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The relationship between debt and growth: an application to the Canadian Provinces

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The focus of this paper is on the relationship between public debt and economic growth in the ten Canadian provinces using data from 1990 to 2012. The study concludes that the direction of causality is opposite to that claimed by Reinhart and Rogoff (2010) in their cross-country study: slow economic growth causes high public debt in Canada's provinces, not the other way round. In addition, we find no evidence suggesting a threshold in the relationship between public debt and GDP growth for high debt-level provinces.

While the risks and dangers of too high a level of debt are well known, what level of debt is "too high" was long thought to be unclear. This changed in 2010 when Reinhart and Rogoff declared they had an answer, and had found a clear threshold: a debt-to-GDP ratio over 90% severely impaired long-term growth prospects. Their result attracted widespread attention, had a significant influence on the debate about fiscal policy, and was used to support fiscal austerity in both Europe and the United States. Interestingly, the influence of Reinhart and Rogoff has not been confined to debates over national debt. In discussing the prospects for economic growth among Canada's provinces, Palacios, MacIntyre, & Lammam (2014) consider the adverse effects of provincial government debt and cite the relevance of the Reinhart-Rogoff result.

The focus of this paper is whether the Reinhart-Rogoff (hereafter denoted RR) result holds up in the context of Canada's provinces. In particular, we address the question of whether there is a relationship between provincial public debt and vincial economic growth in Canada, and whether there is a debt threshold. Clearly, the existence of such a threshold would have serious implications for provincial public finances, provincial programs, and the provinces' future growth prospects. We proceed as follows. The next section briefly reviews the RR result and the subsequent literature. Section 3 presents our empirical results. Section 4 concludes.

Reinhart-Rogoff and their Critics

RR first published 'Growth in a Time of Debt' as a National Bureau of Economic Research paper in January 2010. Their focus was the empirical relationship between public debt, economic growth, and inflation, and their dataset consisted of 3,700 annual observations of 44 countries spanning 200 years.[1]They divided the annual observations into four categories according to the ratio of debt-to-GDP: a debt-to-GDP ratio lower than 30 percent ("low debt"); between 30 and 60 percent ("medium debt"); between 60 and 90 percent ("high debt"); and above 90 percent ("very high debt").Their most influential conclusion was that median real GDP growth drops 1 percent, and average real GDP growth drops 4 percent, when the debt-to-GDP ratio goes above 90 percent (in advanced countries post World War II).

This result attracted widespread attention and had a significant influence on the debate about fiscal policy. It was used to support fiscal austerity in both Europe and the United States. Their findings have been heavily cited in influential conferences and journals, and formed the key component of the testimony before the Senate Budget Committee in 2010. It is clear that RR's work has been very influential.

Nor is the influence of RR confined to debates over national debt. In discussing the prospects for economic growth among Canada's provinces, Palacios, MacIntyre, &Lammam (2014) consider provincial government debt-to-GDP ratios and cite the relevance of the RR result. They state (2014, page 1): "Empirical economic research has found that high government debt is correlated with low economic growth. One of the most influential papers examining the connection between government debt and economic growth is by Harvard professors Carmen Reinhart and Kenneth Rogoff (2010)."

While the RR result is widely known, the subsequent literature criticizing their result is much less so. It is interesting to note in passing that some—such as Krugman (2013, 2015)—argue that this subsequent literature has discredited the RR result. This is partly because of computational errors that came to light when RR shared their data and spreadsheets with Thomas Herndon, a graduate student at the University of Massachusetts.[2] In fact, RR continue to defend their results in the face of these computational errors.[3]

For our purposes, however, the accuracy of the original RR result is mostly moot. What is important for this paper is what the subsequent literature tells us about how to do the analysis correctly, and in particular, the necessity to becareful about cau-

