LCERPA
Laurier Centre for Economic Research & Policy Analysis

LCERPA Working paper No. 2020-2

September 2020

Fiscal implications of the pandemic

Ke Pang, Wilfrid Laurier University
and Christos Shiamptanis, Wilfrid Laurier University

Fiscal implications of the pandemic

Ke Pang
Wilfrid Laurier University
kpang@wlu.ca

Christos Shiamptanis
Wilfrid Laurier University
cshiamptanis@wlu.ca

August 31, 2020

Abstract

This paper studies the Canadian fiscal finances in the aftermath of the pandemic. We use a rich set of fiscal categories to estimate their responsiveness to debt. We find that debt has been financed historically mainly by tax revenue. We use our estimates to derive the Canadian debt limit, the maximum level of debt beyond which debt solvency is in doubt. We use a small open economy model which is subject to exogenous pandemic shocks. The pandemic shocks reduce the hours worked and consumption, which in turn lower output, reduce the tax revenue and raise the debt level. We then investigate whether adverse shocks caused by the pandemic can push the debt beyond its debt limit. We find that even in the worst case scenario, the Canadian government will not breach its debt limit.

- *Key Words:* Fiscal limit; Solvency Crisis; Pandemic; Containment policies;
- *JEL Classification*: E62; F34; H30; H60

1 Introduction

The global pandemic and the resulting emergency transfers, such as the Canada Emergency Response Benefit and the Canada Emergency Wage Subsidy, have already reignited discussions over the future fiscal health of the Canadian economy. Canada is expected to record the largest deficit during peacetime and the Canadian gross debt level is expected to breach 100% of GDP for the first time since the Second World War. Fitch has already downgraded Canada's debt credit rating and there are concerns of further downgrades by the other rating agencies. Every country has a debt limit, where that limit represents a debt level that is so high that the country's economic and political systems cannot raise taxes or reduce spending sufficiently to maintain solvency (Bi 2012; Bi et al. 2013; Ghosh et al. 2013). At the limit, creditors flee, and the government faces a solvency crisis. Solvency crisis, once a problem primarily associated with emerging economies, is now a significant concern in the developed world. Is Canada's fiscal position strong enough to withstand possible future negative shocks? Has the global pandemic raised the probability of future fiscal insolvency? At what point would Canada become insolvent, and how close is Canada to that point? This paper addresses these questions.

Shiamptanis (2019) shows that the position of the debt limit depends on the responsiveness of taxes and government spending to debt. High debt levels eventually elicit a period where the government raises taxes and cuts government spending. The systematic response of taxes and government spending to debt reveals information about the debt limit. Therefore, to derive the Canadian debt limit, we first need estimates for the responsiveness of taxes and government spending to debt. We begin by investigating the Canadian historical experience. Bohn (1998) uses a fiscal feedback rule in which the primary surplus responds to lagged debt and other indicators. The coefficient on lagged debt provides the amount that the primary surplus increases as debt rises. He demonstrates that a positive coefficient is sufficient for sustainable fiscal policy. In this paper, we go beyond the estimated coefficient of the primary surplus to lagged debt. We slice it and estimate the portion of this coefficient that is stemming from tax hikes and spending cuts. We use disaggregate data for tax revenue and government expenditure between 1970 and 2015 from the OECD, and we estimate the coefficient to lagged debt of six tax revenue categories and five government expenditure categories. The first contribution of this paper is empirical. We are able to estimate how the debt has been financed historically. We find that about 60% of the increase in the primary surplus to stabilize debt is done via higher tax revenue, while the remaining 40% is done via expenditure cuts. While there has been extensive work on the estimates of the primary surplus to lagged debt, to the best of our knowledge this is the first paper, which uses Canadian disaggregate data and allows for a rich set of fiscal categories to respond and stabilize debt.[1]

Next, we use a simple small open economy model to derive the debt limit, which is the maximum level of debt consistent with solvency. Fiscal authority issues bonds, collects distortionary taxes, and finances transfers and government purchases.[2] The fiscal authority increases the tax rate and decreases government purchases to reduce debt. Distortionary taxes limit the tax revenue that the government can generate. Additionally, there is the feasibility limit of zero below which the government purchases cannot be reduced. The

[1] Leeper et al. (2010) uses Bayesian methods to estimate a DSGE model for the US, which allows for up to four fiscal categories.

[2] For tractability, the model uses three fiscal categories. It combines the eleven fiscal categories into three broad categories.

upper bound on tax revenue and the lower bound on government purchases allow us to derive the debt limit. Beyond this debt limit, debt embarks on an explosive path, creditors flee, and the country faces a solvency crisis. To prevent a solvency crisis, debt needs to remain below this debt limit. However, adverse shocks caused by the pandemic could push a country over its debt limit.

In our model the pandemic has aggregate demand and aggregate supply effects (as in Eichenbaum et al. 2020). The pandemic exposes the household to the virus when she is working. The supply shock reduces the hours worked. The pandemic also exposes the household to the virus while buying consumption goods. The demand shock reduces consumption. The two pandemic shocks can dramatically reduce output and tax revenue, thereby raising the debt level. In addition, we consider policies that mitigate the household's economic hardship such as the government's emergency fiscal transfers. The transfers increase the government expenditure and further increase the debt level. The second contribution of the paper is theoretical. We endogenously derive the debt limit. Our approach extend's Bi (2012) and Bi et al. (2013) procedure who derive the debt limit by combining the top of the Laffer curve with the government's intertemporal budget constraint. Their approach, however, assumes that the government moves immediately to the peak of the Laffer curve and remains there forever. Daniel and Shiamptanis (2019), among others, find that governments do not instantaneously raise their surplus and keep it indefinitely at the maximum value. The legislative and implementation process exhibits substantial inertia in adjusting taxes and government purchases. Also, Trabandt and Uhlig (2011) do not find evidence of any countries being at the peak of the Laffer curve.

The final contribution of the paper is quantitative. We apply our model to Canada. We estimate the Canadian debt limit and find that the debt limit is well above the current debt level. Next we use our model to ask whether the debt level will breach the debt limit if the economy is bombarded with additional adverse shocks due to the pandemic. While some of our risk scenarios push the debt level closer to the debt limit, we find that the Canadian government has ample of fiscal space to maneuver, implying that Canada most likely will not be put under scrutiny by the markets and will not have to switch to inflation to reduce the elevated debt.

This paper is organized as follows. Section 2 estimates the responsiveness of a rich set of fiscal categories to lagged debt. Section 3 presents the model and derives the debt limit. Section 4 applies the model to Canada, and Section 5 provides conclusions.

2 Empirical

In this section, we estimate the responsiveness of various fiscal categories to lagged debt. We begin at the aggregate level and then examine various sub-categories. Following Bohn (1998), our aggregate fiscal feedback rule is given by

$$s_t = \rho s_{t-1} + \gamma b_{t-1} + \mu_t^s \tag{1}$$

where s_t is the primary balance, b_{t-1} is the lagged gross debt, all shares of GDP, and $\mu_t^s = c + \beta x_t + \varepsilon_t^s$ includes the constant (c), other control variables (x_t) and ε_t^s an error term. The parameter ρ measures the persistence in the primary surplus, which captures the inertia potentially driven by policy commitment. The parameter γ measures the responsiveness to lagged debt. A positive γ implies that the primary surplus rises, either via tax revenue increases or expenditure cuts, as the level of lagged debt rises.

We use annual data for Canada from the OECD Economic Outlook database for the period between 1970 and 2015. In Regression 1, we include the output gap to control for the effect of business cycles. In Regression 2, we include additional control variables, government expenditure gap, trade openness and inflation. The government expenditure gap is included to gauge the short-term fluctuations in government outlays. Trade openness is included to measure the potential effect of globalization. Inflation is included to capture possible effects such as bracket creep and calling for more stringent fiscal discipline to counteract the effects of higher inflation. Estimates of Regression 1 and 2 are in Table 1. We use least squares and robust standard errors to address potential concerns about heteroskedasticity and autocorrelation. We find that the coefficient to lagged debt to be positive and significant in both regressions, suggesting that higher debt is typically associated with an improvement in next year's primary balance. For example, the coefficient γ in Regression 1 implies that a 1% increase in lagged debt is associated with a 0.0478% increase in primary balance. This is the parameter that we will slice in order to find the portion that is coming from the revenue side and the expenditure side.

Next, we take the analysis to the disaggregate level. The primary surplus is equal to total tax revenue (r_t) minus the total government expenditure excluding interest payments (e_t)

$$s_t = r_t - e_t \tag{2}$$

On the revenue side, there are six categories

$$r_t = r_{1t} + r_{2t} + r_{3t} + r_{4t} + r_{5t} + r_{6t}. \tag{3}$$

Category 1 (r_{1t}) includes the total direct taxes on income from employment, property, capital gains or any other source. Category 2 (r_{2t}) includes the total taxes on production and imports, which are mainly value added taxes and import duties. Category 3 (r_{3t}) contains the social security contribution received by the general government. Category 4 (r_{4t}) includes other current receipts. Category 5 (r_{5t}) comprises of the property income received by the government excluding interest receipts, and Category 6 (r_{6t}) contains the capital tax and transfer receipts.

On the expenditure side, there are five categories.

$$e_t = e_{1t} + e_{2t} + e_{3t} + e_{4t} + e_{5t} \tag{4}$$

Category 1 (e_{1t}) is government consumption expenditure. Category 2 (e_{2t}) includes the social security benefits paid by the general government. Category 3 (e_{3t}) includes other current outlays. Category 4 (e_{4t}) comprises of the property income paid by government excluding interest payments. Category 5 (e_{5t}) contains the capital outlays, which include the net government fixed capital formation and other capital payments made by the general government.

Substituting equation (2) into equation (1) yields a revenue feedback rule and an expenditure fiscal rule, which are given respectively by

$$\begin{aligned} r_t &= \rho r_{t-1} + \gamma^r b_{t-1} + \mu_t^r \\ e_t &= \rho e_{t-1} - \gamma^e b_{t-1} + \mu_t^e \end{aligned}$$

where $\gamma = \gamma^r + \gamma^e$. The aggregate primary surplus responsiveness (γ) can be sliced into the tax revenue responsiveness (γ^r) and the expenditure responsiveness (γ^e) to lagged debt. The revenue feedback rule reveals the increase in tax revenue as the lagged debt rises, whereas the expenditure feedback rule shows the decline in government expenditure as the lagged debt rises.

