
Log of the likelihood	−166.90	−159.45	−158.27
Pseudo-R^{2a}	0.592	0.610	0.613
Percent correct predictions[b]	0.657	0.681	0.685
RESET test[c]			
$\hat{y}^{*2}$	2.18†	1.18†	1.43†
$\hat{y}^{*2}, \hat{y}^{*3}$	3.00†	4.99†	5.08†
$\hat{y}^{*2}, \hat{y}^{*3}, \hat{y}^{*4}$	4.51†	5.00†	5.22†

NOTE: The number in brackets under each parameter estimate is the asymptotic t-statistic associated with that estimate.

a The Pseudo-R^2 is calculated as $1 - L^U/L^R$, where L^U is the log-likelihood of the model for which the Pseudo-R^2 is being calculated and L^R is the log of the likelihood of a model that includes only the constant, the six partition parameters, and the variance parameters.

b The predicted category for each observation is the category with the highest predicted probability.

c These are likelihood ratio test statistics. They have a χ^2 distribution with one, two, and three degrees of freedom, respectively.

† Cannot reject the restriction that the coefficient(s) on the power(s) of $\hat{y}^*$ are zero at a 5 per cent level of significance.

smaller provinces are assigned lower values of the creditworthiness index than Ontario, ceteris paribus.[16]

The estimates in table 1 indicate that the federal debt to GDP ratio (FED-DEBT) has a statistically insignificant impact on provincial creditworthiness. However, the estimated parameter associated with the provincial debt-federal debt interactive variable, DEBTFEDDEBT (ψ_2), is negative and statistically significant in all three cases. This implies that, for provinces with a positive debt-GDP ratio, a larger federal debt-GDP ratio contributes to a reduction in provincial creditwor-

16 The signs of the estimated parameters in table 1 indicate the direction of the impact of the explanatory variables on the creditworthiness index, y^*, the variable of interest. However, the signs of the parameter estimates indicate only the impact on the *probability* of being in the *highest* and *lowest* credit-rating categories. On the interpretation of the parameters of ordered probit models see Becker and Kennedy (1992) and Greene (1997).

thiness, an effect that is greater the larger is the provincial debt-GDP ratio.[17] A corollary to this result is that a province's own debt-GDP ratio has a negative effect on its creditworthiness through the interactive variable DEBTFEDDEBT in addition to the direct effect through the variable DEBT. The statistically significant negative estimates of the DEBTFEDDEBT parameter are consistent with federal debt spillover effects on provincial creditworthiness as suggested by the bailout, interdependent revenues, and monetary accommodation hypotheses described in section 2, above.

The aggregate debt of the other provinces (DEBTAGG) has a statistically significant negative impact on a province's creditworthiness in the models of columns II and III in table 1. This result provides evidence that there exist interprovincial negative debt spillover effects (due, perhaps, to bailout provisions, interdependent revenues, or contagion effects).

If the spillover effect associated with the debt of Ontario is not restricted to be the same as that of the other provinces through the inclusion of DEBTONT in the estimating equation (see columns II and III of table 1), the debt of Ontario has a positive and statistically significant effect on the creditworthiness of the other provinces. This result is consistent with the use of Ontario's debt as a benchmark for yardstick comparisons. As the Ontario government expands its debt-GDP ratio, the other provincial governments look *relatively* better in terms of credit risk and so receive higher creditworthiness ratings. On the other hand, the spillover effect of Quebec government debt does not differ significantly from the aggregate effect, as indicated by the statistically insignificant parameter estimate associated with the Quebec government debt-GDP ratio, DEBTQUE (column III of table 1.) If the debt-GDP ratios of the next two provinces by size – British Columbia and Alberta, which account for 13 and 11 per cent of GDP, respectively – are included individually in the estimating equation, they also do not have an impact on the creditworthiness of the other provinces that is significantly different from that of the variable DEBTAGG.

