MONETARY-FISCAL REGIMES AND CANADA'S MULTIPLIER EFFECT

by

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ABSTRACT

I investigate the effects of debt-financed government on the Canadian economy using a dynamic stochastic general equilibrium model with Bayesian estimated parameters that are inferred from four macroeconomic time series. The focus of the analysis is on the differences in fiscal multipliers produced under two distinct monetary-fiscal policy regimes, before-and-after the Great Recession. To maximize the multiplier effects of Canadian government investments, my findings recommend a combination of moderate inflation-stabilizing monetary policy and lenient debt-stabilizing fiscal policy.

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1. INTRODUCTION

The Canadian government has put forth a dual-phase, twelve-year investment plan of $186.7 billion, dubbed by the PBO as Canada's New Infrastructure Plan (NIP). In Budget 2016, the government lays out the initial phase of the NIP – investments of $11.9 billion in public transit, environmentally clean growth, and social infrastructure. For the second phase, the Fall Economic Statement 2016 proposes an additional $81 billion through to 2027–28 in the same areas, plus new investments in transportation infrastructure that will support trade, and in the development of rural and northern communities. Of the additional $81 billion, 31 percent will be allocated to public transit construction and expansion; 27 percent to green infrastructure; 27 percent to social infrastructure, such as affordable housing and child care; 2.5 percent to improve Canada's trade competitiveness; and 2.5 percent to support small communities.

The consequences of these government investments remain to be seen and are best to be predicted in advance. This paper aids our understanding of the effects of such investments by employing a medium scale dynamic stochastic general equilibrium (DSGE) model with Bayesian estimated parameters that are inferred using Canadian data over the period of 1976:2–2017:2.

Although a number of studies have used vector autoregressive (VAR) models to investigate the relationship between government spending and the U.S. economy (Fatás & Mihov, 2001; Blanchard & Perotti, 2002), and others have employed DSGE models (Gali, López-Salido, & Vallés, 2007; Cogan, Cwik, Taylor, & Wieland, 2010; Zubairy, 2014; Leeper, Traum, & Walker, 2015), very few published analyses on this subject have been conducted for the Canadian economy and even fewer have employed a DSGE model (Owyang, Ramey, & Zubairy, 2013).

Therefore, my analysis helps fill the gap on how the Canadian economy, specifically, responds to debt-financed government spending in the context of an ever-growing Canadian debt-to-GDP ratio, which stands at 100.47 percent as of 2016 (Canadian Socioeconomic Database, 2016). I distinguish my work from previous analyses on fiscal multipliers by considering the effects of two distinct monetary-fiscal policy regimes: either active monetary policy and passive fiscal policy, which is referred to as regime M; or passive monetary policy and active fiscal policy, which is referred to as regime F. Furthermore, I employ Bayesian prior and posterior analysis (Geweke, 2010; Faust & Gupta, 2010; Leeper et al., 2015) to trace multiplier estimates to different parameter specifications.

I first outline the features of the new Keynesian DSGE model in section 2 of the paper. I then perform prior predictive analysis in section 3, which provides a range of multipliers that can be produced by the model. In section 4, I perform an exercise in Bayesian estimation, which uses four Canadian time series to infer a set of parameter distributions that characterize the dynamics of the model. In section 5, I examine the estimated multipliers and the transmission mechanisms of government spending shocks. Finally, I conclude with a discussion of the implications of my findings on Canadian fiscal policy.

As a preamble to my analysis, I briefly outline the two main perspectives on the effects of government spending on the real economy – neoclassical and new Keynesian – both of which hinge upon conflicting assumptions on certain features of the economy.

A basic neoclassical approach assumes perfect competition, and forward-looking households who plan their consumption over their life cycle according to "the solution to an intertemporal optimization problem" (Bernheim, 1989). If economic factors are fully employed, persistent budget deficits – financed by over-extended government spending or tax cuts – necessarily imply reduced savings, as budget deficits raise total lifetime consumption by shifting tax increases to future generations. For capital markets to clear, interest rates must rise, which raises the cost of private capital accumulation, hence the crowding out of investment.