Figure 1: Debt-to-GDP Ratio in BC, AB, SK, MB and ON, 1990-2012

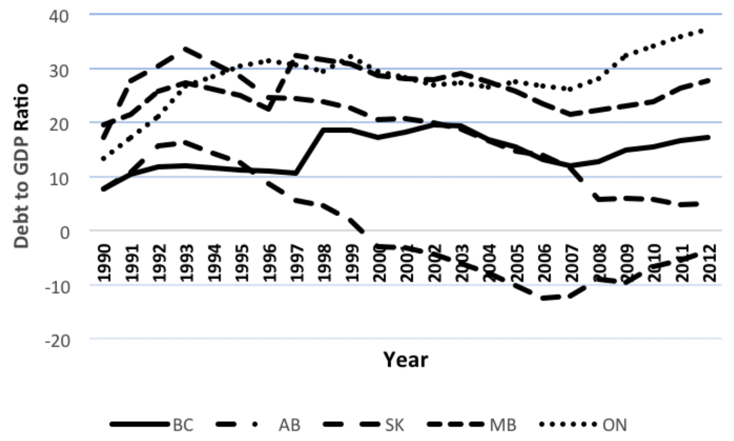
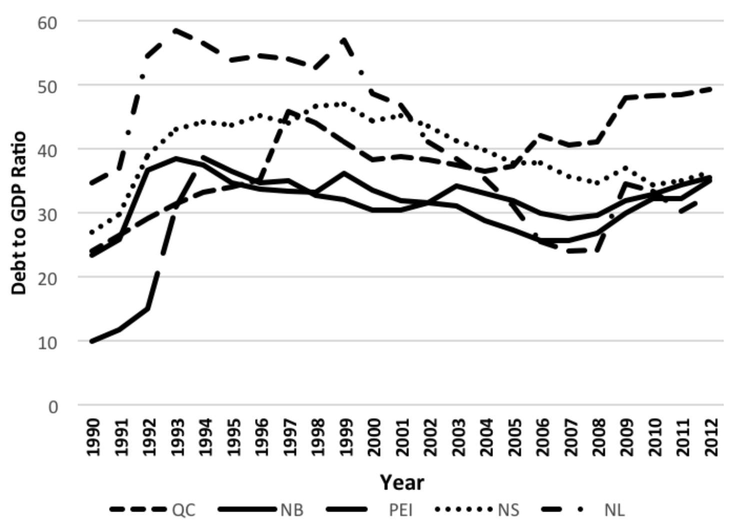


Figure 2: Debt-to-GDP Ratio in QC, NB, PEI, NS and NL, 1990-2012



sality. For example, Bivens& Irons (2010) pointed out that RR offered no evidence that the correlation ran from high debt to low growth rather than the other way around, and other evidence suggested that the latter was more likely.

The question of causality was taken up by Dube (2013). He tested the direction of causality by regressing past, present, and future GDPgrowth rates on the current debt-to-GDP ratio. He found a clear negative correlation between the debt ratio and contemporaneous growth, and between the debt ratio and past growth (a 5-year past average), but almost no relationship between the debt ratio and future growth (a 5-year forward average). This is consistent with reverse causality (low growth causing a high debt-to-GDP ratio). After identifying this issue, Dube (2013) used several methods to address the endogeneity issue on debt caused by reverse causality. He concluded that the relationship between the debt-to-GDP ratio and growth is flat for debt ratios exceeding 30 percent.

What we learn from this is the key importance of taking into account causality and endogeneity. This becomes the focus of our own study in the context of Canada's provinces.

Empirical Results

Our data cover the ten Canadian provinces (British Colombia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland& Labrador) from 1990 to 2012.[4]Figure 1 shows the debt-to-GDP ratios in the five western provinces (British Columbia to Ontario), while Figure 2 shows the five eastern provinces (Quebec to Newfoundland & Labrador), from 1990 to 2012. The overall picture is one of increasing indebtedness in the early 1990s, followed by gradual decline until the early to mid-2000s. Since then most provinces show quite a rapid increase in debt-to-GDP ratios again. Notable exceptions are Newfoundland-Labrador, Nova Scotia, and Saskatchewan.Figure 3 shows the average debt-to-GDP ratio by province for the same period.These data show that no province had a debt-to-GDP ratio over 60 percent at any time. This suggests that we need to modify the debt categories used by RR.