The statistical significance of the debt spillover variables in table 1 suggests that these variables are important determinants of provincial creditworthiness. If all the debt spillover variables are deleted from the estimating equation, the pseudo-R^2 and the value of the log of the likelihood function decline (to 0.519 and -196.77, respectively), and a test of the hypothesis that the spillover coefficients (the ψ parameters) are jointly zero would be decisively rejected.

6. The magnitude of the debt spillover effects

The results in table 1 suggest that provinces suffer a negative spillover effect from an increase in the size of the federal debt; a positive 'yardstick' effect from an

17 The variable DEBTFEDDEBT is equal to zero for those observations in which DEBT is negative (a province has positive net wealth). If an equivalent interactive variable for observations in which DEBT is negative is included in the estimating equation, the estimated parameter associated with this variable is statistically insignificant.

TABLE 2
Creditworthiness elasticities

Creditworthiness elasticity with respect to:	
Own debt[a]	−0.2664
Federal government debt[b]	−0.1128
Debt of provinces other than the province itself and Ontario[c]	−0.0535
Debt of Ontario[d] (applies only to provinces other than Ontario)	0.0907

NOTE: The values in this table are calculated at the means of the explanatory variables. Each elasticity is the percentage point change in $\hat{y}^*$ following a 1 per cent increase in the variable indicated, using the parameter estimates from column II of table 1.

a This elastitity takes into account the direct effect of the variable DEBT (through β_1) as well as the interactive effect through the variable DEBTFEDDEBT (associated with ψ_2).

b This elasticity takes into account the direct effect of the variable FEDDEBT (associated with ψ_1) as well as the interactive effect (associated with ψ_2) that comes through the variable DEBTFEDDEBT.

c This is the elasticity with respect to the variable DEBTAGG when Ontario's contribution to DEBT-AGG is held constant.

d This elasticity takes into account the direct effect of Ontario's debt through the variable DEBTONT (as indicated by ψ_4) as well as its effect through the variable DEBTAGG.

increase in the debt of Ontario; and a negative spillover effect from an increase in the debt levels of the other provinces. In this section we present two methods of comparing the magnitudes of these debt spillover effects.

6.1. Debt spillover elasticities

One method that can be used to examine the relative magnitudes of the estimated debt spillover effects is a comparison of the elasticities of the predicted creditworthiness index, $\hat{y}^*$, with respect to the own-debt and debt spillover variables. These elasticities are presented in table 2. The own-debt elasticity is the largest (in absolute value) of the four elasticities, although the federal government debt elasticity is almost half as large. While the elasticity with respect to the debt of the other provinces (i.e., the provinces other than the province itself and Ontario) is relatively small, the elasticity with respect to the debt of Ontario (for provinces other than Ontario) is one-third the size of the own-debt elasticity. These elasticities suggest that, while a province's own debt is the predominant determinant of its creditworthiness, the federal debt and Ontario's debt may also have relatively large effects on creditworthiness.

6.2. Debt spillover effects and predicted credit ratings

A second method of illustrating the importance of the debt spillover variables is to simulate the change in the proportion of observations predicted to be in each credit rating category following a change in the level of each debt variable. Column I of table 3 lists the proportion of observations in each of the eight credit rating categories as predicted by the model of column II, table 1. The remaining columns in table 3 give the changes in these predicted proportions following a 10 per cent

TABLE 3
Changes in predicted credit rating category proportions due to a 10 per cent increase in debt

	I	II	III	IV	V
		Change in predicted proportion due to a 10 per cent increase in:			
Credit rating category	Proportion in each category predicted by the model of column II, table 1	Own debt	Federal government debt	'Other' provinces' debt (except Ontario)	Ontario debt (Ontario as the 'other' province)
AAA	0.0833	−0.0046	0	−0.0046	0.0093
AA+	0.0972	−0.0046	0.0046	0	0.0093
AA	0.2269	−0.0046	−0.0093	0.0046	−0.0185
AA−	0.0787	0.0046	0.0046	0	0.0046
A+	0.2870	0	−0.0093	−0.0046	0.0046
A	0.0880	−0.0185	0	0	−0.0046
A−	0.1204	0.0093	−0.0093	0.0046	−0.0046
BBB+	0.0185	0.0185	0.0185	0	0
Observations predicted to move categories as a percentage of all observations[a]		9.3	4.6	1.9	4.6