Substituting equations (3) - (4) into equation (1) yields eleven fiscal feedback rules, six for the revenue side and five for the expenditure side, allowing to further slice the coefficient of lagged debt into the various sub-categories

$$
\begin{aligned}
r_{kt} &= \rho r_{kt-1} + \gamma^{r_k} b_{t-1} + \mu_t^{r_k} \\
e_{kt} &= \rho e_{kt-1} - \gamma^{e_k} b_{t-1} + \mu_t^{e_k}
\end{aligned}
$$

where γ^{r_k} is the responsiveness of the revenue category k to lagged debt such that $\gamma^r = \sum_1^6 \gamma^{r_k}$, and γ^{e_k} is the responsiveness of the expenditure category k to lagged debt such that $\gamma^e = \sum_1^5 \gamma^{e_k}$.

Tables 2 and 3 contain the results of the decomposition of Regression 1 and 2, respectively. The disaggregate results reveal the categories that the government has used historically to lower debt. For example, the estimates $\gamma^r = 0.0287$ and $\gamma^e = 0.0191$ in Table 2 imply that a 1% increase in lagged debt is associated with a 0.0287% increase in revenue and a 0.0191% decrease in government expenditures, for a total increase in the primary balance of 0.0478%. Our results suggest that about 60% of the improvement in the primary balance is done through higher tax revenue, while the remaining 40% is done through cuts in government expenditure.

Our decomposition analysis shows that on the revenue side, the two categories that contributed the most are direct taxes (r_{1t}) and social security contributions (r_{3t}). Their coefficients are $\gamma^{r_1} = 0.0123$ and $\gamma^{r_3} = 0.0102$, implying that the revenue from direct taxes and social security contributions increase by 0.0123% and 0.0102%, respectively, as lagged debt increases by 1%. These two categories combined account for about 78% of the increase in total revenues following an increase in lagged debt. On the expenditure side, the government consumption expenditure (e_{1t}) and government investment expenditure (e_{5t}) are the key categories which contribute to the spending cuts. Additionally, the disaggregated data reveals that not all the fiscal categories have contributed to the stabilization of debt as some categories do not have the expected signs.

The decomposition results from Regression 2 in Table 3 provide similar insights. Although the point estimates are not the same, the key conclusions are similar. The Canadian government has mainly used the revenue side to stabilize debt and in particular the direct taxes sub-category.

3 Model

We set up a simple small open economy model to derive the debt limit. The country is small enough that it cannot affect the foreign price level and the interest rate. Initially, the monetary policy is active and fiscal policy is passive (as in Leeper 1991). There is a single good in the world, implying that the goods market equilibrium requires the law of one price. Normalizing the foreign price level at unity and assuming no foreign inflation implies that the equilibrium domestic price level is the exchange rate.

Solvency requires that debt remains below the effective fiscal limit. Once debt breaches its effective fiscal limit, the country faces a solvency crisis and the government adopts a policy switch with passive monetary policy and active fiscal policy, which usually requires debt devaluation via inflation. We assume that agents know the policy response to the crisis.

3.1 Government

We assume that the domestic government issues nominal bonds (B_t), which are either held by the domestic agent $\left(B_t^d\right)$ or the foreign agent $\left(B_t^f\right)$, such that $B_t = B_t^d + B_t^f$. The government's nominal flow budget constraint is given by

$$B_t = (1 + i_{t-1}) B_{t-1} + P_t g_t + P_t z_t - P_t \tau_t A_t (1 - l_t) \tag{5}$$

where P_t is the price level, i_{t-1} is the nominal domestic interest rate, g_t denotes the real government purchases, z_t is the real transfer payments to the household, τ_t is the distortionary labour income tax, A_t is the productivity level, $1 - l_t$ is the household's labour supply and $\tau_t A_t (1 - l_t)$ represents the real tax revenue. Dividing equation (5) by P_t, the government's real flow budget constraint can be expressed as

$$b_t = \left(\frac{1 + i_{t-1}}{1 + \pi_t}\right) b_{t-1} + g_t + z_t - \tau_t A_t (1 - l_t) \tag{6}$$

where $b_t = \frac{B_t}{P_t}$ denotes the real value of bonds, $\pi_t = \frac{P_t}{P_{t-1}} - 1$ is the inflation rate and $\tau_t A_t (1 - l_t) - g_t - z_t$ represents the real primary balance.

We assume that the foreign agent is willing to buy domestic government bonds as long as the domestic interest rate (i_{t-1}) satisfies interest rate parity. Interest rate parity is derived from the foreign agent's Euler equations when the covariance between the domestic interest rate and the foreign agent's consumption is zero,[3] and it can be expressed as

$$1 + i = (1 + i_{t-1}) E_{t-1} \frac{1}{1 + \pi_t} \tag{7}$$

where i is the foreign interest rate, which is assumed to be constant, and E_{t-1} denotes

[3] This follows from the small open economy assumption. Equation (7) also holds when the foreign agent is risk neutral.

the expectation conditional on the information at time $t-1$. Equation (7) implies that the domestic country's interest rate (i_{t-1}) rises above the foreign interest rate (i) when the agents expect debt devaluation via inflation $\left(E_{t-1}\frac{1}{1+\pi_t}<1\right)$.[4]

Define devaluation on debt due to inflation, denoted by a_t, as

$$a_t=\left(1-\frac{1}{1+\pi_t}\right)(1+i_{t-1})\,b_{t-1} \tag{8}$$

where inflation $(\pi_t>0)$ increases the devaluation on debt $(a_t>0)$. When there is no inflation $(\pi_t=0)$, there is no devaluation $(a_t=0)$. Using equation (8), unexpected devaluation due to inflation, or equivalently a price level shock, which reduces the value of domestic debt can be expressed as

$$a_t-E_{t-1}a_t=\left(E_{t-1}\frac{1}{1+\pi_t}-\frac{1}{1+\pi_t}\right)(1+i_{t-1})\,b_{t-1}. \tag{9}$$

Substituting equations (7) and (9) into equation (6) yields the evolution of government's debt as

$$b_t=(1+i)\,b_{t-1}+g_t+z_t-\tau_t A_t\,(1-l_t)-(a_t-E_{t-1}a_t) \tag{10}$$

where expectations of devaluation $(E_{t-1}a_t>0)$ raise debt, and devaluation via inflation $(a_t>0)$ reduces debt and contributes to government revenue. When the devaluation due to inflation is fully anticipated, it raises both a_t and $E_{t-1}a_t$ equally, thereby having no effect on debt $(a_t-E_{t-1}a_t=0)$. Equation (10) allows to linearly separate the terms that affect the domestic interest rate.

[4] If there are no expectations for inflation $\left(E_{t-1}\frac{1}{1+\pi_t}=1\right)$, then the domestic interest rate is equal to the foreign interest rate $(i_{t-1}=i)$.

3.2 Policy rules

The monetary authority determines inflation with an active monetary policy. We assume that the active monetary policy sets the domestic interest rate, i_t, according to the following Taylor rule

$$i_t = i + \kappa \left(\pi_t - \pi\right) \qquad \kappa > 1 \tag{11}$$

where initial inflation and inflation target, π, is set to zero.

We assume that the fiscal authority adjusts the tax rate (τ_t) and government purchases (g_t) in response to increases in lagged debt. This follows our empirical results from Section 1.[5] Our fiscal feedback rules generalize those used by Bi (2012) by allowing the tax rate and government purchases to respond to their own lags and lagged debt (b_{t-1}). The tax and government purchases feedback rules are given by

$$\tau_t - \tau = \rho^{\tau} \left(\tau_{t-1} - \tau\right) + \gamma^{\tau} \left(b_{t-1} - b\right) \tag{12}$$

$$g_t - g = \rho^{g} \left(g_{t-1} - g\right) - \gamma^{g} \left(b_{t-1} - b\right) \tag{13}$$

where τ, g and b are the steady-state values of the tax rate, government purchases and debt, respectively. The parameters ρ^{τ} and ρ^{g} measures the persistence, which partly capture the inertia in the legislative and implementation process, and partly reflects the desire to smooth the effects of debt deviations from its steady-state over time. The coefficient γ^{τ} represents the tax adjustment parameter, which captures the responsiveness of the tax rate to increases in debt. A stronger responsiveness to debt implies that the government is raising the tax rate aggressively to retire debt. The coefficient γ^{g} is the spending adjustment parameter,

[5] For tractability, the model uses three fiscal categories, tax rate (τ_t), government purchases (g_t) and transfers (z_t) instead of eleven categories, where $\tau_t = r_t$, $g_t = e_{1t} + e_{5t}$ and $z_t = e_{2t} + e_{3t} + e_{4t}$.

which captures the rate at which government purchases decline as debt rises. A larger γ^g implies that the government is aggressively lowering government purchases as debt rises.

We specify transfers from the government (z_t) as[6]

$$z_t - z = \rho^z \left(z_{t-1} - z\right) + \varepsilon_t^z, \qquad \varepsilon_t^z \sim N\left(0, \sigma^z\right)$$

where ρ^z measures the persistence in transfers, z is the steady state value of transfers, and ε_t^z is the transfers shock, which represents the government's discretionary response to the pandemic and includes the emergency transfers to the household during the lockdown.

3.3 Household

The small open economy is populated by a representative household, who chooses consumption (c_t), leisure (l_t), and domestic bonds $\left(B_t^d\right)$,[7] and maximizes the following utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\log c_t + \phi_t \log l_t\right],$$

subject to the following budget constraint

$$b_t^d = \left(\frac{1+i_{t-1}}{1+\pi_t}\right) b_{t-1}^d + \left(1-\tau_t\right) A_t \left(1-l_t\right) + z_t - \left(1+\chi_t\right) c_t \tag{14}$$

where $0 < \beta < 1$ is the discount factor, $b_t^d = \frac{B_t^d}{P_t}$ denotes the real value of bonds held by the domestic agent, ϕ_t is a preference leisure parameter, which is equal to ϕ during normal times, and is equal to $\phi + \xi_t$ during the pandemic lockdown, where $\xi_t > 0$ is a shock to the labour-leisure preferences due to the pandemic. The pandemic exposes the household to the

[6] Section 1, we find that Canadian fiscal authorities do not cut transfers when debt rises.

[7] We assume that the domesic household can only hold their own government's bonds, but not foreign assets. This is a simplifying assumption to derive the analytical phase diagram below. Our key result is robust to alternative assumptions. If the domestic household can also purchase foreign assets, the effective fiscal limit will also depend on i) the fraction of foreign assets held by the domestic household and ii) the foreign country's primary balance. But, the key findings of this paper remain unchanged.

virus when she is working. We think of ξ_t as one proxy for the containment measures aimed at reducing working interactions. The lockdown due to the pandemic reduces the labour supply. Alternatively, ξ_t can be viewed as a proxy for the fear of catching the virus while working, thereby reducing her labour supply.