In contrast, the new Keynesian approach assumes nominal rigidities like sticky prices and sticky wages, and imperfect competition in the goods and labour markets, implying that firms charge a markup over marginal costs and households charge a markup over the perfectly competitive nominal wage.

If economic factors are not fully employed, monopolistic competition and nominal rigidities imply that an increase in government spending will lead to a real increase in output and incomes, followed by subsequent increases depending on the nature of the economy's fiscal multiplier. The logic is as follows: government spending raises marginal costs through its effect on interest rates; the firms who cannot raise price must maintain their markups by increasing output which requires hiring more workers and raising wages – thus, incomes rise. Higher incomes imply higher consumption demand, hence the multiplier effect. If the multiplicative positive effects of government spending on output and incomes generate sufficient increases in private savings and capital inflows, the reduction in public savings will not crowd out investment (Traum & Yang, 2015).

The consolidation of neoclassical and new Keynesian perspectives comes, in part, due to Bernheim's emphasis on the separation of *permanent* and *temporary* components of government budgets. The first component could refer to a steady-state level of deficit or surplus while the second could refer to the deviation from steady state. In choosing the permanent component of the budget, one is determining the "level of national saving in some "full employment" equilibrium" (Bernheim, 1989). In solidarity with this view, my model's variables are expressed in log-deviations (percentage-deviations) from steady state.

New Keynesians argue that temporary deficits or surpluses can stabilize short run fluctuations around steady state. Proponents of the neoclassical approach are concerned with the potential accumulation of temporary deficits into permanent reductions in national savings, and are skeptical of the efficiency of demand management practices, as well as the social welfare cost of the business cycle. Lucas (1987) measures the cost of the business cycle as the percentage increase in consumption needed to make households indifferent between a fluctuating business cycle and a smooth one. He finds that the welfare benefit from eliminating all consumption fluctuations is "less than one-hundredth of one percent of consumption when preferences are logarithmic" (Otrok, 2001). On the other hand, Gali, Gertler, and Lopez-Salido (2007) find that, while the "efficiency costs of fluctuations are not large when averaged across booms and recessions," the gross gains of booms, and costs of recessions can be large. For example, Gali et al. (2007) report efficiency losses of approximately 4.5 percent of one year's consumption during each of the major recessions of the 1970s and 1980s. When the parameter of labour supply elasticity is made less elastic, the efficiency losses over the recessions rise to more than 6 percent.

Yellen and Akerlof (2006) attribute Lucas' (1987) undervaluation of welfare gains from business cycle smoothing to four assumptions. First, Lucas' analysis "ignores the possible relationships between the volatility of output and the volatility of inflation –" thus ignoring the potential benefits of inflation-volatility mitigation resulting from policy that stabilizes unemployment.

Second, Lucas implicitly assumes a linear Phillips curve (the relationship between inflation and unemployment). If the short-run Phillips curve is nonlinear, paths with lower unemployment volatility also exhibit lower average unemployment, and higher average consumption.

Third, the efficiency gains from business-cycle smoothing are low in Lucas (1987) because the assumed rate of relative risk aversion is low, which implies "only very modest curvature" of the household utility function. More extreme nonlinearity could imply extreme losses in income for a small fraction of the population during extended periods of non-employment when unemployment is high.

Lastly, Lucas assumes that the relationship between current inflation and expected inflation is one-to-one. Yellen and Akerlof argue that, if the relationship between current inflation and expected inflation is less than one-to-one, "policies to combat unemployment will reduce average levels of unemployment" when inflation is low and unemployment is high.

The conventional view of budget deficits that has arisen, due in part to specifications of the "permanent" and "temporary" sort, is government spending can be expansionary in the short run but contractionary in the long run – though neoclassicists may clarify, impotent or perverse rather than expansionary. Such conventions are scrutinized in this paper, specifically in the Canadian context.