NOTE: Each column of changes in the predicted proportions must sum to zero. For provinces with positive net wealth (negative debt) the predicted change is for a 10 per cent decline in net wealth.
a This is calculated using the change in the predicted proportion for each category and assuming that each observation moves at most one category.

increase in the debt levels of the province, the federal government, all other provinces except Ontario, and Ontario (when Ontario is the 'other' province), respectively.

As would be expected given the parameter estimates in table 1, table 3 shows that a 10 per cent increase in a province's own debt, the federal debt, or the debt of the other provinces except Ontario causes a general movement of provincial credit ratings out of the higher ratings and into the lower credit-rating categories. In contrast, a 10 per cent increase in the debt of Ontario (when Ontario is the 'other' province) generally moves the provincial ratings towards the higher categories.

As is the case for the debt elasticities given in table 2, the largest effect observed in table 3 corresponds to a change in a province's own debt. Specifically, a 10 per cent increase in a province's own debt leads 9.3 per cent of the observations to change credit rating categories. As well, both a 10 per cent increase in the federal debt and a 10 per cent increase in the debt of Ontario cause 4.6 per cent of the observations to move between categories. In contrast, a 10 per cent increase in the debt of the other provinces (excluding Ontario) has a relatively small effect. In this case, only 1.9 per cent of the observations change category.

7. Concluding comments

The results presented above indicate that there are significant interjurisdictional government debt spillover effects on creditworthiness in the Canadian federation. An increase in the debt of the federal (central) government reduces the creditworthiness of indebted provincial (subcentral) governments, while an increase in the debt of the largest province (Ontario) improves the creditworthiness of the other provincial governments. The spillover effect on creditworthiness of the debt of the provinces other than Ontario is negative, but small. These results are robust to a large number of different specifications, and the estimated model exhibits a reasonable ability to predict credit ratings. The statistically significant debt spillover effects on creditworthiness imply that debt accumulation by one government may have an impact on the cost of borrowing of other governments in the federation. This, in turn, could have implications for government behaviour, welfare, and policy design.

The negative relationship between the federal debt and the creditworthiness of indebted provinces is consistent with several of the explanations discussed in section 2. A larger federal debt may increase the risk that the Bank of Canada will be pressured to monetize the federal debt or that the federal government will introduce policies that reduce provincial revenues. In addition, a larger federal debt could reduce provincial creditworthiness by decreasing the likelihood that the federal government will bail out a province in financial distress. While an implicit bailout provision may keep provincial credit ratings higher than they otherwise would be when the debt of the federal government is low, increases in the federal debt, by reducing the probability of bailout, tend to counteract this effect.

The negative, although small, spillover effect on creditworthiness of the debt of the provinces other than Ontario provides evidence of debt spillovers between provinces (potentially a result of bailout, interdependent revenues, and information contagion factors). The finding that the perceived creditworthiness of a province increases with an increase in the debt of Ontario is consistent with lenders' making yardstick comparisons across jurisdictions. One implication of the use of yardstick comparisons by lenders is that these comparisons may encourage debt accumulation by the smaller provinces when Ontario's debt is rising since, in this case, debt accumulation does not appear out of line relative to Ontario. Similarly, when Ontario reduces its debt, the other provinces must follow suit or expect a decline in their creditworthiness.