The second proxy for the containment measures is aimed at reducing consumption interactions and it is given by χ_t. The household can get exposed to the virus while purchasing consumption goods, and $\chi_t > 0$ represents the additional cost on consumption due to the pandemic, which includes the waiting times, spacing requirements, reduced hours while shopping, as well as the PPE fees.

The productivity level (A_t) follows an AR(1) process with A representing the steady-state level and ε_t^A the productivity shocks

$$A_t - A = \rho^A \left(A_{t-1} - A\right) + \varepsilon_t^A, \qquad \varepsilon_t^A \sim N\left(0, \sigma^A\right).$$

where a negative productivity shock $\left(\varepsilon_t^A < 0\right)$ can represent an infected and sick household.

Combining the government budget constraint (equation 6) with the household budget constraint (equation 14), the aggregate resource constraint is given by

$$A_t \left(1 - l_t\right) - c_t - g_t = -\left[b_t^f - \left(\frac{1 + i_{t-1}}{1 + \pi_t}\right) b_{t-1}^f\right] \tag{15}$$

where $b_t^f = \frac{B_t^f}{P_t}$ denotes the real value of domestic bonds held by the foreign agent. The right hand side of equation (15) represents the trade balance. The ratio of the trade balance to the primary balance is denoted by λ_t and follows an AR(1) process

$$\lambda_t - \lambda = \rho^\lambda \left(\lambda_{t-1} - \lambda\right) + \varepsilon_t^\lambda, \qquad \varepsilon_t^\lambda \sim N\left(0, \sigma^\lambda\right).$$

The household's maximization problem yields the typical first-order conditions, and output can be written as

$$A_t\left(1-l_t\right)=\frac{A_t\left(1-\tau_t\right)+\eta_t\left(1-\lambda_t\right)g_t-\eta_t\lambda_t z_t}{1+\eta_t-\tau_t\left(1+\eta_t\lambda_t\right)}, \tag{16}$$

where $\eta_t=\phi_t\left(1+\chi_t\right)=\left(\phi+\xi_t\right)\left(1+\chi_t\right)$ includes the two containment measures due to the pandemic, which can substantially reduce output and tax revenue.

3.4 Dynamics

It is useful to represent the dynamic behaviour of the expected future tax rate, government spending and debt system using a phase diagram, which reveals the direction of movement of the expected future tax rate, government purchases and debt for different values.

We construct the phase diagram for the system by subtracting the lagged value of the tax rate from both sides of equation (12), the lagged value of government purchases from both sides of equation (13) and the lagged value of debt from both sides of equation (10), taking the equations j periods forward, and taking the time t expectation to yield[8]

$$\begin{aligned}
E_t\tau_{t+j}-E_t\tau_{t+j-1} &= \left(\rho^\tau-1\right)\left(E_t\tau_{t+j-1}-\tau\right)+\gamma^\tau\left(E_t b_{t+j-1}-b\right) && (17)\\
E_t g_{t+j}-E_t g_{t+j-1} &= \left(\rho^g-1\right)E_t g_{t+j-1}-\gamma^g\left(E_t b_{t+j-1}-b\right), && (18)\\
E_t b_{t+j}-E_t b_{t+j-1} &= -E_t\left(\frac{A_{t+j}\tau_{t+j}\left(1-\tau_{t+j}\right)+\eta_{t+j}\left(1-\lambda_{t+j}\right)g_{t+j}\tau_{t+j}-\eta_{t+j}\lambda_{t+j}z_{t+j}\tau_{t+j}}{1+\eta_{t+j}-\left(1+\eta_{t+j}\lambda_{t+j}\right)\tau_{t+j}}\right)\\
&\quad iE_t b_{t+j-1}+E_t g_{t+j}+E_t z_{t+j}. && (19)
\end{aligned}$$

Setting equation (17), (18) and (19) equal to zero ($\Delta E_t\tau_{t+j}=0,\ \Delta E_t g_{t+j}=0,\ \Delta E_t b_{t+j}=0$)

[8] Taking the time t expectation implies that $E_t\varepsilon^A_{t+j}=0$, $E_t\varepsilon^z_{t+j}=0$, $E_t\varepsilon^\lambda_{t+j}=0$, and $E_t\left(a_{t+j}-E_{t+j-1}a_{t+j}\right)=E_t a_{t+j}-E_t\left(E_{t+j-1}a_{t+j}\right)=E_t a_{t+j}-E_t a_{t+j}=0$.

and solving for $E_t b_{t+j-1}$ yields

$$
\begin{aligned}
E_t b_{t+j-1} &= \frac{\gamma^{\tau} b + (\rho^{\tau} - 1)\,\tau + (1-\rho^{\tau})\, E_t \tau_{t+j}}{\gamma^{\tau}}, && (20)\\
E_t b_{t+j-1} &= \frac{\gamma^{g} b - (\rho^{g} - 1)\, g - (1-\rho^{g})\, E_t g_{t+j}}{\gamma^{g}}, && (21)\\
E_t b_{t+j-1} &= E_t \left(\frac{A_{t+j}\tau_{t+j}\,(1-\tau_{t+j}) + \eta_{t+j}\,(1-\lambda_{t+j})\, g_{t+j}\tau_{t+j} - \eta_{t+j}\lambda_{t+j} z_{t+j}\tau_{t+j}}{i\left(1+\eta_{t+j} - \left(1+\eta_{t+j}\lambda_{t+j}\right)\tau_{t+j}\right)} \right) \\
&\quad - E_t \left(\frac{g_{t+j} + z_{t+j}}{i} \right). && (22)
\end{aligned}
$$

Equations (20) - (22) divide the system into various stable and unstable regions. The three-dimensional phase diagram is presented in Figure 1. To understand the dynamic behaviour between the tax rate and debt, we slice Figure 1 and look at the cross section when government spending is at g. The two-dimensional phase diagram between the tax rate and debt is presented in Figure 2.

3.5 Debt reduction via tax hikes

In this section, we focus on taxes. We consider the case in which the fiscal authority uses the tax rate to lower debt, while keeping the government spending at its steady state. In Figure 2, the debt is on the vertical axis and the tax rate is on the horizontal axis. The $\Delta E_t \tau_{t+j} = 0$ curve, equation (20), is linear and it has a positive slope, $\frac{1-\rho^{\tau}}{\gamma^{\tau}} > 0$. The $\Delta E_t b_{t+j} = 0$ curve, equation (22), is nonlinear and its shape mimics the shape of the Laffer curve. The arrows of motion, which reveal the direction of movement of debt and the tax rate, are different in each region. If the economy starts at point A, it will travel along the adjustment path AG. The adjustment path AG crosses three regions. In the initial region, the tax rate does not generate enough tax revenue to reduce the debt level, thus both the tax rate and debt are rising. In the second region, the tax rate continues to rise while the debt level is gradually falling. In the third region, both the tax rate and debt are declining, and the economy eventually reaches point G. Point G represents the long-run equilibrium in which the tax rate and debt are equal to their steady-state values.

Adverse shocks, such as the containment measures (ξ_t, χ_t), productivity shocks $\left(\varepsilon_t^A\right)$ and fiscal shocks (ε_t^z), could push the economy to point B. At point B, the debt level is so high that it becomes explosive. The economy will embark on the explosive path BC and thus fail to attain its long-run equilibrium.

The adjustment path DEG in Figure 2 is at the boundary of the stable region and represents the maximum value of debt consistent with the equilibrium.[9] Beginning at any position below DEG, the arrows of motion point towards point G and the economy is expected to reach its long-run equilibrium. If debt were to ever breach DEG due to adverse shocks, then the arrows of motion imply that the economy would embark on an explosive path. When the economy is above the boundary DEG, it finds itself on the wrong side of the Laffer curve, where higher tax rates lower the tax revenue. The primary surplus is less than the interest payments and the debt becomes explosive. This is a position of insolvency as agents would refuse to lend. Therefore, in equilibrium the system should not exceed DEG. We refer to the boundary DEG as the debt limit due to taxes.

Dividing equation (19) by equation (17) yields the time-varying slope of any adjustment path in the debt-tax rate system as

$$\begin{aligned}\frac{\Delta E_t b_{t+j}}{\Delta E_t \tau_{t+j}} &= \frac{iE_t b_{t+j-1} + g + E_t z_{t+j}}{(\rho^\tau - 1)\left(E_t \tau_{t+j-1} - \tau\right) + \gamma^\tau \left(E_t b_{t+j-1} - b\right)} \\ &\quad - \frac{E_t\left[\frac{\tau_{t+j}\left(A_{t+j}(1-\tau_{t+j}) + \eta_{t+j}(1-\lambda_{t+j})g - \eta_{t+j}\lambda_{t+j}z_{t+j}\right)}{1+\eta_{t+j} - \left(1+\eta_{t+j}\lambda_{t+j}\right)\tau_{t+j}}\right]}{(\rho^\tau - 1)\left(E_t \tau_{t+j-1} - \tau\right) + \gamma^\tau \left(E_t b_{t+j-1} - b\right)},\end{aligned} \tag{23}$$

[9] The adjustment path DEG passes just below point H.

which depends on the level of tax rate, the parameters of the tax feedback rule and the containment measures. This in turn implies that the debt limit also depends on all the parameters of the model, and not just on the peak of the Laffer curve (as in Bi 2012).

It is important to note that if the containment measures become permanent, then the $\Delta E_t b_{t+j} = 0$ curve will shift downwards, thereby lowering the debt limit. They permanently lower the tax revenue and the government can repay lower levels of debt.

3.6 Debt reduction via spending cuts

In this section, we focus on government purchases. We consider the case in which the fiscal authority uses spending cuts to lower the debt level, while keeping the tax rate at its steady state. We slice Figure 1 and look at the cross section when the tax rate is at τ. Figure 3 contains the two-dimensional phase diagram between the government purchases and debt. The debt is on the vertical axis and government purchases is on the horizontal axis. Both the $\Delta E_t g_{t+j} = 0$ curve, equation (20), and the $\Delta E_t b_{t+j} = 0$ curve, equation (22), are linear and have a negative slope. Point G represents the long-run equilibrium point, where the debt and government purchases are equal to their steady-state values. The arrows of motion, which reveal the direction of movement of the debt and government purchases, point towards G, confirming a stable system. If the economy starts at point A, it is expected to travel along the adjustment path AG.

There are no unstable regions in the government spending-debt system. Stability assures that the system returns to its long-run equilibrium. Although the debt-government purchases system has no explosive regions, the government spending has to take non-negative values at all times, $E_t g_{t+j} \geq 0$ for all j. The lowest possible level of government purchases is zero.