If we blindly applied RR's definitions to the provinces, none of the provinces would fall into the "high debt" (debt-to-GDP ratio between 60% and 90%) or "very high debt" (> 90%) categories. This seems inappropriate for several reasons. First, there are good reasons to believe that a sub-national government in a federal state cannot sustain levels of debt as high as the federal government. Foremost among these reasons is that federal debt is ultimately backed up by the money supply, whereas provincial debt is not; furthermore, in the Canadian context, the provinces have (by a mixture of tradition and law) less tax room than the Federal government. Thus, a debt to GDP ratio that may be only moderate for the Federal government may be high for a Canadian

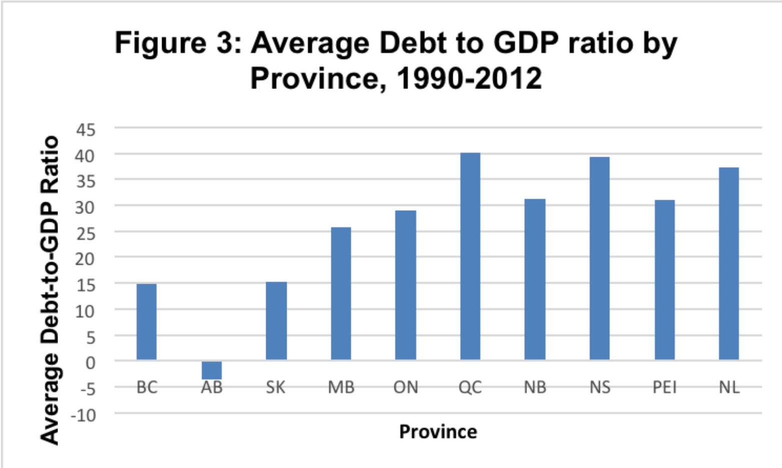


Figure 3: Average Debt to GDP ratio by Province, 1990-2012

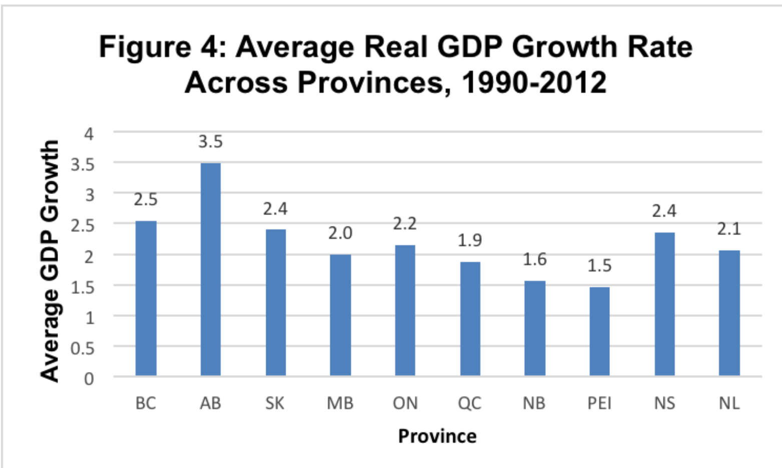


Figure 4: Average Real GDP Growth Rate Across Provinces, 1990-2012

province. Second, public discourse in Canada suggests that some provinces do feel themselves to be suffering from high debt – a feeling reinforced by external rating agencies downgrading the credit ratings (and/or outlook) of several provinces.[5] Finally, for us, there is the practical matter of not wanting empty categories.

For these reasons we adopt the following definitions of debt categories:a debt-to-GDP ratio below 0 percent ("negative debt"), a debt-to-GDP ratio of 0-20 percent ("low debt"), 20 to 40 percent ("medium debt"), and above 40 percent ("high debt").The numbers of observations in the resulting debt categories are summarized in Table 1. There are 13 observations with a negative debt level, 51 observations with a low debt level, 134 observations with a medium debt level, and 32 observations with a high debt level. Around 60 percent of province-year observations fall into the medium debt level category.