The finding that debt spillover effects exist and are significant may have implications for the use of market-based versus rules-based fiscal discipline. The results presented above indicate that there are significant debt spillover effects between jurisdictions in Canada, a federation that relies on market-based fiscal discipline. These spillover effects imply that the signal sent by the market to individual borrowers does not reflect their actions only and, thus, that the market may provide jurisdictions with inadequate incentives to control their borrowing. Advocates of a market-based approach suggest that governments could limit spillover effects by issuing a credible 'no bailout' statement (Lane 1993). The evidence for Canada appears to suggest, however, that the market perceives a bailout clause to exist even when it has not been explicitly established, which lends some support to the view that it may be difficult for a federation to implement a credible 'no bailout' policy.

It should be noted that the finding of significant debt spillover effects does not necessarily imply that rules-based fiscal discipline is preferred. In addition to the standard problem of determining the appropriate fiscal rule, the experience of other federations suggests that such rules may not effectively control debt accumulation. For example, the New York City default in 1974 occurred despite a constitutional balanced-budget requirement. Budget rules in some U.S. states and municipalities have proved to be very elastic, and in Australia there has been concern over the excessive borrowing of some states, even though the state governments have relatively little autonomy in issuing debt (Craig 1997). Given the existence of government debt spillovers that hinder the effectiveness of market-based fiscal discipline and given the recognized problems with fiscal rules, a topic for future research would be to investigate whether some type of federal fiscal arrangement can limit interjurisdictional debt spillovers and, thereby, make market discipline more effective.

Appendix A: variable definitions, data sources and descriptive statistics

All data are from Statistics Canada's CANSIM database unless noted otherwise. CANSIM matrix or series identifiers are provided where applicable. These identifiers are given by province from east to west (excluding Prince Edward Island). The sample consists of data for the nine largest Canadian provinces for the period 1974 through 1997 (twenty-four observations on each province). The dates of the data used were chosen so that all the data would have been available at the end of December for each year.

Credit ratings: Standard and Poor's credit ratings for the provinces of Canada (excluding Prince Edward Island) as of 31 December of each year. Source: 1974–94: Cheung (1996); 1995–97: Standard and Poor's *Bond Guide*, monthly.

DEBT: Net debt-GDP ratio of each province. (DEBT is negative if a province has positive net wealth.) Debt is as of the end of the fiscal year ending in the current calendar year measured on an FMS basis. GDP is for the previous calendar year. Debt is calculated as provincial government 'Financial Assets' minus 'Direct Liabilities' excluding 'Liabilities to Employee Pension Plans,' from CANSIM matrices 3202 through 3211 (excluding matrix 3203). (Note: For the years 1992 to 1997 Saskatchewan had employee pension liabilities in addition to those included in the series 'Liabilities to Employee Pension Plans' (CANSIM series D469437). These additional liabilities, which are included in the 'Other Direct Liabilities' series for Saskatchewan, were also subtracted from the 'Direct Liabilities' series when calculating Saskatchewan's debt. The additional pension liability data for Saskatchewan were obtained from A.J. Gareau, Public Institutions Division, Statistics Canada.) Provincial GDP is from the CANSIM series D31544, D31572, D31586, D31600, D31614, D31628, D31642, D31656, D44000.

DEBTAGG: Weighted average of the debt-GDP ratios of the provinces other than the province for which the observation pertains. Weights are given by each province's share of total provincial GDP. Source is the same as for DEBT.

DEBTFEDDEBT: Interactive variable defined as DEBT × FEDDEBT except for the observations with positive provincial net wealth (negative provincial debt), which are set to zero.

DEBTONT: Ontario's provincial government debt-GDP ratio multiplied by Ontario's share of total provincial GDP. This variable equals zero for those observations that pertain to Ontario. Source is the same as for DEBT.

DEBTQUE: Quebec's provincial government debt-GDP ratio multiplied by Quebec's share of total provincial GDP. This variable equals zero for those observations that pertain to Quebec. Source is the same as for DEBT.