Therefore, the economy must be on a path, along which the expected future government purchases do not decline below zero. The adjustment path, labeled KMG, with government purchases equal to zero (at point M) contain the highest feasible adjustment path towards the long-run equilibrium. If the economy begins below KMG, the expected future government purchases along the adjustment path lie above zero. If adverse shocks send the economy above KMG, the adjustment path is expected to pass through points where the government purchases are below the zero lower bound, implying that these paths are infeasible. Therefore, the path KMG represents the debt limit due to government purchases, which separates feasible paths from those which are not.

Dividing (19) by equation (18) the time-varying slope of the adjustment path in the debt-government purchases system can be written as

$$\begin{aligned}\frac{\Delta E_t b_{t+j}}{\Delta E_t g_{t+j}} &= \frac{iE_t b_{t+j-1} + E_t g_{t+j} + E_t z_{t+j}}{(\rho^g - 1)(E_t g_{t+j-1} - g) - \gamma^g (E_t b_{t+j-1} - b)} \\ &\quad - \frac{E_t \left[\frac{A_{t+j}\tau(1-\tau) + \eta_{t+j}(1-\lambda_{t+j})\tau g_{t+j} - \tau\eta_{t+j}\lambda_{t+j} z_{t+j}}{1+\eta_{t+j} - \left(1+\eta_{t+j}\lambda_{t+j}\right)\tau} \right]}{(\rho^g - 1)(E_t g_{t+j-1} - g) - \gamma^g (E_t b_{t+j-1} - b)},\end{aligned} \tag{24}$$

which depends on the level of government purchases, the parameters of the government feedback rule and the containment measures.

To summarize, when the government uses both the tax rate and the government purchases to lower the debt level, it faces a debt limit because government purchases have to remain above zero and the distortionary tax rate should not be too high. If a string of adverse shocks send the economy above its debt limit, the government is a faced with an inability to borrow and experiences a solvency crisis. To restore equilibrium, the government adopts a policy switch with passive monetary policy and active fiscal policy, which usually requires debt devaluation via inflation.

3.7 Equilibrium with Policy Switching

Definition 1 *Given values for the foreign interest rate, an inflation target, stochastic processes for $\xi_t, \chi_t, \varepsilon_t^A$, ε_t^λ and ε_t^z, an initial active monetary rule (equation 11) and passive fiscal feedback rules (equations 12 and 13) with plans for switching in the event that the government cannot carry out the initial policy mix, an equilibrium is a set of time series processes for $\{b_t, \tau_t, g_t, z_t, A_t, l_t, i_t, \pi_t, a_t, E_{t-1}a_t\}_{t=0}^{\infty}$, such that the government's flow constraint (equations 10) holds, expectations are rational, debt is not expected to exceed the debt limit, and agents expect to receive the return on bonds determined by interest rate parity (equation 7).*

Initially the fiscal authority follows passive feedback rules, allowing the monetary authority to follow the active Taylor rule in equation (11). When the debt breaches the debt limit, the initial policy mix is not viable. To restore expectations of solvency and lending, the monetary authority switches to a passive policy of pegging the interest rate at a value consistent with an inflation target of zero, and the fiscal authority switches to an active fiscal policy. Under an active fiscal policy, the tax rate and government spending do not respond to debt. We model this by setting $\gamma^\tau = \gamma^g = 0$ in equations (12) and (13). We also allow the government to revise its targets to higher levels $(\hat{\tau}, \hat{g})$.[10] The active fiscal feedback rules are given by

$$\tau_t = \rho^\tau \tau_{t-1} + (1 - \rho^\tau)\,\hat{\tau}$$

$$g_t = \rho^g g_{t-1} + (1 - \rho^g)\,\hat{g}$$

This is a Fiscal Theory of the Price Level policy regime, which ensures solvency by having the real outstanding value of debt to adjust through inflation, or equivalently price level jumps.

[10]By allowing the fiscal authority to raise its targets, it allows the government to maintain its initial policy mix as long as possible.

4 Model Applied: The case of Canada

In this section, we apply the model to Canada. We estimate the debt limit implied by our model, and we then simulate various risk scenarios to determine whether the debt will breach its debt limit.

4.1 Canadian debt limit

In this section, we quantify the Canadian debt limit. Table 5 summarizes our parameter values. The model is calibrated at annual frequency. The leisure preference parameter ϕ is set to 2.30 such that the household spends 25% of time working during pre-pandemic, $1-l=0.25$. The productivity level at the steady-state (A) is normalized to 4, such that the steady-state of output is equal to 1. The steady-state fiscal variables are calibrated to match the average Canadian data between 1970 and 2019: the tax rate (τ) is 0.37, the government purchases-to-GDP ratio (g/y) is 0.21, the transfer payments-to-GDP ratio (z/y) is 0.14, and the debt-to-GDP ratio (b/y) is 0.75, yielding a discount factor which delivers a real interest rate (i) of 2.67%. The average ratio (λ) of the trade balance to the primary balance is -1.5 over the sample period. Using an HP filter, we detrend real GDP per worker and real transfer payments to estimate the AR(1) processes for A_t and z_t. The estimates for the persistence are $\rho^A = 0.55$ and $\rho^z = 0.56$, and the estimates for the standard deviation are $\sigma^A = 0.016A$ and $\sigma^z = 0.029z$. For the tax and government spending adjustment parameters, we use our estimates from Table 2. The pre-pandemic values of ξ and χ are set to zero.

Figure 4 shows the debt limit implied by our model over the sample period. Our model yields a debt limit that ranges between 198% and 239% of GDP. The Canadian gross debt level has been well below the debt limit over the period. Figure 5 illustrates that the fiscal space, which is the difference between the debt limit and the level of debt, was at 127% of GDP in 2019, implying that in the run up to the pandemic the general government in Canada had ample of fiscal space.

4.2 Simulations

To investigate the fiscal implications of the pandemic, we need to report our choices for the values of the two containment measures and the productivity shock. We use data from the Statistics Canada: Canadian Economic Dashboard and Covid-19. The first containment measure ξ is set to 0.8 such that the household reduces the hours worked by 12.4%, which is the average decline in hours worked in the first six months of 2020 compared to the 2019 average level. The second containment measure χ is set to 0.085 to yield a 6.8% decline in consumption, which is the average decline in real consumption in the first two quarters of 2020. We set the productivity shock ε^A to -0.04 to yield a 1% decline in productivity, which is equal to the average decline in real GDP per worker in the first half of 2020. Next, we need to choose the fiscal transfers shock. We set ε^z to 0.141 (14.1% of GDP), which is the total support to the households and business to mitigate economic hardship as reported in Canada's Covid-19 Economic Response Plan by the Government of Canada.

Using the above values for ξ, χ, ε^A and ε^z, Figure 6 illustrates the baseline pandemic scenario. In the first year, the economy receives the four shocks.[11] The decline in tax revenue, driven by the sudden drop in output in the first year, coupled with the sharp increase in fiscal transfers push the debt level above the 100% of GDP mark, but debt remains well below its debt limit. Going forward, the tax rate increases and the government purchases

[11]The parameters ξ, χ, and ε^A have a negative impact on output, whereas ε^z has a positive impact on output.

decline to lower the elevated debt level. While in the second period output bounces back as the containment measures disappear, going forward output declines substantially due to the fiscal consolidation via the higher tax rate and the lower government purchases to rein in the elevated debt level.

To disentangle the effects of fiscal consolidation from the pandemic shocks, Figure 7 compares the effects when the four shocks $\left(\xi, \chi, \varepsilon^A, \varepsilon^z\right)$ are set to zero. The new responses are in red dotted lines. This counterfactual experiment reveals the effects of fiscal consolidation in the absence of the pandemic. Although the debt level does not shoot upwards, it is high enough to elicit increases in the tax rate and declines in government purchases. However, the deviations from the steady-states are muted compared to the baseline scenario.

There is a lot uncertainty around the four parameters $\left(\xi, \chi, \varepsilon^A, \varepsilon^z\right)$. As more data becomes available in 2020, these four parameters could change. We consider two sensitivity scenarios, which change the pandemic parameters in the risky direction. In the first scenario, the two containments measures (ξ, χ) and the fiscal transfers (ε^z) continue for five years as shown in Figure 8. Kissler et al. (2020) suggest that the pandemic could last up to 5 years. This captures the scenario in which a vaccine is not ready in a timely manner and the pandemic lasts longer. This experiment has an unprecedented effect on the debt level, which balloons to more than 200% of GDP, and in turn substantially raises the tax rate and lowers government spending. This is the worst case scenario that we consider, and although the debt level approaches the debt limit, it does not breach it.

In the second sensitivity scenario, the four parameters $\left(\xi, \chi, \varepsilon^A, \varepsilon^z\right)$ last for one year, but their magnitudes are larger. This captures the case in which there are additional lockdowns in the second half of 2020 that amplify the magnitude of the adverse shocks. We select the values of ξ, χ, and ε^A to match the large declines recorded in April of 2020, at the onset of the pandemic lockdown. The parameter ξ is set to 3.5 to match the 27% decline in hours worked in April 2020 from a year ago. The parameter χ is chosen to be 0.53 to yield an annual decline in consumption of 31% to match the decline in retail sales in April 2020 from a year ago. The parameter ε^A is set to -0.08 to match the 2% decline recorded in the real GDP per worker in April 2020 from a year ago. Figure 9 shows that these massive adverse shocks create a severe recession and a big increase in the level of debt in the first period. But going forward, the effects (in dotted lines) of tax rates and government spending do not deviate substantially from the baseline scenario (solid lines).

Next, we keep the four shocks at their baseline pandemic values, and we investigate the impact of alternative fiscal consolidation scenarios. The government might not follow the estimated historical responsiveness to lagged debt. We consider the case in which the fiscal authority chooses to cut in half the tax and government purchases responsiveness to lagged debt, $\gamma^\tau = 0.01435$ and $\gamma^g = 0.0096$. Given the negative impact of the pandemic, the government might choose to follow a less aggressive fiscal policy. Figure 10 shows that the increases in the tax rate and the declines in the government purchases are smaller than the baseline scenario. However, the slow consolidation efforts imply that the debt level will remain elevated for an extended period of time.

We then consider the case where the fiscal authority becomes more aggressive. In Figure 11, we doubled the magnitude of $\gamma^\tau = 0.0574$ while keeping γ^g at 0.0191 to capture consolidation efforts which emphasize tax hikes. Figure 12, we doubled γ^g to 0.0382 while keeping γ^τ at 0.0287 to capture consolidation efforts which emphasize spending cuts. The last two scenarios show that if the government decides to intensify the fiscal consolidation efforts, the debt level will decline at a faster rate.

5 Conclusion

This paper investigates whether or not the debt level will breach its limit due to the COVID-19 global pandemic. To derive the debt limit, we require the responses of taxes and government spending to lagged debt. Using a rich set of disaggregated fiscal variables, we estimate their responsiveness to lagged debt. We find that the responsiveness of tax revenue is stronger than the responsiveness of government expenditure to lagged debt, suggesting that the government has historically financed the debt level via higher taxes.

