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Fabrice Dabiré
Université de Sherbrooke
&
GREDI

Hashmat Khan
Carleton University

Patrick Richard
Université de Sherbrooke
&
GREDI

Jean-François Rouillard
Université de Sherbrooke
&
GREDI

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Carleton University

Department of Economics

1125 Colonel By Drive
Ottawa, Ontario, Canada
K1S 5B6

G-multipliers in Canada: How large? And Why?

Fabrice Dabiré[1], Hashmat Khan[2], Patrick Richard[3], and Jean-François Rouillard[*4]

[1,3,4] *Université de Sherbrooke & GREDI*
[2] *Carleton University*

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Abstract

We estimate the effects of government spending on GDP in Canada using the sign restrictions approach with quarterly data that spans from 1961 to 2019. The variables that enter our vector autoregressive model are carefully chosen to reflect the distinct characteristics of the economy, in particular, its linkages with US business cycles. We find large multipliers that are above 2 on impact and in the long-run. They are not specific to the state of the economy. Moreover, neither net exports nor real exchange rates nor terms-of-trade respond significantly to the government spending shock. Hence, we explore two channels that involve specific closed-economy characteristics of Canada to explain the size of the multipliers. First, the production of public goods in Canada features a much larger labour share than the production of private goods. Second, we argue that the level of public capital relative to its GDP is suboptimal. Based on a general equilibrium model, we show and explain how these two characteristics matter for the multipliers.

JEL identification: E32, E62, C51
Keywords: government spending multipliers, sign restrictions, Canadian economy

[*] *Dabiré*: Ph.D. Candidate, Department of Economics, Université de Sherbrooke
Khan: Professor, Department of Economics, Carleton University
Richard: Professor, Department of Economics, Université de Sherbrooke
Rouillard: Corresponding author and Associate Professor, Department of Economics, Université de Sherbrooke, email: j-f.rouillard@usherbrooke.ca.

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1 Introduction

In the context of the recovery from the recession caused by the pandemic, spotlights have moved in the direction of fiscal policy. Our goal in this paper is to increase the brightness of these spotlights for Canada. We do so by estimating government spending (G) multipliers using quarterly data that spans from 1961 to 2019. We find multipliers that are consistently greater than one on impact, and over a horizon of 30 quarters after the shock. In fact, no matter what specification of government expenditures we use, whether it is total G, G in consumption (G_C), or in investment (G_I), and no matter whether the economy is in expansion or recession; a multiplier of size one is just too small to make the cut. By contrast, in her summary of the current state of knowledge for developed economies, Ramey (2019) explicitly suggests that one is the upper bound of G multipliers.[1] Our baseline estimates would have also certainly been puzzling for the late Canadian economist Robert Mundell. In fact, one of the main predictions of the Mundell-Fleming model is that, *all else equal*, a greater share of imports in GDP implies a smaller G multiplier.[2] How can our high estimates of Canadian G multipliers be reconciled with an imports-to-GDP ratio that has been on average three times greater than its US counterpart since 1961? The three key words here are *all else equal*. The degree of openness of the Canadian economy is certainly one of its defining features compared to the US, but it is far from being the only one.

We put forward two characteristics that we think play important roles in generating high G multipliers: i) the composition of Canadian G is biased towards labour-intensive services, and ii) the low level of public capital stock relative to GDP. Note that these two characteristics are domestic, as we have purposely stepped away from an open-economy type of explanation. First, we show that a greater share of public expenditures in labour-intensive sectors, such as education and health care, allows for more income that accrues to workers. Since public-sector workers have higher marginal propensities to consume on average than the owners of capital, it pushes up G multipliers. Second, Canada has a lower stock of public capital relative to its GDP compared to other OECD countries which implies, theoretically, that the further this stock is below its optimal level, the greater G multipliers are. Ramey (2020) shows this result from the simulations of dynamic general equilibrium models characterized by an aggregate production function that embeds public capital. The sensitivity of the G multipliers to the level of public capital is simply explained by the fact that the marginal product of public capital increases the further it stands from its optimal level.

[1] She reports a lower bound of 0.6.

[2] This result is due to net exports being crowded-out following a positive G shock. In contrast, we do not find that net exports respond significantly to G shocks. Therefore, as confirmed by our estimations, the large multipliers are related to the crowding-in of private consumption and investment.

Therefore, another reason why the Canadian G multiplier is high is that its public capital stock is too low.

We use the sign restrictions methodology pioneered by Uhlig (2005) for monetary policy, and later applied for fiscal policy first by Mountford and Uhlig (2009). The restrictions that we implement to identify the effects of G shocks are minimal: real GDP must respond positively to a positive G shock. The system of equations that we estimate is a VARX model, where X stands for exogenous variables. A competing approach that is widely used in the literature is the one put forward by Blanchard and Perotti (2002). Their identification strategy relies on ordering G first in a structural VAR, and in extracting the structural shocks using a Cholesky decomposition. They justify this ordering choice by arguing that there are decision and implementation lags that prevent G from reacting to changes in real GDP and in other variables within a quarter. Hence, their approach excludes any systematic component of fiscal policy (Caldara and Kamps 2017). While we consider that this approach is well-suited for the US, we question its appropriateness for Canada. The reason is that Canadian business cycles lag those of the US, which invalidates the exogenous character of G. Specifically, the cross-correlation of the cyclical components of Canadian GDP at quarter $t+j$ and US GDP at quarter t are 0.6, 0.74, and 0.76 for $j = \{-1, 0, 1\}$, respectively.[3] In light of this data property, the sign restrictions approach is more suitable in the Canadian context.

Since our focus in this paper is solely on Canada, our estimates of the multipliers are the byproducts of specific Canadian characteristics. Even though our approach is country-based, we believe that our results are also informative for other small-open economies more generally. Our reasoning is the following. As discussed in the previous paragraph, the major challenge in identifying G shocks is that these shocks are entangled with business cycle shocks. Based on the cross-correlation function of output between Canada and the US, it is safe to say that variations in the US economic activity drive variations in Canadian GDP that are not related to government spending—or at least there are many common factors affecting both of these countries simultaneously. Therefore, by having the US GDP as an exogenous variable to our model, we are effectively controlling for a large share of business cycle shocks. Since of the largest cross-country correlations in real GDP between the US and other OECD countries is with Canada, our identification

[3]These correlations are based on quarterly real GDP data that spans from 1961 to 2019. As is standard in the literature, this corresponds to the largest correlation (in absolute value) of the cross-correlation function between the two countries' HP-filtered ($\lambda = 1,600$) real GDP in logs. The degree of synchronization of economic activity between Canada and the United States is also high throughout all the sample that we use for the estimations.

strategy is more precise than that of estimating other countries' G multipliers.[4] Moreover, the financial and trade integration between these two countries is high; yet we do not find any role of international variables in explaining the large G multipliers that we estimate. Therefore, the open-economy channels of fiscal policy may not be as strong for other advanced economies as the previous literature suggests.

One way to gauge the importance of controlling for US GDP in the analysis is simply to remove it as an exogenous variable from the baseline model and compare the G multipliers that we obtain. We find a substantially larger G multiplier when US GDP is excluded.[5] It is one unit larger at the peak of the (median) impulse response which occurs around 10 quarters after the G shock. The importance of considering the US GDP is further reinforced by the findings of Faccini et al. (2016) and Ilori et al. (2020) whose estimations reveal large positive transmission effects of US government spending on Canadian GDP.

We complement our main finding that Canadian G multipliers are large with related results. First, we re-estimate the baseline model by allowing for differences in responses for two regimes: recessions and expansions, which are set prior to the estimation, in similar fashion to Auerbach and Gorodnichenko (2013). Specifically, the regimes are determined by a threshold on a detrended moving average growth rate of real GDP. We find large G multipliers over all phases of the Canadian business cycle, not solely in recessions. This result has important implications for policy-makers in Canada as it suggests that public spending during booms remains as effective as in recessions. Second, we decompose G into its consumption (G_C) and investment (G_I) components. To sharpen our identification strategy for shocks to these two components, we add the labour share—total labour compensation over total income—to the baseline model, and impose additional sign restrictions on their responses. These restrictions are in line with the two characteristics of the Canadian economy mentioned above. Specifically, given that the labour intensity of Canadian G_C goods and services is greater than that of private goods, we impose that the labour share increases on impact in response to positive G_C shocks. Conversely, we assume that it decreases on impact in response to positive G_I shocks, since the income generated by this category of spending accrues proportionally more to the owners of capital than to workers. To briefly summarize our results related to the decomposition of G, we find long-lasting effects of both types of shocks on

[4] Ambler et al. (2004) find that the correlation is the largest for Canada using HP-filtered quarterly data that spans from 1960Q1 to 2000Q4.

[5] This finding is specific to the sign restriction approach. In contrast, the G multiplier falls significantly when the US GDP is removed as an exogenous variable in the context of the Blanchard-Perotti setup. These results are available upon request to the authors.

output—cumulative multipliers exceed unity for all time-periods over a horizon of 30 quarters.

The rest of the paper is organized as follows. In section 2, we discuss previous work that provides specific point-estimates of the Canadian G multiplier. In section 3, we describe the data and summarize the sign restriction methodology. Section 4 presents the main empirical results of large G multipliers. Based on these results, in section 5, we provide two explanations that rely on specific characteristics of the Canadian economy for why they might be high. Finally, section 6 concludes.

2 Related literature

The literature on fiscal multipliers is too vast to be reviewed in this section; hence, we focus our attention on work that employ Canadian data. First, we review research based on panel methods for which Canada is featured in the sample. Ilzetzki et al. (2013) estimate a panel VAR model and rely on Blanchard and Perotti's (2002) approach to identify the shocks to G_C for 20 high-income countries and 24 developing countries. They find multipliers of 0.39 and 0.66, on impact and in the long run, respectively. The multipliers that we find for Canada are above the 90% confidence intervals for all the horizons that they plot. Other interesting results concern the sensitivity of multipliers to trade openness. Specifically, the authors split countries into two groups based on whether the sum of their exports and imports over GDP is below or above 60% on average.[6] The multipliers for the group of countries that they consider "open" are even smaller—*i.e.* -0.08 and -0.46 on impact and in the long run, respectively. This finding is consistent with the Mundell-Fleming model; however, in the absence of impulse responses for net exports, we do not know if it is the crowding-out of this variable that indeed drives their estimated multipliers as in the theory.