DNF, DNS, DNB, DQ, DM, DS, DA, DBC: Provincial dummy variables for Newfoundland, Nova Scotia, New Brunswick, Quebec, Manitoba, Saskatchewan, Alberta, and British Columbia, respectively. These equal one if an observation in the sample pertains to the province for which the dummy variable applies and zero otherwise.

FEDDEBT: Debt-GDP ratio of the federal government of Canada. This variable is the same for all the observations in a particular year. Both federal debt and GDP are measured at the end of the fiscal year ending in the current calendar year. Source: Quarterly GDP for Canada is summed to give the fiscal year total (CANSIM series D20000.) Government of Canada debt is given by CANSIM series D469420.

PENSION: Provincial government liabilities to employee pension plans divided by provincial GDP. Source is the same as for DEBT.

Y: Real per capita provincial GDP in the previous calendar year. Source for provincial GDP is the same as for DEBT. The deflator used is the implicit price index

TABLE A1
Summary of credit rating data

Category	Observations in category (per cent)	Movements into category (per cent)	Movements out of category (per cent)
1 AAA	21 (9.7)	4 (11.4)	4 (11.4)
2 AA+	24 (11.1)	7 (20.0)	6 (17.1)
3 AA	50 (23.1)	6 (17.1)	10 (28.6)
4 AA−	28 (13.0)	5 (14.3)	3 (8.6)
5 A+	38 (17.6)	4 (11.4)	2 (5.7)
6 A	23 (10.6)	3 (8.6)	6 (17.1)
7 A−	24 (11.1)	4 (11.4)	3 (8.6)
8 BBB+	8 (3.7)	2 (5.7)	1 (2.9)
Total	216	35	35

for final domestic demand by province: D44764, D44792, D44806, D44820, D44834, D44848, D44862, D44876, D44890. Population for each province is from the CANSIM series: C892586, C893222, C893540, C893858, C894176, C894494, C894812, C895130, C895448.

Appendix B: Specification and robustness

B1. The variance specification

As noted in section 4 of the text, the empirical methodology allows the variance of ϵ_k in equation (1) to vary by province. The parameters given in table 1, however, are estimated with the Z_k vector in the variance equation, $\sigma_k^2 = [\exp(Z_k'\alpha)]^2$, incorporating only two provincial dummy variables, those for Saskatchewan (DS) and New Brunswick (DNB). All the other provincial dummy variables were statistically insignificant when included individually in the variance equation for all three specifications given in table 1 (except for the Ontario and Nova Scotia dummy variables, which were significant only in the specification of column I). In order to provide evidence of whether the variance of ϵ_k was a function of variables other than the provincial dummy variables – three additional variables, chosen to reflect potential differences in provincial industrial, economic, and social structures – were incorporated individually in the Z_k vector along with DS and DNB. These three variables were provincial GDP relative to national GDP, the provincial unemployment rate, and the percentage of GDP accounted for by manufacturing. The parameters in the variance equation associated with all three of these variables were statistically insignificant for all three specifications included in table 1 (except for the percentage of GDP accounted for by manufacturing, which was significant only in the specification of column I).

B2. The statistical insignificance of alternative non-spillover explanatory variables

In order to examine the robustness of the estimates given in table 1, seven types of additional non-debt spillover variables that may have had an impact on the creditworthiness of a province were included individually in the X_k vector of explanatory variables. A description of these variables and a brief discussion of why they might affect a province's creditworthiness is provided below. When included individually in each of the three versions of the model given in table 1, however, all seven types of variables were statistically insignificant using an asymptotic t-statistic and a 95 per cent confidence interval. To conserve space, parameter estimates associated with the versions of the model augmented with these seven types of variables are not included here.