Figure 4 presents average real GDP growth rates by province. Alberta has the highest average growth rate at 3.49 percent, while PEI has the lowest at 1.46 percent. In general, real growth of the Western provinces is stronger than the Eastern provinces.

Figure 5 shows how the average real GDP growth rates vary by debt category. There is a declining trend in the first three categories: average real GDP growth decreases from 3.2 percent (for a debt-to-GDP ratio below 0 percent) to 2.6 percent (for a debt-to-GDP ratio between 0-20 percent), and then continues to drop to 1.9 percent (for a debt-to-GDP ratio between 20-40 percent). However, the last category did not continue with the declining trend; instead, average growth rises to 2.5 percent when the debt-to-GDP ratio exceeds 40 percent. Figure 5shows no evidence of a debt threshold (where GDP growth drops sharply with high debt).

RR's contention is that in the long run a build-up of debt slows down the economy, as shown by a simple negative correlation between growth and the debt-to-GDP ratio. However, there are problems interpreting this as a causal negative relationship running from high debt to low growth. As Dube (2013: 1) argues: "One reason is just algebraic. The independent variable, debt-to-GDP, is a ratiothat has a numerator (debt) and denominator (GDP): any fall in GDP will mechanically boost the ratio."

Dube clarifies that in a simple bivariate setting, the correlation between growth and the debt-to-GDP ratio will reflect a mixture of both of these relationships: lower growth spurred by a high debt ratio (the RR thesis, which we call hypothesis A); and a higher debt ratio spurred by lower growth (hypothesis B). Writing these two hypotheses as OLS regressions, we have:

A: $g_{i,t} = \gamma_1 + \alpha\, d_{i,t} + e_{1i,t}$ (1)

B: $d_{i,t} = \gamma_2 + \beta\, g_{i,t} + e_{2i,t}$ (2)

where 'g' stands for the GDP growth rate and 'd' stands for the debt-to-GDP ratio. Assuming both α and β to be negative, stability requires that α exceed β (i.e. α must be a smaller negative number than β) in the neighbourhood of equilibrium.[6] As shown by Dube (2013) and Panizza&Presbitero (2013), in these conditions the bivariate regression coefficient ('b' in Figure 6) will overstate the influence of debt on growth (hypothesis A). (The Figure is reproduced from Dube, 2013)

The question is, then, can we show that there is causal relationship running from growth to debt?We investigate this question using a Granger causality test; see Granger (1969).

Time series X is said to Granger-cause Y if the current value of Y can be better be predicted by including past values of X alongside past values of Y.

Table 1. The number of observations in each debt category: 1990-2012.

Province	*Debt/GDP below 0%*	*Debt/GDP 0-20%*	*Debt/GDP 20-40%*	*Debt/GDP above 40%*
British Colombia	0	23	0	0
Alberta	13	10	0	0
Saskatchewan	0	12	11	0
Manitoba	0	1	22	0
Ontario	0	2	21	0
Quebec	0	0	13	10
New Brunswick	0	0	23	0
Nova Scotia	0	0	12	11
Prince Edward Island	0	3	20	0
Newfoundland & Labrador	0	0	12	11
Total number of observations	13	51	134	32

Table 2. Panel unit root tests results

Variables	*Levin, Lin and Chu adjusted t-test*	*Probability value*
GDP Growth	-6.10*	0.00
Debt-to-GDP Ratio	-1.99**	0.02

Note.* denotes significant at the 1 percent level. ** denotes significant at the 5 percent level.

Accordinglyour two hypotheses can be written as:

$$A: g_{i,t} = \sum_{j=1}^{m} \theta_j \, g_{it-j} + \sum_{j=1}^{m} \alpha_j \, d_{it-j} + \mu_{1i,t} \quad (3)$$

$$B: d_{i,t} = \sum_{j=1}^{m} \rho_j \, d_{it-j} + \sum_{j=1}^{m} \beta_j \, g_{it-j} + \mu_{2i,t} \quad (4)$$

There are several procedures that are necessary before performing the Granger causality test. First, we test for stationarity using the panel unit root test proposed by Levin, Lin, & Chu (2002). The null hypothesis is that the panel contains unit roots (integrated at order 1,I(1)).The alternative hypothesis is that the panel is stationary (integrated at order 0, I(0)).The results are reported in Table 2.The Levin, Lin and Chuadjusted t-statistics are -6.1 for GDP growth, and -1.99 for debt. These are both significant at the 5 percent level. Therefore we reject the null hypothesis and conclude that the panel is stationary (and therefore co-integrated).