Using more recent panel data (1995:Q1-2016:Q4) and estimating G shocks à la Blanchard and Perotti (2002), Priftis and Zimic (2021) find G_C multipliers that exceed one at a 12-quarter horizon.[7] Auerbach and Gorodnichenko (2013) also estimate G multipliers from panel regressions. They examine the effects of G shocks, which consist of semi-annual forecast errors of growth rates in G of OECD countries, by running local projections. As mentioned above, they find asymmetric G multipliers; specifically, positive multipliers during recessions, but negative during expansions.

[6] Somewhat oddly, with a ratio of 54.8%, Canada falls short of making the 'open' economy cutoff used in Ilzetzki et al. (2013).

[7] Their main result is that fiscal multipliers are larger when public debt is financed by foreigners instead of residents.

Baum et al. (2012) also investigate whether G multipliers differ during recessions compared to expansions for G7 countries adopting a country-by-country approach. They estimate threshold VARs for which the threshold variable is the output gap, and the G shock is identified using Blanchard and Perotti's (2002) approach. They do not find larger Canadian G multipliers during recessions. However, what is bothersome is that, although the multipliers that they find for Canada are not significant, they are large and negative.[8] In contrast, Owyang et al. (2013) find larger multipliers when the Canadian economy experiences high versus low unemployment spells—two years after the shock they report 1.6 and 0.44, respectively. Their identification strategy relies on news of military spending which are mainly centered around two events: WWII and the Korean war. Moreover, the changes in regimes, which rely on the unemployment rates, are far from being cyclical for Canada, in contrast to the US. For example, all the time period that spans from the mid-1970s to the mid-2000s is considered as a period of slack by the authors. Our results differ from those of these two studies, as the multipliers that we find are consistently high during expansions and recessions.

There is also a literature that investigates the international dimensions of fiscal policy and their effects on exchange rates. Given that the Canadian dollar has been floating since 1970, it is often featured in this strand of the literature. Corsetti and Müller (2006) and Monacelli and Perotti (2010) identify G shocks using Blanchard and Perotti's (2002) approach in structural VARs. In both papers, the responses of output are not significantly different from zero, as the lower one-standard error confidence bound stands in negative territory.[9] The net exports-to-GDP ratio also falls for both of them. For Corsetti and Müller (2006), the response of this variable is significant at the one and three year-mark—the only horizons that they report—while Monacelli and Perotti (2010) find that the fall is only significant after one and two quarters. Therefore, there is some evidence of crowding-out that originates from international trade as emphasized by the Mundell-Fleming model. As for the responses of relative prices, both of these studies find that they are not significant for terms-of-trade nor real exchange rates.

Ilori et al. (2020) also order G—precisely, G_C—first in the VAR as advocated by Blanchard and Perotti (2002); however, they use Bayesian VAR methods. They find some crowding-out effects of investment and net exports for Canada, yet consumption responds positively to a positive G_C shock. The negative effects on net exports do not seem to be driven by the responses of relative international prices as both the terms of trade and the real exchange rate depreciate. Finally, the

[8]As mentioned in the footnote 5, the addition of US GDP as an exogenous variable would most likely reverse the sign of the multipliers that they find.

[9]Over a horizon of 20 quarters, the responses reported by Monacelli and Perotti (2010) are even always negative.

response of real GDP suggests a positive but very small G_C multiplier. The shape of this response would also be very difficult to reconcile with economic theory, as it is positive on impact, falls to zero 3 to 5 quarters after the shock, and goes back up before starting to plateau after 10 quarters. Moreover, they do not control for US GDP, which, as we have argued, could have much influence on the size and persistence of the G multipliers that they find.

Based on an innovative methodology that involves using the conditional heteroscedasticity of the structural shocks to identify G shocks in the context of VARs, Bouakez et al. (2014) find that the Canadian dollar appreciates following a positive G shock—significantly for about three years after the shock though. Another interesting result that they report for Canada is that the decline in the current account over a horizon of one year is significant. The time periods, variables, and identification strategies differ from ours in these previously discussed four studies, which can explain why our results diverge. In fact, our findings show no role for international quantity nor price variables in explaining G multipliers even though Canada is a small open economy.

Cacciatore and Traum's (2020) results also run against the majority of empirical and theoretical findings in the literature, as they challenge some of the Mundell-Fleming model's predictions. Specifically, they show that openness to trade can contribute to larger G multipliers. Their two-country new Keynesian model features Canadian and US data and is estimated using Bayesian methods. Based on an analytical development, they emphasize the appreciation of terms of consumption to a positive G shock as the main channel behind larger G multipliers. They define terms of consumption as the relative price of domestic to imported goods, which, as they explain, corresponds to terms of trade under the assumption of complete exchange rate pass-through. In their model, exchange rate pass-through is incomplete, yet they show that terms of trade also respond positively given their posterior estimates. In contrast, as mentioned in the previous paragraph, our results do not confer any role to terms of trade, no matter the horizon.

Pappa (2009) uses the sign restriction methodology for Canada, among other countries, with data that spans from 1970 to 2007. As for the restrictions that she imposes, they consist of positive responses on output and on the primary budget deficit on impact. Nine variables are included in her model and some of them differ from the ones that we select. Importantly, from the standpoint of our paper, the US GDP and the real exchange rate are not featured as exogenous variables. Twelve quarters after the shocks, she finds cumulative multipliers of G_C and G_I of 1.02 and 0.61, respectively, which are lower than the ones we find. On top of the different variables featured in her model, another reason why the multipliers that we find are larger than hers might be that she does not control for the other category of G when estimating the effects of a particular category of G. Specifically, G_I is excluded from the model when the shock is to G_C, and vice versa.

Finally, Azad et al. (2021) also estimate the effects of G using the sign restriction methodology for Canada, and following very closely Mountford and Uhlig's (2009) approach. The authors do not present the G multipliers that they obtain; however, we suspect that, based on their median responses, they must be close to zero for the first year and negative further on. Their results are far away from ours, since we use different methodologies and data. Some of the different aspects on the methodological side are the following: (i) they first identify a business cycle shock that is orthogonal to other shocks, (ii) they do not impose any sign restriction on the response of GDP following a G shock, (iii) their estimators are based on a penalty function which implies that they also consider models that come close to satisfying the restrictions. On the second aspect, we reiterate that the restriction that we impose on the response of GDP is consistent with the simulation results of the great majority of RBC and New Keynesian models. On the third aspect, we use pure sign restrictions which we deem more suitable than the penalty function in light of various critiques that it has received (Arias et al. 2014, Caldara and Kamps 2017). Finally, their data spans from 1990Q1 to 2020Q4, which comprises the Great Lockdown. Given the large variations in macroeconomic variables that occured during this period, we worry about their effects on the VAR estimates.

3 Data and Methodology

In this section we provide details of the data used in the analysis followed by a description of the methodology.

3.1 Data

The data that we use goes back in time as far as possible—for Canadian expenditure-based data this corresponds to the first quarter of 1961—and ends in the fourth quarter of 2019. The baseline specification features five endogenous variables and one exogenous variable which are listed in Table 1. Note that transfer payments are not included in G. We provide a detailed description of these variables in Table 5 of Appendix A. We apply the logarithms to all variables, except to the real interest rate. We include US GDP given both countries' high degree of synchronization of economic activity, that is also captured by the adage: "when the US sneezes, Canada catches

Table 1: Endogenous and exogenous variables used in the baseline model

Endogenous (Canadian)	Exogenous
GDP (GDP) Government expenditures (G) Government revenues (T) Real interest rate (r) Real exchange rate (RER)	US real GDP (X)

Notes: We construct real Canadian quantity variables by dividing the nominal series (GDP and government expenditures and revenues) by the GDP deflator. As for the real interest rate, we subtract the one-quarter ahead inflation rate (annualized growth rate of the GDP deflator) that is observed ex-post from the nominal interest rate. The real exchange rate corresponds to the ratio of the US and Canadian GDP deflators multiplied by the nominal exchange rate between the Canadian and US dollars.

a cold".[10] The reverse, however, is not true, since Canadian business cycle lags that of the US, hence, the exogenous role of US GDP in the models that we estimate.

3.2 Methodology

Our analysis is based on the VARX(2) model

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + C_1 X_t + u_t, \tag{1}$$

where y_t is a 5×1 vector of endogenous variables (GDP, G, T, r and RER) and X_t denotes real US GDP. We choose the lag order based on the AIC. The model also includes vectors of constants and time trends which are suppressed from equation (1) to simplify notation. A_1 and A_2 are 5×5 matrices of coefficients and C_1 is a 5×1 vector. Finally, u_t is assumed to be an *iid* sequence of 5×1 random vectors such that $E(u_t) = 0$ and $E(u_t u_t^\top) = \Sigma_u$, where Σ_u is a positive definite non-random matrix. This reduced-form VARX model corresponds to the linear structural model

$$B_0 y_t = B_1 y_{t-1} + B_2 y_{t-2} + D_1 X_t + \varepsilon_t, \tag{2}$$

where the structural coefficient matrices B_0, B_1, B_2 and D_1 are related to the reduced-form matrices A_1, A_2 and C_1 as $A_1 = B_0^{-1} B_1$, $A_2 = B_0^{-1} B_2$ and $C_1 = B_0^{-1} D_1$. The 5×1 vector ε_t contains structural shocks which are assumed to have unit variance and to be orthogonal.

[10]It is also true during good times—a healthy US economy gives rise to sunny ways for the Canadian economy.

Table 2: The sign restrictions

	GDP response	G response	T response	r response	RER response
G shock	$+$	$+$	*	*	*
r shock	$-$	*	*	$+$	*
T shock	$-$	*	$+$	*	*
shock 4	*	*	*	*	*
shock 5	*	*	*	*	*

Notes: All the sign restrictions are imposed at horizon 0 only. The * denote the absence of a restriction on this specific combination of shock and response.

We use sign restrictions to identify three policy relevant shocks: a government expenditure shock (G shock), a government revenue shock (T shock) and a monetary policy shock (r shock). The other two shocks are left unidentified and may therefore be considered as “residual" shocks from sources other than fiscal and monetary policy that affect the variables in the model. The fiscal and monetary policy shocks are identified through a set of sign restrictions on some elements of the impact matrix B_0.