We then use a simple small open economy model which is subject to pandemic shocks to derive the debt limit in Canada. The pandemic shocks reduce hours worked and consumption, which in turn lower output and tax revenue, and raise the debt level. We find that the current debt level is well below its limit. Additionally, we find that even if the economy is bombarded with additional adverse shocks due to the pandemic, the debt level will get closer to the debt limit, but it will never breach it. The Canadian government has ample of fiscal space to maneuver and there is no risk of a solvency crisis.

References

[1] Bi, Huixin, (2012) "Sovereign Risk Premia, Fiscal Limits, and Fiscal Policy." *European Economic Review*, 56(3), 389-410.

[2] Bi, Huixin, Eric Leeper and Campbell Leith, (2013) "Uncertain Fiscal Consolidations." *Economic Journal*, 123, 31-63.

[3] Bohn H (1998), "The Behavior of U.S. Public Debt and Deficits," *Quarterly Journal of Economics*, 113, 949-963.

[4] Daniel, Betty C. and Christos Shiamptanis, (2019) "Identifying Countries at Risk of Fiscal Crises: High-Debt Developed Countries." LCERPA Working Paper 2015-8

[5] Eichenbaum, Martin, Sergio Robelo, and Mathias Trabandt, (2020) "The Macroeconomics of Epidemics." Working Paper

[6] Ghosh, Atish, Jun Kim, Enrique Mendoza, Jonathan Ostry, and Mahvash Qureshi, (2013) "Fiscal Fatigue, Fiscal Space And Debt Sustainability in Advanced Economies." *Economic Journal*, 123, 4-30.

[7] Kissler, Stephen M, Christine Tedijanto, Edward Goldstein, Yonatan H. Grad, Marc Lipsitch, (2020) "Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period." *Science*, 368 (6493), 860-868.

[8] Leeper, Eric, (1991) "Equilibria under 'Active' and 'Passive' Monetary Policies." *Journal of Monetary Economics,* 27(1), 129-147.

[9] Leeper, Eric M., Michael Plante, and Nora Traum, (2010) "Dynamics of fiscal financing in the United States." *Journal of Econometrics,* 156(2), 304-321.

[10] Trabandt, Mathias and Harald Uhlig, (2011) "The Laffer curve revisited." *Journal of Monetary Economics*, 25, 305-327

[11] Shiamptanis, Christos (2019) "Tax Austerity: Does it avert solvency crisis?" LCERPA Working Paper

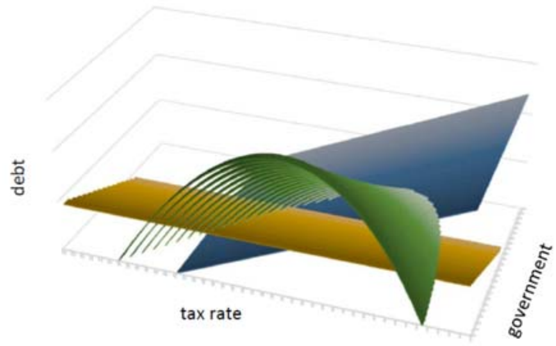

Figure 1: Three–dimensional phase diagram

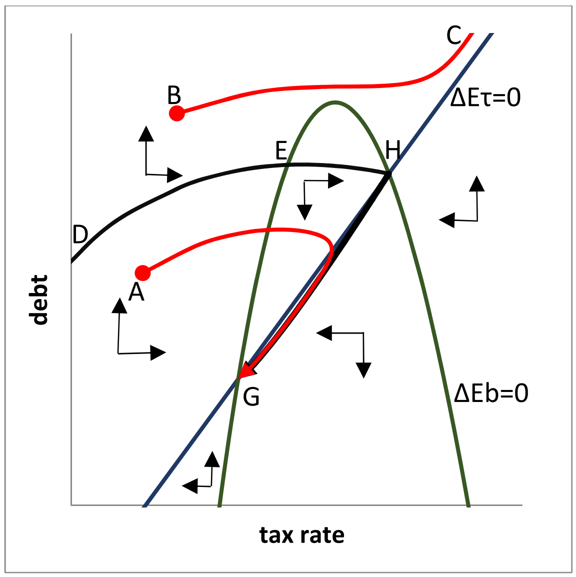

Figure 2: Dynamic behaviour between the tax rate and debt.

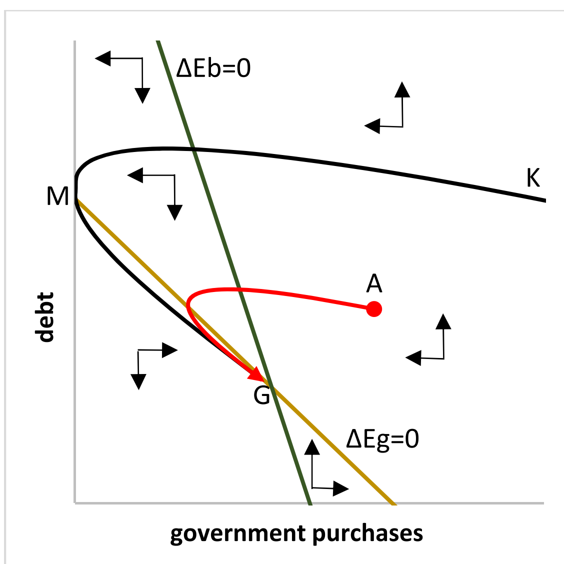

Figure 3: Dynamic behaviour between the government purchases and debt.

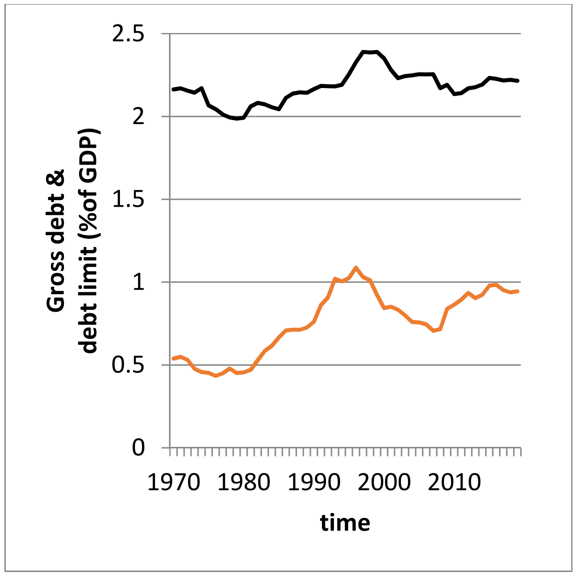

Figure 4: Canadian debt limit (% of GDP).

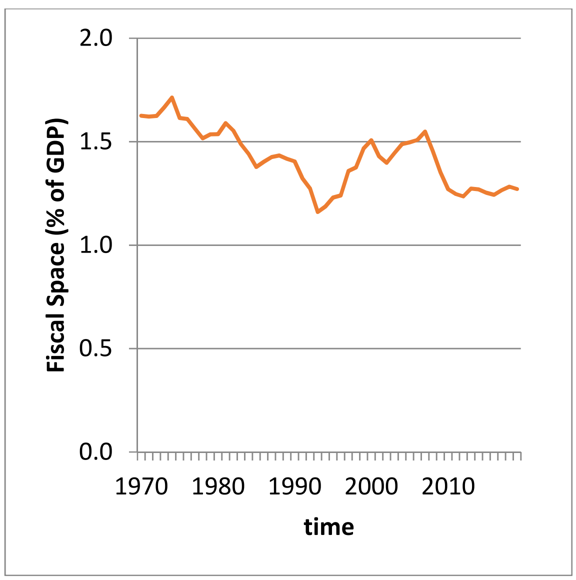

Figure 5: Canadian fiscal space (% of GDP).