Next, we need to determine the optimum lag lengthsin equations (3) and (4). This is determined using the two-stage procedure suggested in Engle & Granger (1987), and Abdalla&Murinde (1997). In the first stage, we determine the optimal number of lagged dependent variables by maximizing the value of R^2 in the following regressions:

$$g_{it} = \gamma_{it} + \sum_{i=1}^{m=12} \theta_j \, g_{it-1} + \mu_{1i,t} \quad (5)$$

$$d_{it} = \gamma_{it} + \sum_{i=1}^{m=12} \rho_j \, d_{it-1} + \mu_{2i,t} \quad (6)$$

In the second stage, we hold the number of lagged dependent variables at their optimal level (determined from stage one), and vary the number of lags on the independent variable from 1 to 12, selecting the lag length that maximizes the value of R^2.

We conclude that the optimal-number of lagged GDP growth terms, and lagged debt-ratio terms, are both 12 in equation (3); while the optimal number of lagged GDP growth terms, and lagged debt-ratio terms, are both 11 in equation (4). The p-value of the F-test that no explanatory power is jointly added by the debt terms in equation (3) is 0.53. Since this p-value is greater than 5 percent, we cannot reject the null hypothesis of no Granger causality running fromdebt to GDP growth. On the other hand, the p-value of the F-test that no explanatory power is jointly added by the growth terms in equation (4) is 0.03, which is smaller than 5 percent. Hence, the null hypothesis of no Granger causality running from GDP growth to the debt ratio is rejected.

Thus the conclusion of this section is that the Granger causality test supports hypothesis B: one-way causality running from growth to the debt ratio.

These causality results could be regarded as insufficient proof. Causality tests are best used for time series containing high frequency data (daily, weekly or monthly); applications using annual data are perhaps less persuasive. Furthermore, some may be concerned about degrees of freedom: we have 220 observations, but with 12 lagged variables (across 10 provinces) we lose 120 observations. With limited degrees of freedom, some may argue that our failure to find that debt has a causal effect on growth does not mean there is *no* effect. At best we have shown that growth does seem to have a causal effect on debt.

With this interpretation in mind, we proceed to estimate a simple bivariate linear relationship between 'g' (as the dependent variable) and 'd' (as the explanatory variable). The OLS regression result is:

$$g_{i,t} = \underset{(0.42)}{2.56} - \underset{(0.012)}{0.014} \, d_{i,t} + e_{i,t} \quad (7)$$

The standard errors are shown in brackets. The p-value of the independent variable, the debt ratio, is 0.27, which is larger than 0.05maximum threshold. However, before we conclude that debt has no significant negative effect on growth there are several statistical issues that need to be addressed.

Figure 5: Average Real GDP Growth by Debt Category

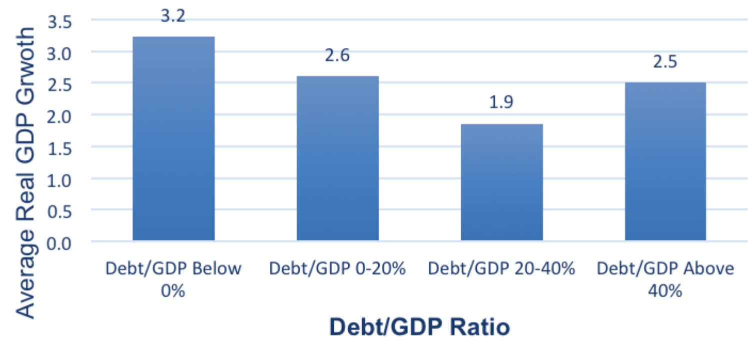
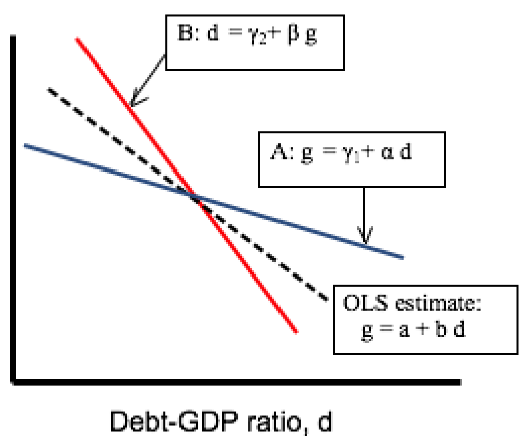