One typically characterizes government spending as either expansionary or contractionary by estimating multipliers. In this paper, I assess the multipliers of output, consumption, investment, and labour-hours supplied. The types of multipliers of interest are the impact, 4-quarter, 10-quarter, and 25-quarter mean multipliers, as well as the cumulative multipliers over 25 quarters. The multipliers arise from the impulse-response functions produced by the new Keynesian DSGE model. The impulse-response functions illustrate the effects of an exogenous shock to government spending on the endogenous variables over time, ceteris paribus, which may elucidate the potential isolated effects of such shocks on the actual Canadian economy.

My model is a modified version of Leeper et al. (2015), with the most notable specification of two monetary-fiscal policy regimes: either active monetary policy and passive fiscal policy (regime M); or passive monetary policy and active fiscal policy (regime F).

Monetary policy is characterized as either *active* or *passive* depending on the policy parameter ϕ_π, which describes the degree of responsiveness of the nominal interest rate to changes in inflation – the greater the value of the parameter, the greater the monetary authority's preference for low inflation. Similarly, the behaviour of fiscal policy is governed by five policy parameters: γ_G, γ_Z, γ_C, γ_N, and γ_K ,which describe the degree of responsiveness of fiscal instruments to the real government-debt-to-output ratio. The fiscal instruments are: government spending (G), lump-sum taxes/transfers (Z), and distortionary tax rates for consumption (C), labour (L) income, and capital (K) gains. The greater the value of γ_G, the more the fiscal authority reduces spending in response to a rising debt-to-output ratio. The greater the value of γ_Z, γ_C, γ_N, and γ_K, the more the government raises lump-sum taxes and distortionary tax rates when the debt-to-output ratio increases.

Regime M entails high ϕ_π and high $\gamma_J, J = \{G, Z, C, N, K\}$, that is, monetary policy reacts aggressively to inflation, and fiscal instruments adjust to stabilize debt. Regime F entails low ϕ_π and low γ_J, that is, monetary policy reacts weakly to inflation, and fiscal policy reacts weakly or does not react to rising debt. The specific values of ϕ_π and γ_J are detailed in section 3 and 4 of the paper.

Like in model 4 of Leeper et al. (2015), government spending directly enters the household utility function as a delineation that not all government spending is "unproductive." Households gain utility from consuming "composite-consumption," which is equal to the consumption of goods and a share, α_G, of government spending. Parameter, α_G, describes the degree of substitutability of private and public good consumption and is informed by historical data through Bayesian inference. Higher α_G implies that private and public consumption are stronger substitutes.

Unlike Leeper et al., I exclude "non-savers" as their presence is typically a large and indiscriminate driver of greater-than-one output multipliers and positive consumption multipliers in new Keynesian models – as in, Gali, López-Salido, and Vallés (2007); Traum and Yang (2015); and Leeper et al. (2015). Since non-savers are defined as consumers who do not have access to financial or capital markets, they cannot save, and simply consume their disposable income in each period. In imposing some fraction of households as non-savers, one is artificially preventing the potential crowding out of consumption from an increase in government spending. Therefore, in the spirit of approaching the issue of government spending multipliers agnostically, I exclude non-savers from the model.

In this analysis, the fiscal multiplier is defined as the increase or decrease in the variable in question in response to, and relative to, an increase in government spending. For example, an output multiplier of two would suggest, an increase in output is double that of an antecedent increase in government spending. Formally, an output multiplier in period k after a government spending shock in period t is defined as: $\frac{Y_{t+k}}{G_t}$.