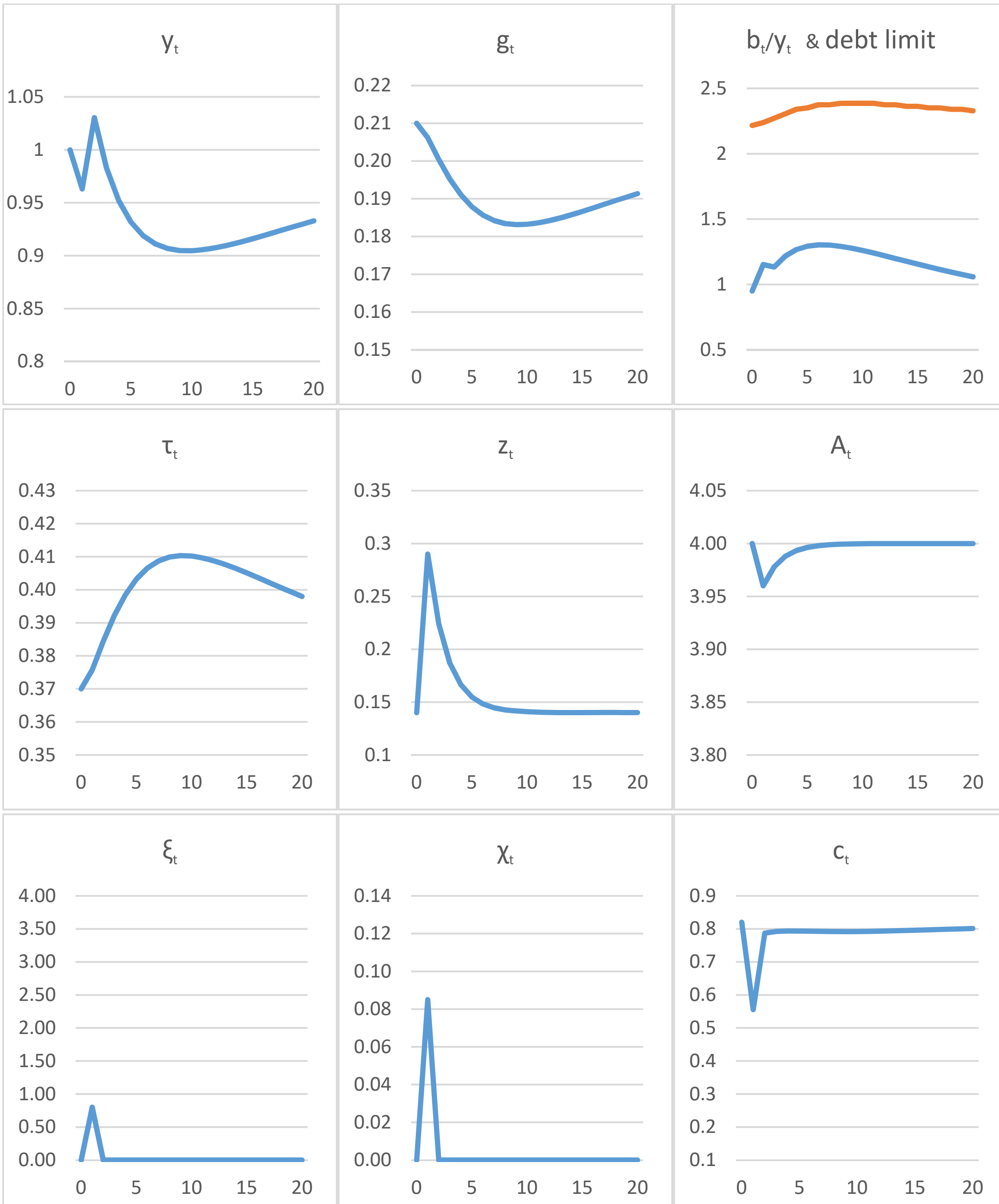

Figure 6: Baseline pandemic scenario

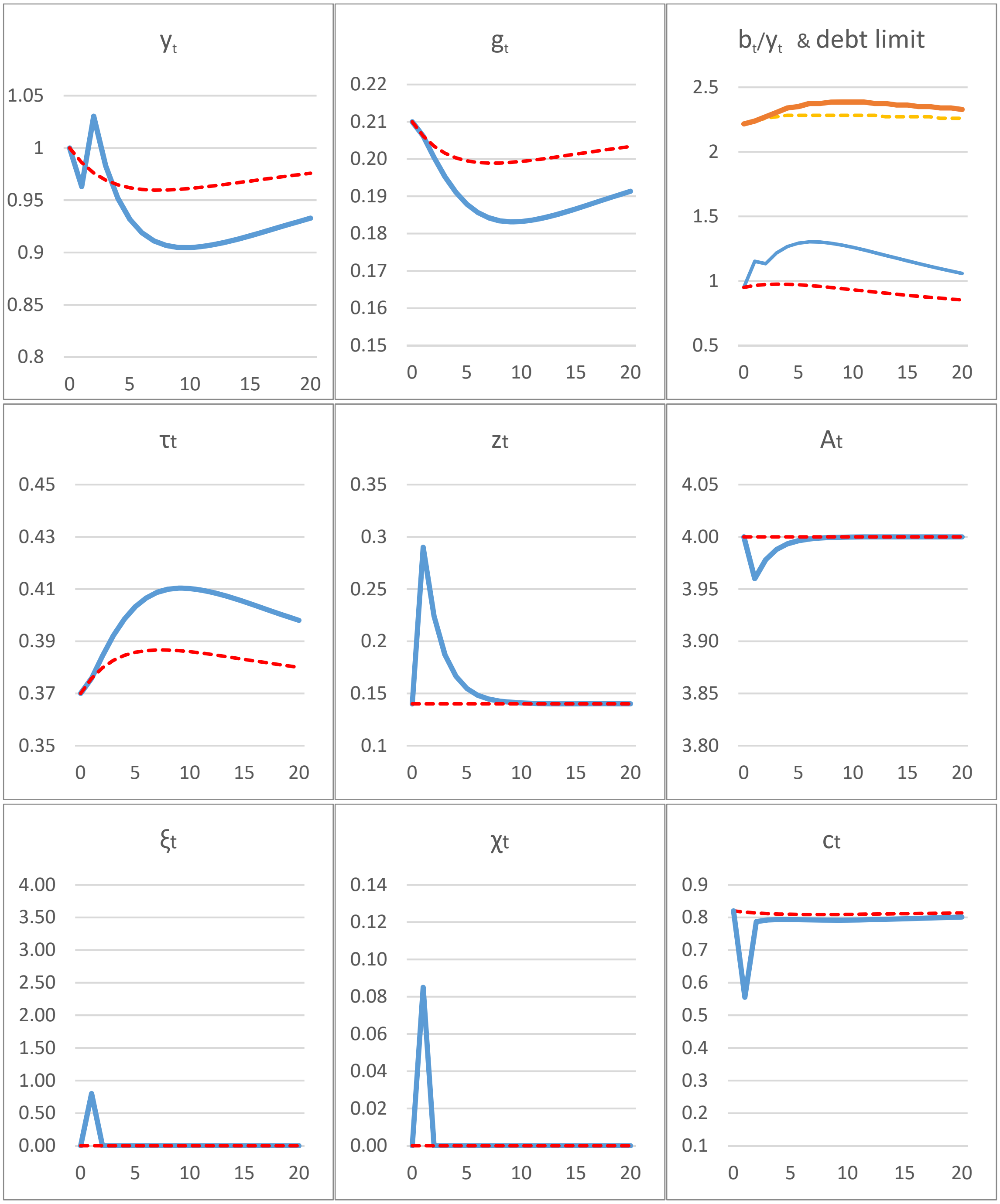

Figure 7: Baseline pandemic scenario (solid line) vs no-pandemic scenario (dotted line)

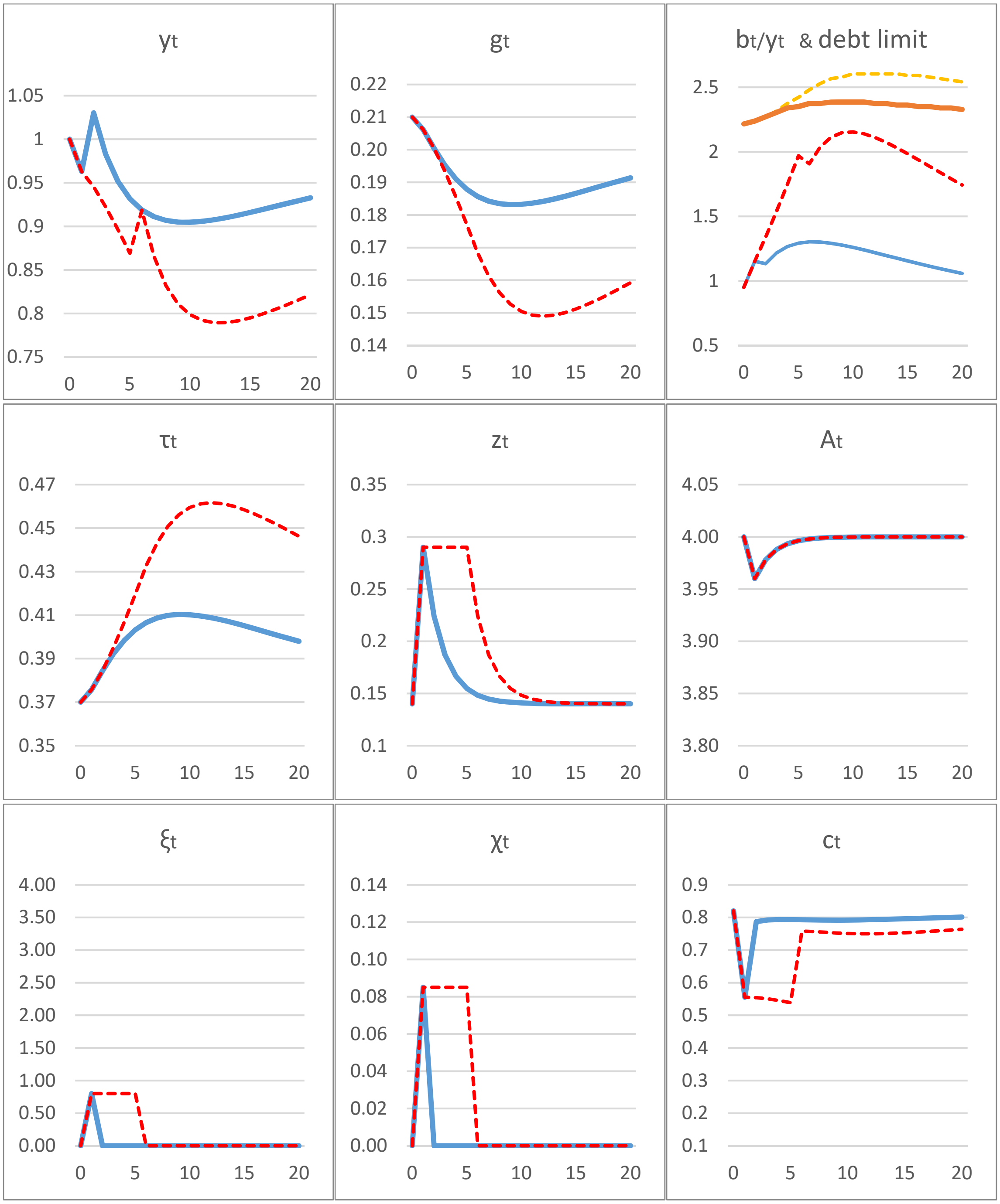

Figure 8: Baseline pandemic scenario (solid line) vs a 5-year-pandemic scenario (doted line)