The impact sign restrictions are summarized in Table 2. A positive G shock is defined as one which has a positive contemporaneous impact on both GDP and G while having an unspecified impact on the other three variables. Notice that imposing a positive immediate impact of G on GDP does not imply that the multiplier is positive over time since we impose no restrictions on the response of GDP for future quarters after the shock. Thus, for example, our model does not exclude the possibility of a crowding-out effect of private investment and consumption developing over time following the G shock. Even though we are only interested in measuring the size of the G multiplier, we use sign restrictions to identify government revenue and monetary shocks (the reasons for this is discussed below). A positive revenue shock is defined as having an immediate positive impact on T and a negative impact on GDP. The monetary shock is defined as having a positive impact on r and a negative impact on GDP.

Sign-identified models are set-identified. This means they allow researchers to obtain a set of structural models coherent with the observed data as expressed through the reduced form VARX model (1), and satisfying the specified sign restrictions. This set of structural models is approximated by numerical simulations, see Appendix B for a description of the algorithm used in this paper.

Structural impulse responses are constructed from these admissible structural models and G multipliers are computed. Consequently, what we obtain is a set of impulse responses and multipliers that have a structural interpretation because they result from a shock that exhibits the patterns of responses that serve as the basis to our identification strategy. Because we are interested only in the G multiplier (and impulse responses to a G shock), it may seem useless, if not counter-productive, to impose identifying restrictions for the T and monetary shocks.[11] There are, however, at least two reasons why this is not so.

The first is that these extra identifying restrictions serve to reduce the size of the set of admissible structural models, and therefore provide sharper approximations for our impulse responses and multipliers. The second reason is to reduce what Fry and Pagan (2011) call the "multiple shock problem". This problem results from the possibility that one or several unidentified "residual" shocks could exhibit the same pattern of response as the identified G shock. If this were to happen, the response of both the G shock and the unidentified shock could be interpreted as a response to unexpected government expenditure, which would obviously compromise the validity of our results. To put it differently, the decision to include the response to the identified G shock in our admissible set and not the response to the unidentified shock would be completely arbitrary and may have an impact on our reported results. The identification of the tax revenue and monetary shocks with sign restrictions different from those of an expenditure shock, means that only two, rather than four, unidentified shocks remain in our model. This obviously reduces the probability of encountering the "multiple shock problem".

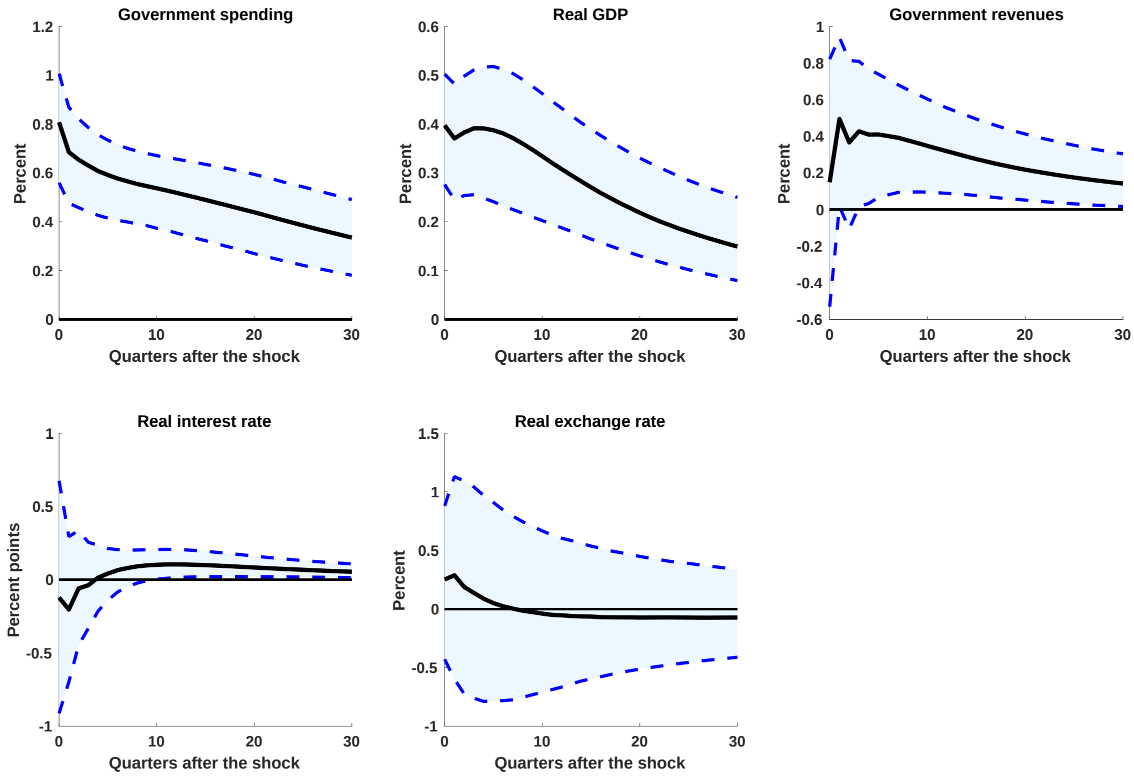
As most papers using sign-identified models, we conduct inferences on the results of our model using Bayesian methods to estimate the posterior distribution of the impulse responses. See Appendix B for details. Finally, Section 4 investigates the possibility that the government expenditure multiplier may differ when the shock occurs in a recession or an expansion. We implement this analysis with a regime switching threshold VAR version of model (1) similar to that of Auerbach and Gorodnichenko (2012) but with the sign restrictions described above imposed to achieve identification (see Appendix C for more details).

4 Results

Figure 1 plots the impulse responses of the five endogenous variables comprised in the linear VARX to a one standard deviation shock to G. A first observation is that the G shock itself and the response of real GDP are persistent, since the lower bound of their credible sets are always in

[11] For example, Uhlig (2005) studies the impact of monetary policy shocks and identifies only a monetary shock, leaving the other four shocks of his model unidentified.

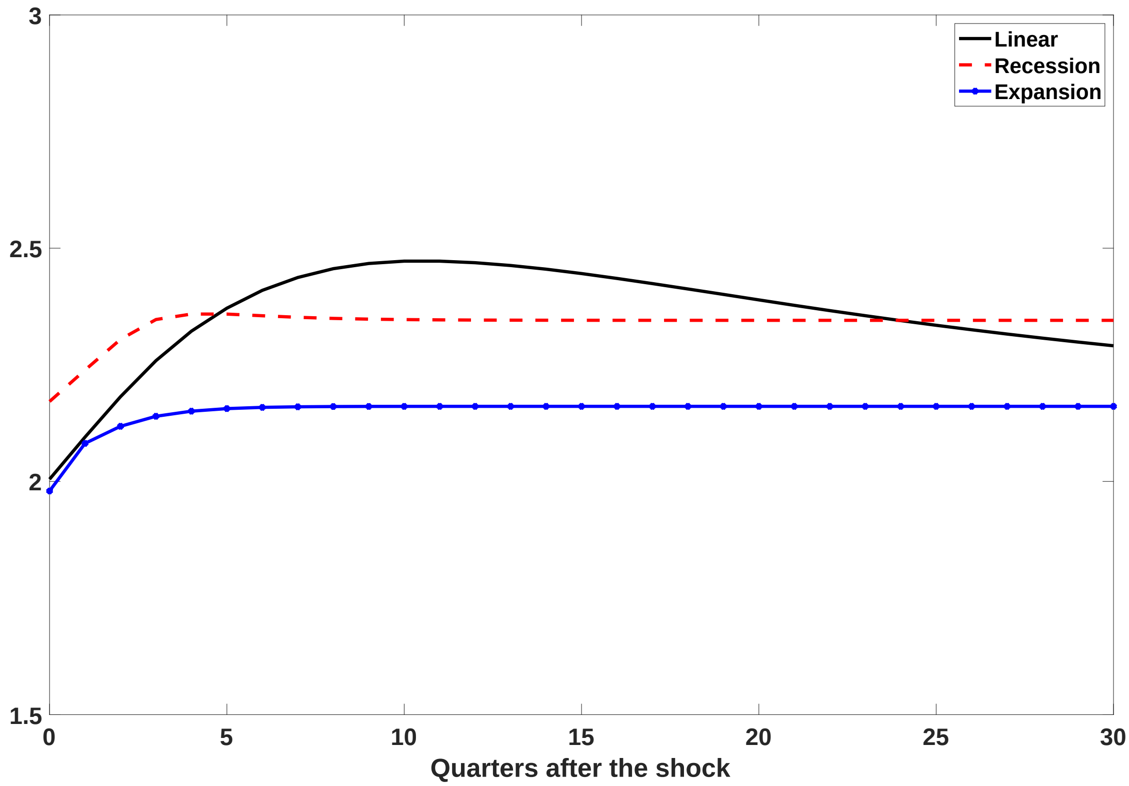
Figure 1: The impulse responses to a one standard deviation shock to government expenditures



Note: These responses are obtained from the estimation of the VARX model described in the previous section. The black solid lines correspond to the median responses, while the dashed blue lines are the 16th and 84th percentiles.

positive territory. As a reminder, the restrictions that we impose are only on impact, *i.e.* at period 0, so the persistence is not an artifact of these restrictions. The median response of government revenues increases following a positive G shock—the 16th percentile however lies in negative territory on impact. This is probably related to the positive impact on GDP, as greater economic activity goes hand in hand with greater tax revenues. Moreover, based on the absence of responses of the real interest and real exchange rates, we infer that monetary policy and international prices dynamics do not interfere with the G multipliers that we find. The lack of significance of these responses is also at odds with the predictions of the textbook Mundell-Fleming model with flexible exchange rates. According to this model, the real interest rate should increase and the exchange rate appreciate.

Figure 2: The cumulative multipliers of the linear and the two-regime models



Note: See equation (3) for the details on the construction of these multipliers.

In Figure 2, we compare the cumulative G multipliers at different horizons (h) obtained for the baseline and non-linear (expansion vs. recession regimes) models.[12] We follow the standard approach in the literature to construct the multipliers as:

$$CM_G(h) = \frac{\sum_{j=0}^{h} (1+\bar{r})^{-1} Y_{Gj}}{\sum_{j=0}^{h} (1+\bar{r})^{-1} G_{Gj}} \frac{\bar{Y}}{\bar{G}} \tag{3}$$

where $\bar{r} = 1.61\%$ that is the average value of the real interest rate in our sample. The summations correspond to the net present values of the responses of GDP and G to G shocks: Y_G and G_G, respectively. Finally, $\bar{Y}$ and $\bar{G}$ are the average values of GDP and G, respectively, in the sample.