Examining the model under two distinct monetary-fiscal regimes applies and removes pressures in the model that may or may not drive the results. Understanding which features of the model give rise to which characteristics of the results is crucial because the relevance of the results is, to some degree, determined by how well the model and its parameters reflect the Canadian economy. Accordingly, I use prior predictive analysis as in Leeper et al. (2015), which gives a range of possible multipliers that can be produced by the model before it is confronted with the data, and I use Bayesian estimation as it contextualizes the model in the real world. Bayesian estimation infers a set of model parameter distributions (posteriors) that best fit the historical data in accordance with a set of pre-stated parameter distributions (priors). Furthermore, examining the model under two distinct fiscal-monetary regimes allows for a greater range of possible multipliers with consideration to which regime best reflects Canadian institutions.

Leeper et al. (2015) find that monetary-fiscal policy regime distinctions, of the sort described in this paper, have important implications for the transmission mechanisms of government spending shocks, and for fiscal financing schemes.

In my analysis, over the full sample period of 1976:2-2017:2, government spending shocks have larger and more persistent effects under regime F than under regime M. Under regime F, cumulative multipliers of all variables of interest are positive, and persist for over 25 quarters. In contrast, regime M exhibits exclusively negative cumulative multipliers that only persist for approximately 22 quarters. Composite-consumption impact multipliers for regime F and regime M are: -0.030 and 0.004, respectively. After the initial impact, composite-consumption becomes exclusively negative under regime M. After 4 quarters, composite-consumption becomes exclusively positive under regime F. As for investment, the impact multiplier is positive in regime F (0.088), whereas, in regime M, investment is immediately crowded out with an impact multiplier of -0.053. Cumulatively, the investment multiplier is negative in regime M and positive in regime F. Lastly, labour effects are exclusively positive in regime F (impact of 0.296) but exclusively negative in regime M (impact of -0.006).

The differences in multipliers between the regimes can be explained by differences in the transmission mechanisms of government spending shocks, which can be attributed to differences in fiscal financing and monetary policy behaviour. In regime M, debt stabilization is achieved through increased distortionary taxation balanced against lump-sum transfers to households. Coupled with a reduced nominal interest rate that tempers the fall in consumption, debt stabilization has the effect of swiftly stabilizing price and wage inflation. The result is negative multipliers across the board but low persistence shock-effects.

In regime F, debt accumulation is tolerated and acts as the main financier of government spending, while distortionary and lump-sum taxation are less utilized, with the consumption tax rate left virtually unchanged over the whole sample period. In further contrast to regime M, the nominal interest rate increases, as price inflation and output rise. Overall, the shock effects are larger in magnitude and more persistent under regime F than under regime M.

The variance in multipliers between the regimes can be traced to the parameter posterior estimates, particularly to the estimates of the policy parameters. Regime F exhibits strong nominal rigidities, especially wage stickiness, low-mean and low-variance fiscal policy parameters, as well as weaker responses of the nominal interest rate to inflation and output than in regime M. Comparatively, regime M entails lower nominal rigidities, stricter fiscal rules, and more hawkish monetary policy.

The parameter posterior estimates are discussed in further detail in section 4, and how they relate to the government spending transmission mechanisms is discussed in section 5.

In comparison to my results, Leeper et al. (2015) find “substantially larger multipliers in regime F than in regime M at long horizons” with positive consumption effects in both regimes, and mostly positive investment multipliers in regime F but “decidedly negative” ones in regime M. Posterior estimates reveal that debt stabilization in regime F is driven by revaluations of debt through “surprise changes in inflation and bond prices,” whereas in regime M, debt stabilization is virtually entirely managed by government spending reversals of the variety emphasized by Corsetti, Meier, and Muëller (2012).

To form a more complete understanding of government spending shocks in Canada, I extend my analysis to two sub-samples, the pre-Great-Recession period (1976:2–2007:2), and the post-Great-Recession period (2011:4–2017:2). I find remarkably different results between the two sub-samples, that are consistent with Owyang, Ramey, and Zubairy

(2013) who find that government spending multipliers are larger during periods of relatively high unemployment.