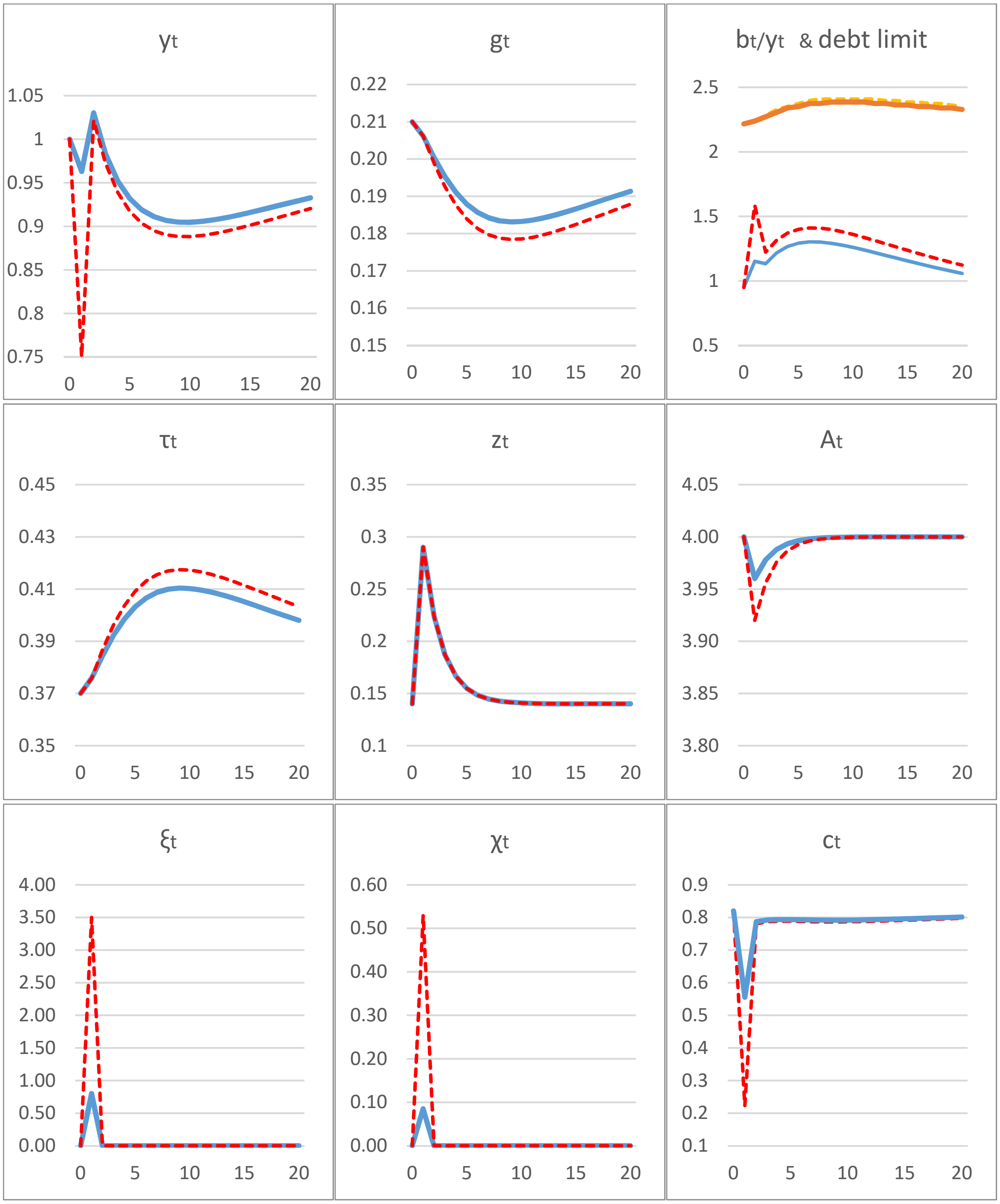

Figure 9: Baseline pandemic scenario vs a 1-year extreme pandemic scenario

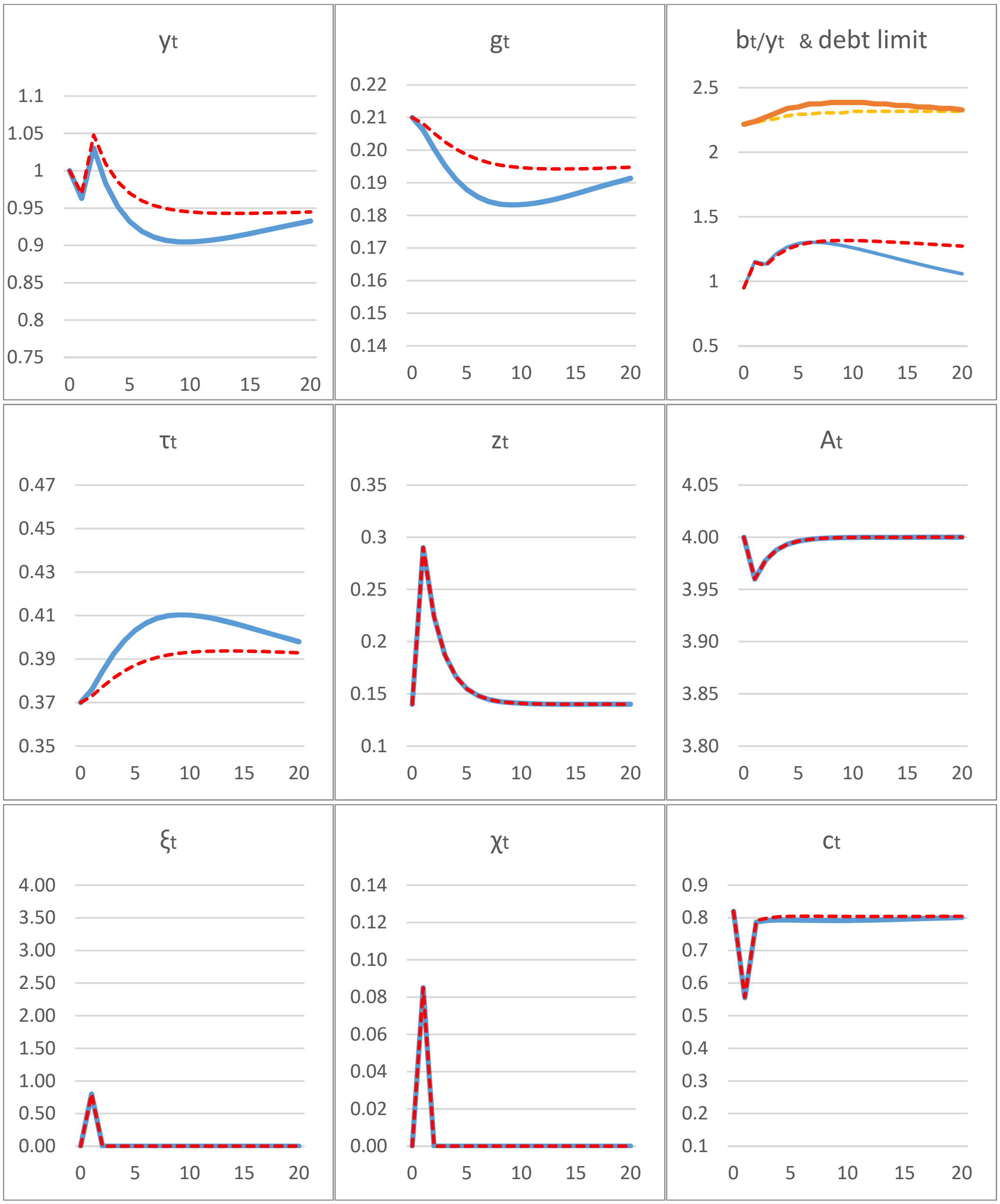

Figure 10: Baseline pandemic scenario vs a pandemic scenario with less aggressive fiscal authority

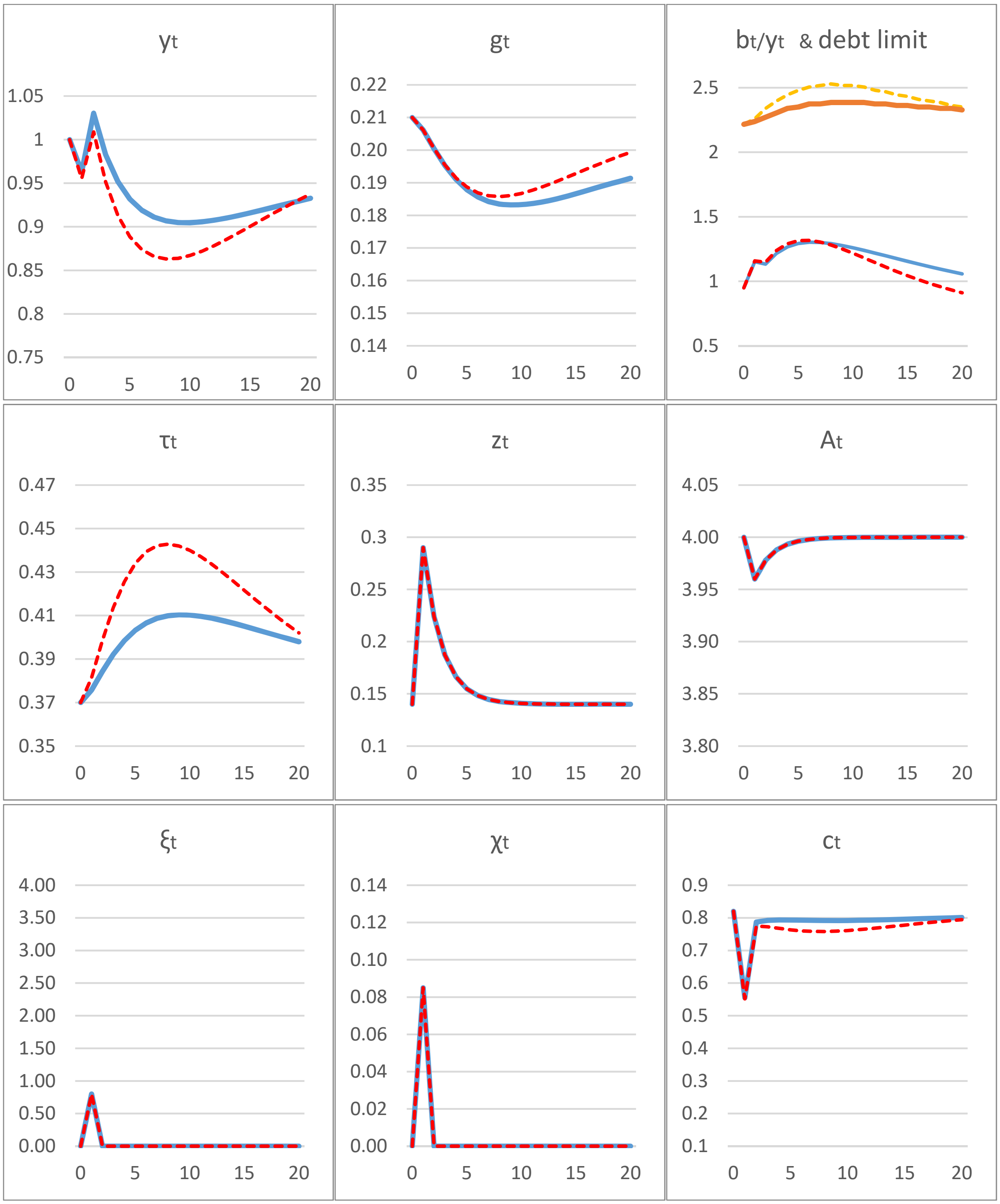

Figure 11: Baseline pandemic scenario vs a pandemic scenario with more emphasis on the tax rate