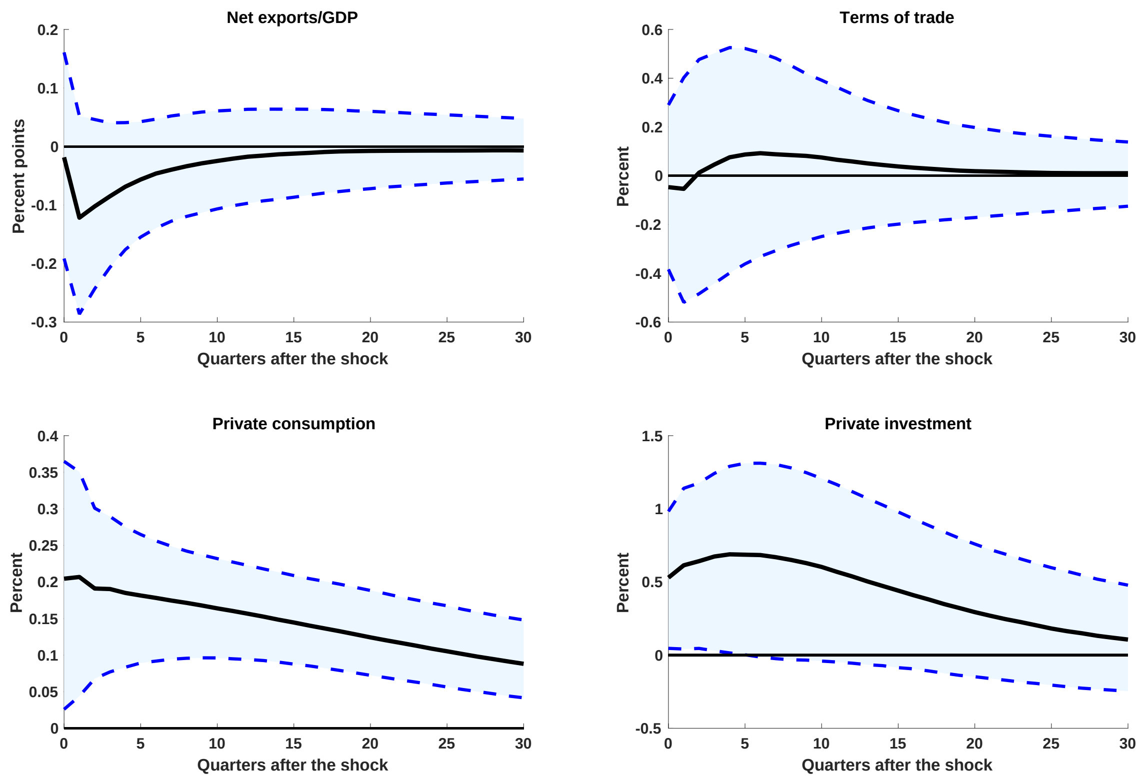
[12]Since the responses obtained from the estimation of the non-linear model are similar to the ones shown for the baseline model, we do not present them.

There are two important results that Figure 2 conveys. First, just visually it is evident that the G multipliers are not sensitive to the state of the economy. The literature on the US G multipliers is split between work that find evidence of state dependency, led by Auerbach and Gorodnichenko (2012, 2013), and others that reject it, led by Ramey and Zubairy (2018). Our results show that the evidence speaks with one voice in Canada and supports no state dependency in the size of the G multiplier. The second finding is about the scale of multipliers that we find: they are large and very persistent. On the size of the G multiplier, Ramey (2019) claims that "the bulk of the estimates across the leading methods of estimation and samples lie in a surprisingly narrow range of 0.6 to 1." Based on a meta-analysis, however, Gechert (2015) does not find such a narrow range—the upper bound for the G multipliers (one standard deviation over the mean) lie around 1.5 for a horizon between 0 to 8 years after the shock. The G multipliers that we find are certainly not the largest ever reported in the literature, but they could be in the top 5% of the estimates. They are comparable to the multipliers found by Auerbach and Gorodnichenko (2012) for the US in recessions only. Such large magnitudes once again do not support the predictions of the Mundell-Fleming model that a small open economy (like Canada) should have lower G multipliers than countries with smaller trade openness, such as the US.

We have already shown that the real exchange rate does not respond much to G shocks. Is it also the case for other international variables? To avoid overloading the models that we estimate, we add three different set of variables, each in turn, to the baseline model: i) net exports over GDP, ii) terms of trade, and iii) private consumption and investment. Since the impulse responses of the five original endogenous variables are similar to the ones displayed in Figure 1, we only present the responses of the new variables in Figure 3. The results suggest that the G multipliers in Canada are not driven by the open-economy dimension. The different international channels simply do not play any role neither to amplify nor to dampen the multipliers.

First, the majority of theoretical models predict a fall in net exports, which is what we find; however, the upper bound of the credible set is always in positive territory, and even the median response is too small to have significant effects on the multipliers. This result contrasts with the findings of Corsetti and Müller (2006) and Monacelli and Perotti (2010), as they find larger trade deficits following positive G shocks in Canada. Second, the median response of terms of trade that we find is very close from being muted. This evidence goes against the transmission channel that Cacciatore and Traum (2020) emphasize—*i.e.*, based on their posterior estimates, an increase in Canadian G leads to an appreciation of terms of consumption and terms of trade, and

Figure 3: Assessing the potential open-economy transmission channels and the degree of crowding-out



Note: These responses are obtained from the estimation of three different configurations of the augmented baseline model as described in the text. The black solid lines correspond to the median responses, while the dashed blue lines are the 16th and 84th percentiles.

thereby amplifies the G multiplier.[13]. Third, we infer from the responses of private consumption and investment, that there is no evidence of crowding-out—as it is often the outcome of theoretical models. The absence of significant responses of international variables guides our investigation of the large Canadian G multipliers towards closed-economy explanations.

All the impulse responses to G shocks and G multipliers that we have presented so far are obtained under the assumption that G is unanticipated. However, as argued by Ramey (2011) and

[13] The authors estimate their structural two-country model with Bayesian methods. They define terms of consumption in footnote 3 of their paper as follows: "With incomplete exchange rate pass-through, the domestic terms of consumption equals the terms of trade multiplied by the ratio of domestic to export markups."

Auerbach and Gorodnichenko (2012), it is also important to consider agents' anticipations of G. Hence, we follow one of Auerbach and Gorodnichenko's (2012) specification which consists in augmenting the baseline model with $\Delta g^f_{t|t-1}$, *i.e.* the expected growth rate of G_t realized in period $t-1$. As a proxy to agents' anticipations of G, we use the Bank of Canada's Staff Economic Projections and the real-time historical data contained therein—which are available on a quarterly frequency from 1986Q4 to 2015Q4.[14] Adding this variable to the model ensures us that the disturbances in G_t that we identify are orthogonal to the anticipations. We augment the baseline model with this variable and we follow the literature in imposing zero contemporaneous restrictions on other shocks to explain its dynamics. We estimate this augmented model and the baseline model over the same time period. We do not find any significant differences in the G multipliers, and the median response of real GDP to an anticipated G shock is close to zero.[15] Therefore, our results are robust to the anticipations of G.

Prior to examining the potential transmission channels, we investigate the effects of G_C and G_I shocks separately as is typically done in the literature. One important characteristic of Canadian G_C is that they are on average more labour-intensive than the production of private goods. Therefore, this feature allows us to introduce additional sign restrictions on the response of the labour share; specifically that, it needs to be positive (negative) on impact in response to a positive G_C (G_I) shock. The justification of the restriction on the G_I shock is simply that an increase in public capital increases the share of all capital in GDP which implies that the labour share falls. All the other restrictions are the same as the ones used to estimate the baseline model. Moreover, in order to consider the responses of G_I to a G_C shock, and vice-versa, we adapt the computation of the cumulative multiplier (equation (3)), such that:

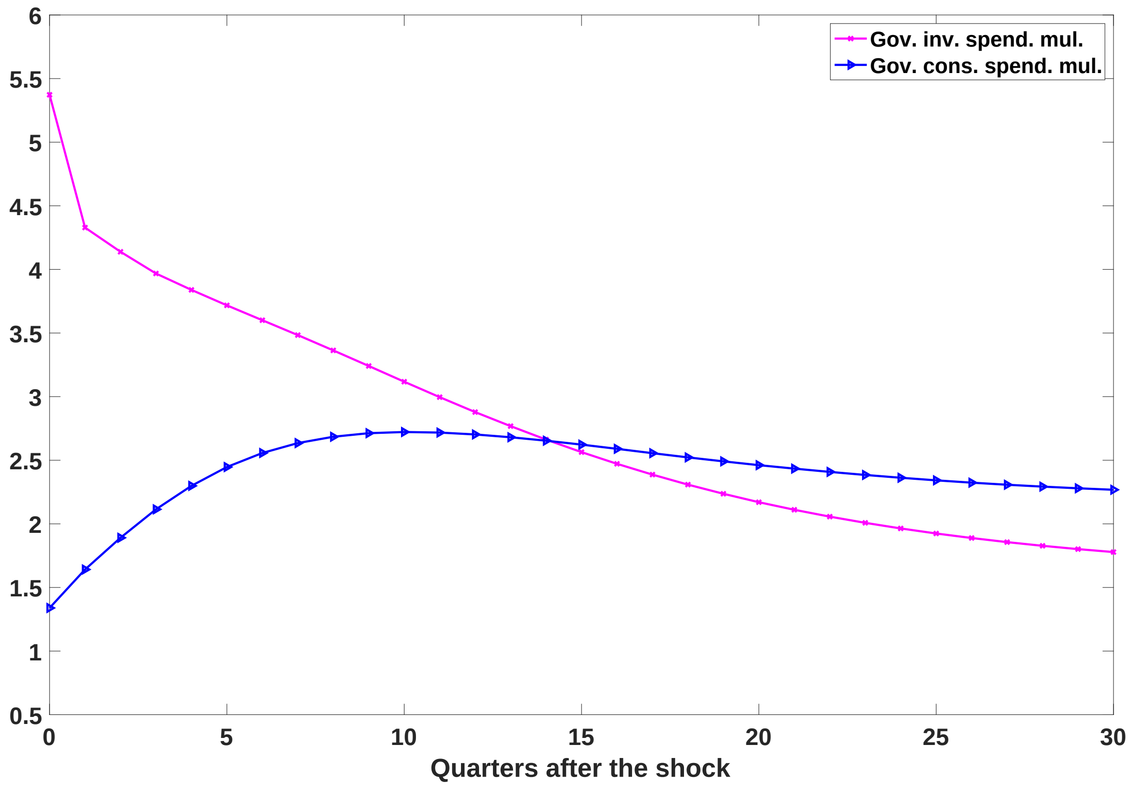
$$CM_{G_C}(h) = \frac{\sum_{j=0}^{h} (1+\bar{r})^{-j}\, Y_{G_{Cj}}}{\sum_{j=0}^{h} (1+\bar{r})^{-j} \left(G_{CCj} + G_{ICj} \frac{\bar{G}_I}{\bar{G}_C} \right)} \frac{\bar{Y}}{\bar{G}_C} \tag{4}$$