Figure 6: Bias in the Regression Estimate



First, since there is only one independent variable in the model, and there are many variables thatmay help to explain growth, omitted variable bias is a concern. The p-value from Ramsey's specification error test for omitted variables (using the Stata command *ovtest*) is 0.28, which is greater than 0.05, and indicates we cannot reject the null hypothesis that the model has no omitted variables.

Second, there is the problem of reverse causality shown in the previous section. This can be framed econometrically as a problem of endogeneity bias in the explanatory variable. We use two strategies to address the problem. First, Panizza&Presbitero (2013) mention that it is common in the literature to use the 5-year forward growth rate instead of the present growth rate to mitigate the endogeneity problem. The 5-year forward growth rateis defined as:

$$g_{i,t+1,t+5} = \frac{1}{5}\sum_{\tau=1}^{5} \frac{Gt+\tau+1 - Gt+\tau}{Gt+\tau}$$

The second method is to use the instrumental variables approach. In particular, the current debt ratio is instrumented with its own lag. This is similar to using the five-year forward growth rate in that the idea is to put some time distance between the debt and growth variables. It removes the contemporaneous correlation between debt and growth that arises because temporary shocks in output affect both the debt-ratio and growth

The results are contained in Table 3. Comparing first the rows of column (1) we see that the effect of replacing the dependent variable $g_{i,t}$ with a 5-year forward growth rate $g_{i,t+1,t+5}$, is to reduce the absolute size of the coefficient on the debt ratio by about 71 percent (from -0.014 to -0.004).The p-value of the debt ratio is even higher than before, increasing from 0.27 to 0.79. We should not be surprised that the size of the coefficient is smaller than before.This fits our expectation ofthe effect of reverse causality as depicted in Figure 6.

Comparing columns 1 and 2, we find that instrumenting for the debt-to-GDP ratio, $d_{i,t}$, has a substantial effect when using current growth as the dependent variable (row one) – it reduces the absolute size of the debt coefficient from -0.014 to -0.0002 – but haslittle additional impact when using the 5-year forward average growth rate (row two). This is to be expected because these two methods are designed to correct for the same endogeneity effect.

Conclusion

To conclude, when we analyze Canadian provincial data by average debt category we find no evidence of a debt threshold beyond which real growth is lower(in the period from 1990 to 2012). While average growth is lower as debt increases from negative to low, and from low to medium, average growth increases as we move from medium to the high debt category. Given that there is no theoretical basis for expecting this effect, the reasonable conclusion is that there is no systematic relationship at all. Second, when we analyze the data using the concept of Granger-causality we find no evidence that high debt causes lower growth. We cannot, however, reject the null hypothesis that low growth Granger-causes high debt. Finally, when we run bivariate regressions between growth and debt (with growth as the dependent variable) using provincial panel data, the debt ratio has an insignificantly small negative effect on growth. Further, this effect becomes smaller and even more insignificant when we correct for endogeneity, confirming the existence of

Table 3. Results of regressing growth on debt-to-GDP ratio

	Column(1) No instrument	*Column (2) Instrumented Debt.*
(a) Current GDP Growth Rate		
Row (1)	-0.014	-0.0002
Debt-to-GDP	(0.012)	(0.02)
(b) 5-year Forward GDP Growth Rate		
Row (2)	-0.004	-0.007
Debt-to-GDP	(0.15)	(0.02)

Note. The table reports results from regressions of growth on current debt-to-GDP ratio. In the first row, the outcome is the current year growth. In the second row, the outcome is the 5-year forward growth rate. Column 1 indicates results from simple bivariate OLS regression. Column 2 indicates results from IV estimation where current debt is instrumented with its lag.

reverse causality. In sum, there is no evidence of a Reinhart-Rogoff effect for Canada's provinces.