The product of the real interest rate and a province's own debt-GDP ratio was included as an element of the X_k vector (for the indebted provinces), since even a high ratio of debt to GDP may be manageable if interest rates are low, but a more modest debt-GDP ratio may become unmanageable if interest rates are high. This interactive variable also reflects the cost of debt service and, thus, the magnitude of one benefit of default. To account for the fact that higher interest rates may not be as large a burden for quickly growing jurisdictions, a modified version of this variable, with the real growth rate subtracted from the real interest rate, was also incorporated in the vector of explanatory variables.

To reflect the dependence of a jurisdiction on federal transfers and, thus, the vulnerability of its revenues to unilateral reductions in these transfers, the vector X_k was augmented with a variable representing the proportion of provincial revenues accounted for by federal transfers.

The forecast budgetary deficit (relative to calendar year GDP) for the current fiscal year was added to the estimating equation to indicate the current budgetary stance (as opposed to the stance of past budgets which is reflected in the accumulated debt).

The change in the unemployment rate over the previous year was added to reflect the current state of health of the economy as well as to act as a proxy for recent growth in GDP (which is unobservable when the credit rating is being determined).

The estimating equation was also augmented with the ratio of provincial government revenues to provincial GDP. This variable was intended to reflect the potential for upward flexibility in revenues, since governments with smaller revenues as a proportion of GDP are likely to have more revenue flexibility than governments with large revenues relative to GDP. It may also be the case that smaller governments are associated with more flexible economies that may be able to grow more quickly out of a financial crisis (or that may be less likely to suffer from such a crisis).

Bishop (1992) notes that the gearing ratio, debt service payments to revenues, is a signal of a jurisdiction's ability to repay its debt. Three different definitions of the gearing ratio were used to augment the model (debt service payments divided by revenues, divided by expenditures and divided by provincial GDP).

Finally, credit-rating agencies may penalize governments that issue a greater percentage of their debt in foreign currencies, since most government revenues are denominated in domestic currency. To examine this possibility, the ratio of Canadian dollar government bonds outstanding to total government bonds outstanding for each province with positive net debt was included in the estimating equation.

B3. In and out-of-sample predictions

The robustness of the parameter estimates given in table 1 can also be examined by evaluating the estimated model's ability to predict the true credit rating associated with each observation. If the within sample predicted credit ratings are calculated using the parameter estimates from the model of column II of table 1, 68.1 per cent of the actual credit ratings are predicted accurately, and for only 13 of the 216 observations did the prediction error exceed one credit-rating category and for only four did it exceed two categories. (Note that if the model is estimated with only a constant term and the fixed effects as explanatory variables, as well as allowing for a non-constant variance, only 32 per cent of the credit ratings are predicted correctly.)

A more rigorous test of the robustness of the parameter estimates is to compare the out-of-sample and in-sample predicted credit ratings for a subset of observations. In-sample predictions are the predictions made with parameters estimated using the entire set of 216 observations. Out-of-sample predictions are the predictions made when the model is estimated using a subset of the available observations, and the parameters estimated using these observations are used to predict the credit ratings for the observations that were not included in this subset of observations.

The comparison of the in-sample and out-of-sample predictions was carried out using the model of column II in table 1 for the four middle observations associated with each province (thirty-six observations in total representing 16.7 per cent of the sample). Thus, the out-of-sample predictions were made using the parameters estimated with the first ten and last ten observations for each jurisdiction. (There are too few observations (only two) in the BBB + category in the first twenty years of the sample to reasonably estimate the model over this period and make out-of-sample predictions for the last four years of the sample.) The in-sample parameter estimates predict 69.4 per cent of the thirty-six ratings correctly, while a relatively similar, and high, 63.9 per cent of the out-of-sample predictions were correct. (The out-of-sample estimates mispredict two of the observations that the in-sample estimates predict correctly.) Furthermore, when the model is re-estimated over the subsample of 180 observations (excluding the middle four observations for each jurisdiction), the statistically significant parameters associated with the variables in the X_k and S_k vectors have the same signs as they do when estimation is carried out over the whole sample, and there are no changes in the conclusions of the analysis.

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