where $Y_{G_{Cj}}$ corresponds to the median impulse response of real GDP to a positive G_C shock at horizon j. As for the responses of government spending, G_{CCj} and G_{ICj}, note that the first subscript position indicates the response of G_C or G_I, while the second subscript position indicates that the variable shocked is G_C. The terms with a bar above them are the average values of the

[14] Typically, researchers use forecasts for G that are provided by the OECD; however, these forecasts are only available at a semiannual frequency.

[15] These results are available upon request to the authors.

Figure 4: The cumulative multipliers of government expenditures in consumption and in investment



Note: See equations (4-5) for the details on the construction of these multipliers.

variables over the sample period.[16] This adjustment of the multipliers is needed to consider the effects of both categories of government spending when examining the effects of a shock specific to one of these categories. Since we consider total changes in G when computing the multipliers of a specific category of G, we need to sum the responses of both categories.[17]

Figure 4 presents the cumulative multipliers for G_C and G_I. The shape of the G_C multipliers

[16]The cumulative multipliers for G_I are obtained symmetrically from the following equation:

$$CM_{G_I}(h) = \frac{\sum_{j=0}^{h} (1+\bar{r})^{-j} Y_{G_{Ij}}}{\sum_{j=0}^{h} (1+\bar{r})^{-j} \left(G_{IIj} + G_{CIj} \frac{\bar{G}_C}{\bar{G}_I}\right)} \frac{\bar{Y}}{\bar{G}_I}. \tag{5}$$

[17]The adjustment term in the denominator is required because these responses are not expressed in the same units.

over time is similar to the ones obtained for G multipliers, and they are all above unity. Since G_C accounts for the majority of government expenses, this result is not surprising. The persistence of their effects can be linked to accrued spending in education which improves aggregate human capital, and thereby labour productivity at short and long horizons. As for the G_I multipliers, they also all are above unity; however, their shape differs markedly. In fact, the large effects that we find on impact dissipate over a longer horizon. On average, G_I multipliers are greater than G_C—which is consistent with the meta-analysis conducted by Gechert (2015) that reports an average gap of 0.5 unit between these two categories of G multipliers.[18]

5 Potential transmission channels

In this section, we present two closed-economy channels that we believe could explain the large multipliers that we obtain for Canada. The first one is related to labour intensity in the production of public consumption goods (G_C), while the second one is related to the fact that the level of Canadian public capital is low, and potentially suboptimal, which entails a greater G_I multiplier.[19]

5.1 Labour intensity in the production of G_C

Contrary to the US, a large share of education and health care expenditures are provided publicly in Canada. Since the 1960s, the federal and provincial governments have allocated a large share of their budgets specifically to these expenditures. For example, they sum up to 63% of G on average from 2008 to 2019. An important feature about the production of these goods is their high degree of labour intensity. Based on data that spans from 1997 to 2004, Sharpe et al. (2008) find that the average labour compensation to GDP ratios are 92% and 80% for education services, and health care and social assistance, respectively.[20] How can this characteristic matter for G multipliers? Note that in contrast to capital income, labour income is earned by households that are relatively less wealthy that have on average a higher marginal propensity to consume (MPC).

[18] However, based on a panel of OECD countries, Boehm (2020) finds G_I multipliers that are not different from zero in the short-run.

[19] We view these two channels as complementary to other potential ones that can elevate G multipliers. For example, Devereux et al. (1996) find stronger effects of G shocks in a model that features increasing returns to specialization and monopolistic competition relative to a standard neoclassical model. Specifically, following an increase in G, there is an expansion in the number of varieties of goods produced which lead to an endogenous increase in TFP.

[20] These ratios are of the same order of magnitude as the compensation shares for the US between 1987 and 2015 reported by Díez-Catalán (2018)

Since an increase in G_C leads to a higher share of total labour compensation in GDP that pushes up the average MPC and the multiplier.

To illustrate this channel, we augment Galí, López-Salido, and Vallés's (2007) (GLSV, hereafter) two-agent New Keynesian model by allowing for different labour income shares in the production of public and private goods. The objective in presenting this model is precisely to show this channel at work, instead of closely matching the G multipliers that we find in the previous section. The key elements of this model are as follows. First, the economy is populated by two types of households: "hand-to-mouth" and "optimizing", whose shares are λ and $1 - \lambda$, respectively. The "hand-to-mouth" households simply consume their current period labour income net of lump-sum taxes. The "optimizing" households also work, and face intertemporal decisions; specifically, they invest in physical capital and trade contingent securities. Their income is composed of labour income, capital income that they earn from renting out capital to firms, and dividends since they also own these firms that operate in a monopolistic competition environment. Sticky prices à la Calvo and capital adjustment costs are the only rigidities embedded in the model. As for policies, the nominal interest rate adjusts to contemporaneous developments in inflation, and taxes are set to react linearly to exogenous movements in G and to government debt. Finally, contrary to GLSV who present results for two labour market structures, we focus on the results obtained with a perfectly competitive market.

While we present the full set of equations of the augmented model in Appendix D, in this section we only focus on the ones that emphasize the channel described and that differs from GLSV. First, we assume the following production function for public goods:

$$G_t = N_{Gt}^{\psi} Y_{Gt}^{1-\psi} \tag{6}$$

where N_{Gt} corresponds to hours worked in the public sector, and Y_{Gt} to the purchase of privately produced goods that the government acquires. A greater value of the parameter $\psi \in (0, 1)$ pushes up the labour share in the public sector, while we retrieve GLSV's model when $\psi = 0$. For the sake of simplification, we assume that both N_{Gt} and Y_{Gt} are exogenous and that they follow the same autoregressive process. Hence, a G shock in our model is a shock to its inputs.

The government pays public hours worked at wage W_G which we assume fixed throughout time.[21] With an additional source of income, the budget constraints of households are altered from

[21] Note that this assumption is reasonable, since we assume that the marginal product of labour in the public sector is also fixed.

the ones featured in GLSV's model; yet, we maintain the assumption of equal consumption and hours worked (private and public) for all households in the steady state.[22] Since hours worked in the public sector are the same across households, one cannot argue that our results are driven by the fact that the G shock directly targets "hand-to-mouth" households. However, they are still the ones that benefit the most from positive G shocks when the labour share of the public sector is high. The reason is simply that the labour income earned from working in that sector accounts for a larger fraction of total income for them, since wages are their only source of income. Therefore, greater effects on "hand-to-mouths" result into larger G multipliers.

We show the implications on the other equations of the model. In order to derive labour supply in the model, we need a utility function which we assume is the following:

$$U(C, N_P, N_G) \equiv \log C - \frac{\left(N_P^{\omega} N_G^{1-\omega}\right)^{1+\varphi}}{\omega(1+\varphi)} \tag{7}$$

where N_P corresponds to the quantity of hours worked in the private sector. Note that hours worked in both sectors are aggregated à la Cobb-Douglas, where ω governs the weight allocated to the private sector, and, similar to GLSV, φ is the inverse of the Frisch elasticity of labour supply. Under perfectly competitive labour markets, wages in the private sector W_{Pt} are obtained by combining the first order conditions with respect to consumption and to private hours worked, and by aggregating these conditions across the two types of households:

$$W_{Pt} = C_t \left(\frac{N_{Gt}}{N_{Pt}}\right)^{(1-\omega)(1+\varphi)} N_{Pt}^{\varphi} \tag{8}$$

where aggregate variables are given by the following equations:

$$\begin{aligned} C_t &= (C_t^r)^{\lambda} (C_t^o)^{1-\lambda} \\ N_{Pt} &= (N_{Pt}^r)^{\lambda} (N_{Pt}^o)^{1-\lambda} \\ N_{Gt} &= (N_{Gt}^r)^{\lambda} (N_{Gt}^o)^{1-\lambda} . \end{aligned}$$

Therefore, the labour supply equation implies that an exogenous change in N_{Gt} exerts downward pressure on private hours worked.[23] Finally, in similar fashion to GLSV, the log-linearized aggre-

[22]As discussed by GLSV, equal consumption is realized by adjusting the levels of lump-sum taxes, and, under a competitive private labour market, it ensues that hours worked are also equalized.

[23]Specifically, that it is case when $\varphi > (1-\omega)/\omega$, which we deem reasonable.