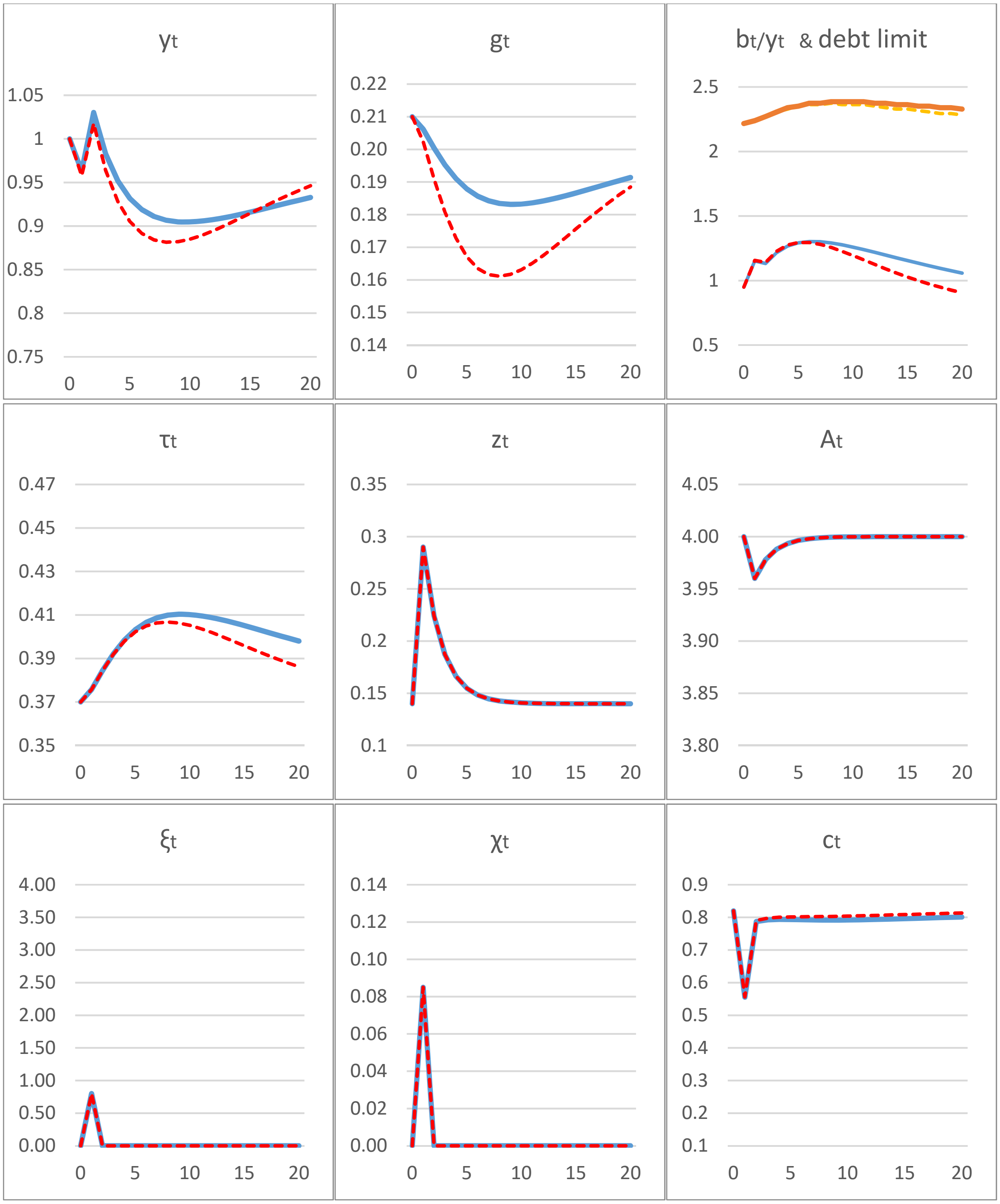

Figure 12: Baseline pandemic scenario vs a pandemic scenario with more emphasis on government purchases

Table 1: Fiscal Feedback Rules: 1970-2015

Variables	Regression 1 (1)	Regression 2 (2)
Lagged Primary Fiscal Balance	0.7079	0.7021
	(0.0696)***	(0.0684)***
Lagged Debt	0.0478	0.0707
	(0.0135)***	(0.0201)***
Output Gap	0.3410	0.2793
	(0.1090)***	(0.0960)***
Government Gap		−1.5170
		(0.4429)***
Trade Openness		−2.3637
		(2.9196)
Inflation		0.1381
		(0.0641)**
Adjusted R^2	0.85	0.90
Standard Error of Regression	1.2346	1.0065

Note: [1] The dependent variable is the primary fiscal balance. [2] Robust standard errors are reported in parentheses. [3] The symbols "*", "**", and "***" indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 2: Decomposition: Regression 1 (1970-2015)

Variables	r	r_1	r_2	r_3	r_4	r_5	r_6
Lagged Debt	0.0287	0.0123	-0.0005	0.0102	0.0050	$6.47E-05$	0.0017
	(0.0074)***	(0.0049)**	(0.0034)	(0.0020)***	(0.0015)***	(6.42E-05)	(0.0009)*
Output Gap	-0.0233	0.0524	-0.0437	-0.0126	-0.0208	0.0003	0.0011
	(0.0466)	(0.0271)*	(0.0419)	(0.0151)	(0.0146)	(0.0003)	(0.0054)
Adjusted R^2	0.31	0.18	0.04	0.51	0.34	0.03	0.07
Standard Error of Regression	0.8268	0.4827	0.4858	0.2013	0.1542	0.0076	0.0965
Variables	e	e_1	e_2	e_3	e_4	e_5	
Lagged Debt	-0.0191	-0.0149	0.0072	-0.0048	0.0027	-0.0092	
	(0.0116)	(0.0051)***	(0.0043)	(0.0022)**	(0.0019)	(0.0019)***	
Output Gap	-0.3643	-0.1586	-0.1411	-0.0454	0.0005	-0.0196	
	(0.0984)***	(0.0513)***	(0.0398)***	(0.0118)***	(0.0047)	(0.0176)	
Adjusted R^2	0.26	0.28	0.35	0.15	0.04	0.33	
Standard Error of Regression	1.2716	0.6188	0.4687	0.2590	0.1740	0.2478	

Note: [1] The dependent variable is various category of government revenue and spending. [2] Robust standard errors are reported in parentheses. [3] The symbols "*", "**", and "***" indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3: Decomposition: Regression 2 (1970-2015)

Variables	r	r_1	r_2	r_3	r_4	r_5	r_6
Lagged Debt	0.0551	0.0281	0.0219	0.0067	-0.0037	0.0001	0.0020
	(0.0215)**	(0.0109)**	(0.0106)**	(0.0035)*	(0.0030)	(0.0001)	(0.0017)
Output Gap	0.0014	0.0506	-0.0107	-0.0090	-0.0278	0.0003	-0.0019
	(0.0686)	(0.0343)	(0.0340)	(0.0136)	(0.0129)**	(0.0004)	(0.0046)
Government Gap	-0.1166	-0.3268	-0.0053	0.2068	0.0694	-0.0048	-0.0558
	(0.3778)	(0.1717)*	(0.1857)	(0.0918)**	(0.0403)*	(0.0046)	(0.0391)
Trade Openness	-2.3733	-1.3861	-2.4955	0.7158	0.8594	-0.0220	-0.0450
	(2.2299)	(1.3063)	(1.3072)*	(0.5086)	(0.3932)**	(0.0204)	(0.2502)
Inflation	0.1062	0.0756	0.0738	-0.0102	-0.0356	$-6.67E-05$	0.0026
	(0.0768)	(0.0395)*	(0.0406)*	(0.0189)	(0.0166)**	(0.0004)	(0.0076)
Adjusted R^2	0.33	0.29	0.11	0.61	0.51	0.02	0.08
Standard Error of Regression	0.8240	0.4506	0.4591	0.1825	0.1344	0.0074	0.0963
Variables	e	e_1	e_2	e_3	e_4	e_5	
Lagged Debt	-0.0156	-0.0039	0.0088	-0.0043	0.0008	-0.0169	
	(0.0270)	(0.0121)	(0.0099)	(0.0053)	(0.0027)	(0.0035)***	
Output Gap	-0.2779	-0.0956	-0.1067	-0.0537	$-6.61E-05$	-0.0218	
	(0.1127)**	(0.0459)**	(0.0418)**	(0.0152)***	(0.0070)	(0.0165)	
Government Gap	1.4004	0.7313	0.4651	0.1294	-0.0006	0.0751	
	(0.5211)**	(0.2277)***	(0.2317)*	(0.1021)	(0.0249)	(0.0555)	
Trade Openness	-0.0096	-1.3373	-0.3826	1.1682	0.0419	0.5002	
	(3.1056)	(1.3507)	(1.1675)	(0.6074)*	(0.2257)	(0.4220)	
Inflation	-0.0319	0.0040	-0.0231	0.0387	-0.0123	-0.0392	
	(0.0967)	(0.0447)	(0.0357)	(0.0257)	(0.0319)	(0.0208)*	
Adjusted R^2	0.43	0.53	0.48	0.26	0.11	0.36	
Standard Error of Regression	1.1171	0.5030	0.4213	0.2425	0.1791	0.2424	

Note: [1] The dependent variable is various category of government revenue and spending. [2] Robust standard errors are reported in parentheses. [3] The symbols "*", "**", and "***" indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4: Variable Definitions and Data Sources

Variable	Description	Source
Dependent Variable		
Primary Balance to GDP Ratio	In percent	OECD Economic Outlook Database
Total Revenue to GDP Ratio	In percent	OECD Economic Outlook Database
Total Expenditure to GDP Ratio	In percent	OECD Economic Outlook Database
Sub − Category of Revenue to GDP Ratio	In percent	OECD Economic Outlook Database
Sub − Category of Expenditure to GDP Ratio	In percent	OECD Economic Outlook Database
Explanatory Variable		
Lagged Debt to GDP Ratio	In percent	OECD Economic Outlook Database
Output Gap	Difference between actual and potential real GDP (calculated using the Hodrick-Prescott filter)	OECD Economic Outlook Database
Government Gap	Difference between actual and potential real government consumption expenditure (calculated using the Hodrick-Prescott filter)	OECD Economic Outlook Database
Trade Openness	Sum of exports and imports to GDP ratio (in percent)	OECD Economic Outlook Database
Inflation	Total CPI year-over-year growth rate (in percent)	FRED

Table 5: Calibration to the Canadian economy

Parameters	Value
Discount factor (β)	0.974
Labour ($1 - l$)	0.25
Leisure preference parameter (ϕ)	2.30
Technology (A)	4
Tax rate (τ)	0.37
Government spending/GDP (g/y)	0.21
Transfers/GDP (z/y)	0.14
Total debt/GDP (b/y)	0.75
Trade balance/primary balance (λ)	-1.5
Persistence of taxes (ρ^{τ})	0.71
Tax adjustment (γ^{τ})	0.0287
Persistence of government spending (ρ^{g})	0.71
Government spending adjustment (γ^{g})	0.0191
Persistence of technology $\left(\rho^{A}\right)$	0.55
Standard deviation of technology $\left(\sigma^{A}\right)$	$0.016A$
Persistence of transfers (ρ^{z})	0.56
Standard deviation of transfers (σ^{z})	$0.029z$
Taylor rule (κ)	1.5