We would like to caution against going too far with the policy implications of this study. There may be a debt threshold; it is just that at current levels of debt Canada's provinces appear not to have reached it, so it is not there for us to find in our dataset. On the other hand, the data does not support all out austerity for the sake of bringing down debt either. High growth drives low debt. Government borrowing to stimulate long term growth would seem to be supported. (But here we must emphasize a basic point: Granger causality tests and bivariate regressions cannot ever give us a complete story of the determinants of economic growth.) Certainly, our paper certainly cautions against citing results from one context (RR's international data set) as being appropriate to an entirely different context (Canadian provinces), as Palacios, MacIntyre, &Lammam(2014) did in their Fraser Institute study.

Finally, we should note there are still reasons to be concerned about high levels of government debt, even if that debt has no discernable impact on growth rates. It could be that high debt ratios do adversely impact the interest rates that provincial governments must pay.In any event, even if interest rates are not adversely affected, high debt ratios imply high debt service payments, which may squeeze out other forms of government spending. Finally, there is the question of looming implicit liabilities. These include future pension obligations (which official measures of debt invariably ignore), as well as the moral obligation to spend more on health care in the face of an aging population.[7]

Acknowledgement

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[1] The creation of the historical dataset was one of the main contributions of their paper.

[2]The computational errors include a coding error that caused them to omit relevant data for five countries by accident, and an intuitively odd weighting scheme in which each "episode" of high debt counted the same, whether it occurred during one year of bad growth or seventeen years of good growth. See Herndon, Ash, &Pollin (2013) for details.

[3]See Carmen Reinhart (2013)

[4]Provincial net debt data comes from the Department of Finance's (Canada) Fiscal Reference Tables, October 2013. [Department of Finance, Publication and Reports, Fiscal Reference Tables – 2013: Part 5 of 10. http] It is measured in millions of current dollars. Data for provincial nominal GDP and real GDP are obtained from the Canada Socioeconomic Database in Statistics Canada, Table 384-0038.

[5]Moody's downgraded the outlook for Ontario's debt in July 2014 from stable to

negative; similarly it downgraded the outlook for Manitoba's debt to negative in August 2014 – a move said to increase Manitoba's borrowing costs by half a percentage point. (Winnipeg Free Press, August 8, 2014). New Brunswick had its rating downgraded from AA-minus to A-plus by Standard and Poor's rating service in June 2012.

[6]Equation (1) tells us what 'g' will be for any level of'd'. If g is temporarily off this line, we know it will tend towards it. So, implicitly equation (1) is a g-dot =0 line, where 'g-dot' denotes the time rate of change of 'g'. Similarly, equation (2) is implicitly a d-dot = 0 line.Figure 6 then is a phase diagram showing the stable case. Stability can be verified graphically by choosing a point away from the intersection. For example, suppose initially 'd' is to the right of the intersection point. This causes a level of 'g' determined by line A; given 'g' next period's 'd' can be determined from line B. This process takes us back toward the point of rest.If the slopes were reversed, the same exercise would trace a path moving away from the intersection point.

[7] Robson (2004) was one of the first to sound the alarm bells concerning unfunded implicit liabilities. On the other hand, Ruggeri &Zou (2006) argue that population aging is the new "Boogeyman" and implicit liabilities have been vastly exaggerated. Their main point is that the baby boomers will be the richest generation of retired people so far. Not only do most of them have employer-provided pensions, but they also have billions stashed away in RRSPs (registered retirement savings plans). These billions must be withdrawn between the ages of 68 and 90, implying a huge windfall of tax revenue. So when the baby boomers retire, they will cease working but not cease paying taxes. Moreover, most of the government-provided benefits they will receive are means tested.