Table 3: Calibration

	Symbol	Value
Parameters borrowed from GLSV		
Discount factor	β	0.99
Capital depreciation	δ	0.025
Price markup	μ^P	1.2
Price stickiness	θ	0.75
Capital adjustment costs	η	1
Response of monetary policy to inflation	ϕ_π	1.5
Response of the tax policy to G	ϕ_g	0.1
Response of the tax policy to government debt	ϕ_b	0.33
Other assigned parameters		
Inverse of the Frisch elasticity of labour supply	φ	0.25
Average G_C-to-GDP ratio	γ_g	0.21
Endogenously chosen parameters		
Elasticity of private production w.r.t. capital	α	0.354
Weight of hours worked in public production	ψ	0.463
Weight of private hours worked in the utility functions	ω	0.857

gate Euler equation is as follows:

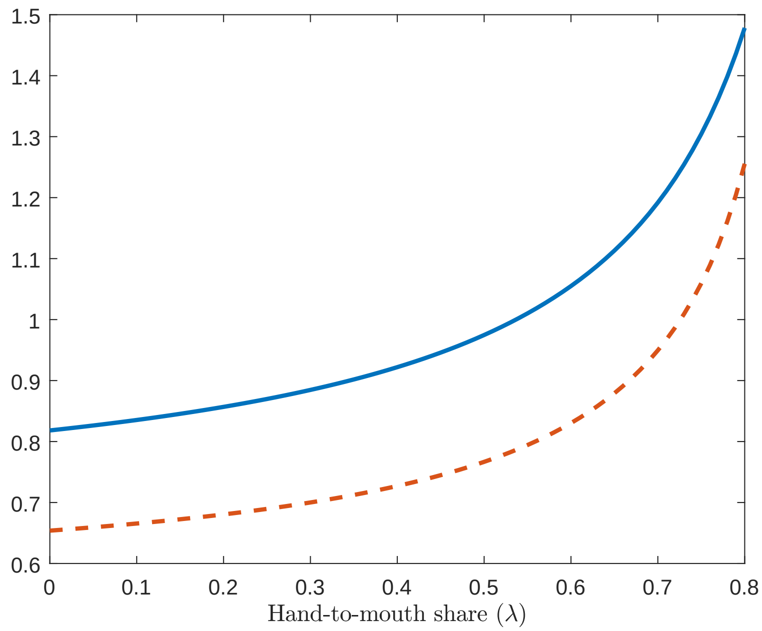
$$c_t = E_t\{c_{t+1}\} - \frac{1}{\tilde{\sigma}}\left(r_t - E_t\{\pi_{t+1}\}\right) - \Theta_n E_t\{\Delta n_{t+1}\} + \Theta_\tau E_t\{\Delta t^r_{t+1}\} - \Theta_g E_t\{\Delta g_{t+1}\}.$$

where lower-case letters denote log-deviations of variables from their steady state values (*i.e.* $x_t \equiv \log X_t/\bar{X}$). The Euler equation still nests the one featured in GLSV; however, under a more general form, the set of parameters $(\sigma, \Theta_n, \Theta_\tau)$ differ, and the G shock intervenes directly.

We present the calibration of the model in Table 3. Most parameters are borrowed from GLSV and are standard in the literature. Note that we do not pick a specific value for the share of "hand-to-mouth" households λ in the economy, as we present results for a wide range of this parameter.[24] There are only two assigned parameters that differ from GLSV. We follow Ramey (2020) and set the Frisch elasticity of labour supply equal to 4, which is one unit lower than the value used by GLSV. Since we focus on the effects G_C to assess the channel that we put forward, we use its average share of GDP in Canada between 1981 and 2019 to calibrate γ_g. Finally, the last three parameters are chosen endogenously to match three steady state targets: (i) the average ratio of to-

[24]Moreover, this parameter does not interfere with the calibration of the endogenously chosen parameters.

Figure 5: The sensitivity of the G multipliers on impact to the share of “hand-to-mouth"



Note: The blue solid line corresponds to impact multipliers generated with a greater public labour share (0.81), and the red dashed line to GLSV for which both the public and private labour share are equal to 0.68. We assume perfectly competitive labour markets.

tal labour compensation over GDP, (ii) the average ratio of public labour compensation over total labour compensation, and (iii) the average share of public employment in total employment. For Canada, these average ratios correspond to 68%, 25%, and 23.6%, respectively. This implies that public labour compensation in G_C corresponds to 81% which is in line with the average labour compensation shares for the US education and health care sectors computed by Díez-Catalán (2018).[25] The details about the algebraic manipulations achieved to pin down these ratios, and about the sources of data that we use are located in Appendix D.

Figure 5 presents the G multipliers on impact obtained from the simulation of the model for which the labour share in the public sector is greater (0.81) than in the private sector, and compares these multipliers to the ones for which labour shares in the public and private sectors are equal (0.68)—that is GLSV’s model featuring a slightly different calibration.[26] As can be seen, the size

[25]From 1987 to 2015, he finds labour compensation shares that are larger than 90% and 80%, for the education and health care sectors, respectively.

[26]Specifically, only three parameters differ from the calibration presented in Table 3, *i.e.* $\alpha = 0.32$, $\psi = 0$, and $\omega = 1$.

of the multipliers increase with the share of “hand-to-mouth" in the economy; however, this result is not novel.[27] The one that we want to emphasize is that a greater labour share in the public sector pushes up the multipliers no matter the size of “hand-to-mouth". Moreover, it is not possible to gather these informations from Figure 5, but the G multipliers decrease monotonically over time and the differences between G multipliers generated by both models are approximately the same at horizons that range from 1 to 20 quarters. Therefore, a different labour share in the public sector have amplification effects, yet no persistence effects. The intuition behind these results is that the source of income matters for G multipliers when households have different income composition and marginal propensities to consume. A larger bias towards the use of labour in the production of public goods benefits proportionally more “hand-to-mouth” households, since their income is exclusively based on labour. By definition, they do not save any of their income; therefore, their additional consumption generates greater G multipliers. The channel that we propose could be enhanced under a different labour market structure, and with additional frictions such as search-and-matching on the labour market, for example.

Bouakez et al. (2020) also find that the sectoral composition of G is important for the size of the multipliers. In one section of their work, they simulate a multi-sector DSGE model where parameters are calibrated based on an input-output matrix of 57 sectors for the US. Their model features many sources of sectoral heterogeneities which include different labour shares. However, contrary to the channel that we put forward, the specific feature that matters the most for them is whether the industry that is impacted by the shock is located upstream or downstream of the production network. Specifically, they show that, as long as sectoral G shocks trigger asymmetric changes in sectoral relative prices, the effects are stronger when the recipients are downstream industries.

5.2 Sub-optimal level of public capital

The other channel that we emphasize is related to the high levels of the G_I multiplier. As can be seen in Figure 6 in Appendix A, there is a significant downward trend of the G_I-to-GDP ratio between 1960 and 2000 roughly. Based on data from the IMF, the ratio of public capital over GDP also follows a similar trend. We argue that it has been too low in Canada, and that this sub-optimality leads to greater G_I multipliers. We do not provide a precise account of this sub-optimality; however, Table 4 shows that, on the public capital measure, Canada ranks 14th out of

[27] Note that, as reported by GLSV, there is some indeterminacy issues for larger shares.

Table 4: Average public capital stock to GDP ratios for OECD countries (1961-2017)

Japan	115%	Portugal	65%
New Zealand	113%	Finland	63%
Sweden	99%	Norway	61%
Denmark	93%	**Canada**	61%
United States	83%	Switzerland	55%
Netherlands	82%	Korea	54%
Austria	79%	Italy	52%
United Kingdom	74%	Belgium	51%
Germany	71%	Ireland	42%
France	70%		
Mean	73%		
Median	70%		

Source: The IMF Investment and Capital Stock Dataset (IMF 2017).
Notes: The ratio of general government capital stock over GDP is in national currency (current costs and prices). We selected OECD countries for which a long span of data is available. All the national series end in 2017, and most of them start in 1960, except for Austria (1970), Canada (1961), Denmark (1971), Italy (1970), Korea (1970), New Zealand (1962), and Portugal (1977).

19 advanced countries. Even though government total tax receipts in the US are lower per capita than in Canada, its average ratio of public capital over GDP is over 20 percentage points than Canada's.

There is a vast literature on the positive externalities that public capital creates on the private production of goods and its effects on long-run economic growth. When the elasticity of output with respect to public capital is assumed to be constant, one can derive its socially optimal level—as shown by Ramey (2020) for example. She also finds that a public capital-to-GDP ratio which would be lower in the steady state than the optimal ratio contributes in elevating the G_I multipliers. The effects are quantitatively important and are at force for the neoclassical and New Keynesian models that she puts forward. In fact, for a given optimal public capital-to-GDP ratio, the lower its steady state value is the greater the multiplier is.[28] This inverse relationship is analogous to the one between the marginal product of capital and its level. As simulations of theoretical models

[28] Specifically, for an aggregate production function that features public capital, she shows that the optimal ratio of public capital to GDP is given by $\theta_G/\left(\beta^{-1} - 1 + \delta_G\right)$ where θ_G corresponds to the elasticity of output with respect to public capital, β to the discount factor, and δ_G to the depreciation rate of public capital. For the following parameterization: θ_G=0.1, β=0.99, and δ_G=0.01, this implies an optimal ratio of 124% (annualized). With an initial steady state ratio of public capital to GDP of 87.5%, she finds long-run multipliers of 2.2 and 2.8 for the baseline neoclassical and New Keynesian models, respectively. With a lower initial steady state ratio of 37.5%, these multipliers jump up to 4.4 and 5.4.

show that the average level of public capital significantly affect the size of the G_I multiplier, we conjecture that the low level of public capital in Canada also matters for the multiplier that we estimate.

6 Conclusion

We find high and persistent G multipliers for Canada, which are above 2 on impact and for all horizons up to 8 years after the shock. These results ensue from the estimation of a vector autoregressive model where G shocks are identified using the sign restrictions approach. They also challenge the received idea about fiscal policy in the context of small open economies which calls for crowding-in of imports and, consequently, smaller G multipliers. We do not find responses of international quantity nor price variables that are significantly different from zero. Given the high financial and trade integration between Canada and the US, the lack of responsiveness of international variables is an important finding for other small open economies. It suggests that policy-makers may focus on national factors when evaluating the effects of spending hikes and cuts. Moreover, the multipliers that we find are not conditional on the state of the Canadian economy, *i.e.* whether it is in recession or in expansion. Given the implementation lags of government spending, this result is good news for policy-makers as they do not need to worry about the state of the business cycles to give the go-ahead for publicly-funded projects.

As it is typically done in the literature, we decompose government spending into expenses in consumption (G_C) and in investment (G_I). The multipliers for both of these categories are consistently above one, for horizons that range from 0 to 8 years after the shock. The peak of these multipliers are large: above 2.5 and 5 for G_C and G_I, respectively. We propose two channels to explain the size of these multipliers. The fact that G_C is more labour-intensive than privately-produced goods in Canada can contribute to amplifying the G multipliers. The main reason is that labour income is a larger fraction of total income for households that have higher marginal propensities to consume. We illustrate these effects by augmenting Galí et al.'s (2007) two-agent model. There are potentially greater amplification effects that could be obtained by deviating from lump-sum taxation and by assuming a greater degree of heterogeneity across households. The importance of these additional features for multipliers is worth investigating in future work. As for the size of the G_I multipliers, our explanation is that Canada suffers from low levels of public capital relative to its GDP which signifies high marginal product of this type of capital, and therefore, greater sensitivity of output to changes in G_I.

References

AMBLER, S., E. CARDIA, AND C. ZIMMERMANN (2004): "International business cycles: What are the facts?" *Journal of Monetary Economics*, 51, 257–276.

ARIAS, J., J. F. RUBIO-RAMIREZ, AND D. F. WAGGONER (2014): "Inference based on SVARs identified with sign and zero restrictions: Theory and applications," .

AUERBACH, A. J. AND Y. GORODNICHENKO (2012): "Measuring the output responses to fiscal policy," *American Economic Journal: Economic Policy*, 4, 1–27.

——— (2013): "Fiscal Multipliers in Recession and Expansion," in *Fiscal Policy after the Financial Crisis*, ed. by A. Alesina and F. Giavazzi, University of Chicago Press, chap. 2.

AZAD, N. F., A. SERLETIS, AND L. XU (2021): "Covid-19 and monetary–fiscal policy interactions in Canada," *The Quarterly Review of Economics and Finance*, 81, 376–384.

BAUM, A., M. POPLAWSKI-RIBEIRO, AND A. WEBER (2012): *Fiscal Multipliers and the State of the Economy*, 12-286, International Monetary Fund.

BAUMEISTER, C. AND J. D. HAMILTON (2015): "Sign restrictions, structural vector autoregressions, and useful prior information," *Econometrica*, 83, 1963–1999.

BLANCHARD, O. AND R. PEROTTI (2002): "An empirical characterization of the dynamic effects of changes in government spending and taxes on output," *The Quarterly Journal of Economics*, 117, 1329–1368.

BOEHM, C. E. (2020): "Government consumption and investment: Does the composition of purchases affect the multiplier?" *Journal of Monetary Economics*, 115, 80–93.

BOUAKEZ, H., F. CHIHI, AND M. NORMANDIN (2014): "Fiscal policy and external adjustment: New evidence," *Journal of International Money and Finance*, 40, 1–20.

BOUAKEZ, H., O. RACHEDI, AND E. SANTORO (2020): "The Sectoral Origins of the Spending Multiplier," Tech. rep.

CACCIATORE, M. AND N. TRAUM (2020): "Trade flows and fiscal multipliers," *Review of Economics and Statistics*, 1–44.

CALDARA, D. AND C. KAMPS (2017): "The analytics of SVARs: a unified framework to measure fiscal multipliers," *The Review of Economic Studies*, 84, 1015–1040.

CORSETTI, G. AND G. J. MÜLLER (2006): "Twin deficits: squaring theory, evidence and common sense," *Economic Policy*, 21, 598–638.

DEVEREUX, M. B., A. C. HEAD, AND B. J. LAPHAM (1996): "Monopolistic competition, increasing returns, and the effects of government spending," *Journal of Money, Credit and Banking*, 28, 233–254.

DÍEZ-CATALÁN, L. (2018): "The labor share in the service economy," .

FACCINI, R., H. MUMTAZ, AND P. SURICO (2016): "International fiscal spillovers," *Journal of International Economics*, 99, 31–45.

FRY, R. AND A. PAGAN (2011): "Sign restrictions in structural vector autoregressions: A critical review," *Journal of Economic Literature*, 49, 938–60.

GALÍ, J., J. D. LÓPEZ-SALIDO, AND J. VALLÉS (2007): "Understanding the effects of government spending on consumption," *Journal of the European Economic Association*, 5, 227–270.

GECHERT, S. (2015): "What fiscal policy is most effective? A meta-regression analysis," *Oxford Economic Papers*, 67, 553–580.

ILORI, A. E., J. PAEZ-FARRELL, AND C. THOENISSEN (2020): "Fiscal policy shocks and international spillovers," Tech. rep., Sheffield Economic Research Paper Series.

ILZETZKI, E., E. G. MENDOZA, AND C. A. VÉGH (2013): "How big (small?) are fiscal multipliers?" *Journal of Monetary Economics*, 60, 239–254.

IMF (2017): "FAD Investment and Capital Stock Database 2017," .

KILIAN, L. AND H. LÜTKEPOHL (2017): *Structural Vector Autoregressive Analysis*, Themes in Modern Econometrics, Cambridge University Press.

MONACELLI, T. AND R. PEROTTI (2010): "Fiscal policy, the real exchange rate and traded goods," *The Economic Journal*, 120, 437–461.

MOUNTFORD, A. AND H. UHLIG (2009): "What are the effects of fiscal policy shocks?" *Journal of Applied Econometrics*, 24, 960–992.

OWYANG, M. T., V. A. RAMEY, AND S. ZUBAIRY (2013): "Are government spending multipliers greater during periods of slack? Evidence from twentieth-century historical data," *American Economic Review*, 103, 129–34.

PAPPA, E. (2009): "The effects of fiscal expansions: an international comparison," *UAB Manuscript*.

PRIFTIS, R. AND S. ZIMIC (2021): "Sources of borrowing and fiscal multipliers," *The Economic Journal*, 131, 498–519.

RAMEY, V. A. (2011): "Identifying government spending shocks: It's all in the timing," *The Quarterly Journal of Economics*, 126, 1–50.

——— (2019): "Ten years after the financial crisis: What have we learned from the renaissance in fiscal research?" *Journal of Economic Perspectives*, 33, 89–114.

——— (2020): "The Macroeconomic Consequences of Infrastructure Investment," .

RAMEY, V. A. AND S. ZUBAIRY (2018): "Government spending multipliers in good times and in bad: evidence from US historical data," *Journal of Political Economy*, 126, 850–901.

SHARPE, A., P. HARRISON, AND J.-F. ARSENAULT (2008): *The relationship between labour productivity and real wage growth in Canada and OECD countries*, Centre for the Study of Living Standards Ottawa, Ontario.

UHLIG, H. (2005): "What are the effects of monetary policy on output? Results from an agnostic identification procedure," *Journal of Monetary Economics*, 52, 381–419.

Appendices

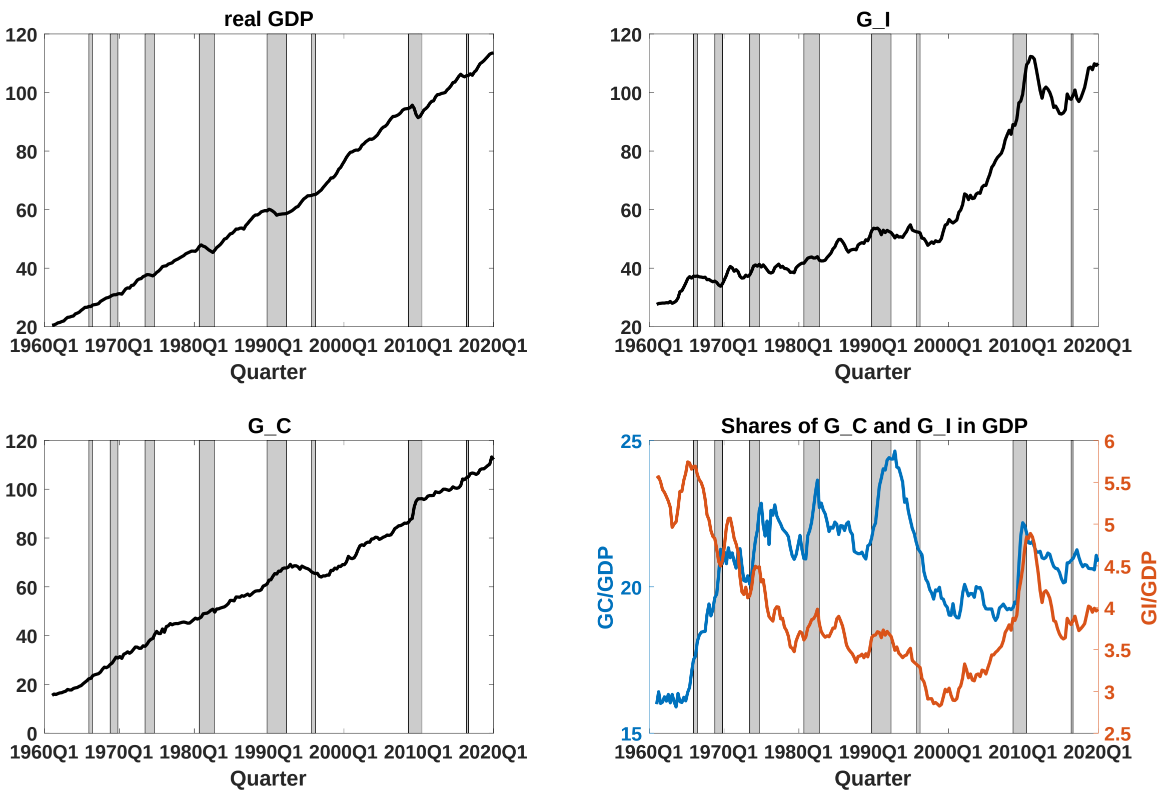
A Data

Table 5: Sources and definitions of variables

Variable	Source and definition
GDP deflator [P]	SC Table: 36-10-0106-01, line 36
US GDP deflator [P_{US}]	U.S. Bureau of Economic Analysis, Table 1.1.4
Real gross domestic product [GDP]	GDP=nominal GDP/P, source of nominal GDP: SC Table: 36-10-0104-01, line 40
Government expenditures in consumption [G_C]	SC Table: 36-10-0104-01, line 19
Government expenditures in investment [G_I]	SC Table: 36-10-0104-01, line 28
Total government expenditures [G]	$G = G_C + G_I$
Government revenues [T]	SC Table: 36-10-0477-01, we use Blanchard and Perotti's (2002) definition, *i.e.* T = General government revenues - Current transfers to households - Current transfers to non profit institutions serving households - Subsidies - Current transfers to non residents - Capital transfers
Real interest rate [r]	r=nominal interest rate-expected inflation rate, nominal interest rate corresponds to the Treasury bill auction - average yields: 3 month, source: SC Table: 10-10-0122-01, line 43, and the expected inflation rate to the one-quarter inflation rate (growth rate of the GDP deflator) that is observed ex-post.
Net exports to GDP ratio [NX/GDP]	Source of net exports: SC Table: 36-10-0121-01, line 10
Nominal exchange rate between the Canadian and U.S. dollars [E]	International Financial Statistics (IMF)
Real exchange rate RER	$RER = E \cdot P_{US}/P$
U.S. real GDP [GDP_{US}]	U.S. Bureau of Economic Analysis, Table 1.1.3
Labour share	Total compensation/GDP, source of compensation of employees: SC Table: 36-10-0114-01, line 4
Expected growth in G [$\Delta g^f_{t\|t-1}$]	Staff Economic Projections of the Bank of Canada (1986Q4-2015Q4). Since the forecasts of G_t are in nominal terms, we deflate them using the forecasts of the implicit price deflator for GDP also available in the Staff Economic Projections.

Notes: SC stands for Statistics Canada. Unless it is specified, all the variables that we use are Canadian, and they span from 1961Q1 to 2019Q4.

Figure 6: Main Canadian time series that we use for the estimations



Notes: The index of the real GDP, G_I, and G_C time series is 2012Q1=100, while the shares of G_C and G_I in GDP are expressed in percentages. The shaded areas correspond to recessions which are identified such that 20% of periods are recessionary. See Appendix C for details.

B Technical details on the methodology

This appendix contains technical details on the methods used to construct the set of admissible structural models and Bayesian credible sets for the impulse responses. The objective is to compute response functions to impulses in the structural shocks ε_t. From (1) and (2), we have $u_t = B_0^{-1}\varepsilon_t$, and it can be seen that structural impulse responses could be obtained from the reduced-form impulse responses if B_0^{-1} was known. Let P be the lower-triangular Cholesky decomposition of Σ_u. Then, by definition, $u_t = Pe_t$, where e_t is a k-vector of uncorrelated random variables. Let Q be a $k \times k$ matrix such that $QQ^\top = I_k$. Then, $u_t = PQQ^\top e_t = B_0^{*-1}\varepsilon_t^*$, where $B_0^{*-1} = PQ$ is a candidate impact matrix and ε_t^* is a candidate vector of uncorrelated structural shocks.

The set of admissible structural models consists of all candidate matrices B_0^{*-1} that satisfy the sign restrictions. This set is constructed using the following algorithm.

Step 1. Estimate the reduced form VARX model (1) by OLS to obtain estimates $\hat{A}_1$, $\hat{A}_2$, $\hat{C}_1$ and $\hat{\Sigma}_u$ of the coefficient matrices. Let $\hat{P}$ be the lower-triangular Cholesky decomposition of $\hat{\Sigma}_u$.

Step 2. Draw a $k \times k$ matrix H of independent N(0,1) random variables. Derive the QR decomposition of H such that $H = QR$ where $QQ^\top = I_k$.

Step 3. Construct the matrix $\hat{B}_0^{*-1} = \hat{P}Q$ and the associated impulse responses. If $\hat{B}_0^{*-1}$ satisfies the sign restrictions, retain the impulse responses. If not, discard the impulse responses.

Step 4. Repeat steps 2 and 3 M times. For large enough M, the set of retained models should be a good approximation to the admissible set.

The result of this algorithm is not a point estimate of the impulse responses (or the multiplier) but a set of admissible responses and multipliers. This poses the question of what quantity should be reported to convey the most meaningful information about the findings of the model and how inference should be conducted. Bayesian methods are typically used with sign-identified VAR models. We follow this approach and report pointwise posterior median responses and credible sets.

To do this, draws are taken from the posterior distribution of the coefficients matrices of the reduced-form VARX model (1) and of Σ_u. Then these simulated coefficients are substituted in step 1 of the algorithm instead of the OLS estimates and the algorithm is run. Repeating the algorithm N times yields a set of impulse responses and multipliers drawn from the posterior of the structural model. If N is sufficiently large, this can be used to conduct inference, see section 13.6.2 of Kilian and Lütkepohl (2017) for details.

In the present paper, we use the common Gaussian-inverse Wishart prior for the coefficients of the reduced form VARX model. Drawing the rotation matrix Q in the way described above is equivalent to imposing a Haar prior on it. It is known that the choice of prior for the rotation matrix may be informative for the coefficients of the structural model and consequently for the structural responses (Baumeister and Hamilton 2015). The only satisfying solution to this problem would be to impose a prior for the elements of the matrix B_0^{-1} or on the structural responses themselves. Because we have no convincing theoretical basis on which this could be done, we use the standard approach and impose the Haar prior on the rotation matrix. The reader may consult section 13.7 of

Kilian and Lütkepohl (2017) for a discussion of this issue.

C Details on the 2-regime model

Some of the results reported in the paper explore the possibility that the government expenditure multiplier may be different in recessions and in expansions. This analysis is carried-out using a two-regime threshold version of the VARX model (1). This two-regime specification is

$$y_t = I(z_{t-1} < \bar{z})\left[A_{R,1}y_{t-1} + A_{R,2}y_{t-2} + C_{R,1}X_t\right] + (1 - I(z_{t-1} < \bar{z}))\left[A_{E,1}y_{t-1} + A_{E,2}y_{t-2} + C_{E,1}X_t\right] + u_t, \tag{9}$$

with

$$E(u_t u_t^\top) = \Sigma_u = I(z_{t-1} < \bar{z})\Sigma_{R,u} + (1 - I(z_{t-1} < \bar{z}))\,\Sigma_{E,u}, \tag{10}$$

where the subscripts R and E denote matrices and vectors of parameters in recession and expansion respectively and z_t is an observed threshold variable. Model (9) is a special case of Auerbach and Gorodnichenko's (2012) smooth transition VAR model with the smoothness parameter set to 0. This value is imposed to simplify the estimation of the model, but our results do not appear to be affected by this choice.

We follow Auerbach and Gorodnichenko (2013) in defining z_t to be the deviation of a seven-quarter moving average of real GDP growth centered around period t and its trend counterpart as extracted with the Hodrick-Prescott filter with a smoothing parameter $\lambda = 40,000$. The value of the threshold $\bar{z}$ is chosen so that the economy spends 20% of the time in recession. The C.D. Howe Institute identifies less recessions for Canada than we do; however, the quarters that are labeled as recessions are a subset of the ones that we identify. Moreover, our results are not affected when we use a recession dating provided by the OECD.

The fact that the coefficient matrices and vector in (9) and the covariance matrix (10) are regime-dependent means that a regime-dependent version of the structural model (2) corresponds to (9). We consequently use the sign-identification strategy in Section 3.

D Details on the augmented two-agent New Keynesian model

As discussed in the main text, since most equations are the same as GLSV, we focus on the ones that differ. First, the log-linearized wage schedule based on equation (8) is:

$$w_{pt} = c_t + \chi_p n_{pt} + \chi_g \gamma_g g_t$$

where $\chi_p \equiv \omega(1+\varphi) - 1$ and $\chi_g \equiv (1-\omega)(1+\varphi)$. We use the fact that the deviations from steady state in public employment are the same as the exogenous shock in G.

We derive the aggregate Euler equation in a similar fashion as GLSV (see the steps in Appendix C.1 of their article). Note that the Euler equation that we obtain nests theirs for $\omega = 1$ and $\psi = 0$. The coefficients are as follows:

$$\begin{aligned}
\Gamma &\equiv \left(\mu_p \gamma_c \chi_p + (1-\alpha)(1-\psi\gamma_g)\left[1-\lambda(1+\chi_p)\right]\right)^{-1} \\
1/\tilde{\sigma} &\equiv (1-\lambda)\Gamma\left(\mu_p \gamma_c \chi_p + (1-\alpha)(1-\psi\gamma_g)\right) \\
\Theta_n &\equiv \lambda\Gamma(1-\alpha)(1-\psi\gamma_g)(1+\chi_p)\chi_p \\
\Theta_\tau &\equiv \lambda\Gamma\mu_p\chi_p \\
\Theta_g &\equiv \lambda\Gamma\left((1-\psi\gamma_g)\chi_g\gamma_g\chi_p + \mu_p\chi_p\psi\right)
\end{aligned}$$

As for the parameterization, we use different sources of data. The share of G_C in GDP, $\gamma_g = 0.21$, is set in accordance to data retrieved from Table 36-10-0222-01 of Statistics Canada. As for the ratio of public labour wages and salaries over total labour wages and salaries, $pubs_{wn} = pub_{wn}/\left(pub_{wn} + pr_{wn}\right) = 0.25$, we use the data that spans from 1997 to 2019 (Table 36-10-0114-01, Statistics Canada). We identify public sectors as educational services, health care and social assistance, and government public administration. Similar sectors are used to construct the share of public employment over total employment, $pubs_{emp} = pub_{emp}/\left(pub_{emp} + pr_{emp}\right) = 0.236$, also from 1997 to 2019 (Table 14-10-0023-01, Statistics Canada). Finally, the labour share for the aggregate economy, $ls = 0.68$, is from the OECD. These values imply the following average ratios and parameters:

$$
\begin{aligned}
\frac{pub_{wn}}{G} &= pubs_{wn} \cdot ls/\gamma_g && = 0.81 \\
\frac{pr_{wn}}{Y_P} &= \frac{ls - \gamma_g \cdot \frac{pub_{wn}}{G}}{1-\gamma_g} && = 0.646 \\
\alpha &= 1 - \frac{pr_{wn}}{Y_P} && = 0.354 \\
\psi &= \left(\frac{pub_{wn}}{G} - \frac{pr_{wn}}{Y_P}\right) / \left(1 - \frac{pr_{wn}}{Y_P}\right) && = 0.463 \\
w_{ratio} &= \frac{1-pubs_{emp}}{pubs_{emp}} \frac{\gamma_g}{1-\gamma_g} \frac{\frac{pub_{wn}}{G}}{\frac{pr_{wn}}{Y_P}} && = 1.0791 \\
\omega &= \frac{\log pub_{wn}}{\log\left(\mu_p \psi \gamma_g / \left(pr_{wn}(1-\psi\gamma_g) w_{ratio}\right)\right)} && = 0.857.
\end{aligned}
$$

Therefore, wages are 7.91% greater in the public than in the private sector.