Overall, my analysis contributes two main insights to the literature of Canadian fiscal multiplier effects. First, the monetary-fiscal interactions and prevailing macroeconomic trends of a given time period have strong influences on the effectiveness of Canadian government spending. Second, my findings generally recommend moderate inflation-stabilization and lenient debt-stabilization, like in regime F, to maximize multiplier effects and to minimize the crowding out of consumption and investment.

2. THE MODEL

In this section of the paper, I detail the features of a new Keynesian DSGE model with final and intermediate productions sectors, forward-looking households with access to complete asset and capital markets, a labour packer who aggregates the differentiated labour services of households, a monetary authority that follows a Taylor-type rule, and a government that can utilize debt and distortionary taxes to finance its expenditures. This model draws heavily from Leeper et al. (2015) and Sims (2017).

Firms and Price Setting

The production sector of the model consists of a representative competitive final goods producer who supplies a final good, Y_t, that is an aggregate of a continuum of differentiated intermediate goods, $Y_t(j)$, where $j \in [0,1]$. The intermediate goods are produced by monopolistically competitive firms who choose price, $P_t(j)$, to minimize cost.

Final Goods Producer

The final good, which is referred to as aggregate output, is a constant-elasticity-of-substitution (CES) aggregate of intermediate goods:

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\epsilon_p - 1}{\epsilon_p}} \, dj \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}, \quad (1)$$

where $\epsilon_p > 1$ represents the price elasticity of demand or the inverse elasticity of substitution between intermediate goods. As ϵ_p approaches 1, firm market power increases, and as ϵ_p approaches infinite, the goods market moves towards perfect competition.

The final goods producer chooses a level of output, Y_t, that maximizes profits subject to the CES technology, which through Dixit-Stiglitz aggregation yields a downward-sloping demand curve for each intermediate good:

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\epsilon_p} Y_t. \quad (2)$$

Equation 2 states that the demand for intermediate good j in relation to aggregate output is in function of the price elasticity of demand, and the good's price relative to the final good price (or aggregate price index), P_t, where P_t is:

$$P_t = \left(\int_0^1 P_t(j)^{1-\epsilon_p} dj \right)^{\frac{1}{1-\epsilon_p}}. \quad (3)$$

Intermediate Goods Producers

An intermediate firm produces output according to a constant-returns-to-scale (CRS) technology in capital and labour:

$$Y_t(j) = A_t K_t(j)^{\alpha} N_t(j)^{1-\alpha}, \quad (4)$$

where A_t represents a homogeneous productivity shock, $K_t(j)$ is the capital input of firm j, and $N_t(j)$ is its labour input. Productivity shocks follow the stationary AR(1) process:

$$\hat{A}_t = \rho_a \hat{A}_{t-1} + \epsilon_{a,t}, \tag{5}$$

where a hat denotes that a variable is expressed in percentage-deviations from steady state, and a lack of time-subscript indicates the steady state level – $\hat{A}_t = \frac{A_t - A}{A}$. Parameter ρ_a represents the persistence of the productivity shock, and $\epsilon_{a,t} \sim N(0, \sigma_a^2)$ expresses the exogenous shock to productivity.

Intermediate firm j chooses production inputs, $K_t(j)$ and $N_t(j)$, to minimize total cost, taking as given: a nominal wage (or aggregate wage index) common to all firms, W_t, and a common nominal capital rental rate, R_t, subject to the constraint of meeting demand:

$$\min_{K_t(j), N_t(j)} W_t N_t(j) + R_t K_t(j) \tag{6}$$

$$\text{s.t.} \quad A_t K_t(j)^{\alpha} N_t(j)^{1-\alpha} \geq \left(\frac{P_t(j)}{P_t}\right)^{-\epsilon_p} Y_t. \tag{7}$$

As a result of the optimization problem, the optimal mix of capital and labour is given by:

$$\frac{K_t(j)}{N_t(j)} = \frac{\alpha}{1-\alpha} \frac{w_t}{r_t} \ \forall j. \tag{8}$$

Since the optimal capital-labour ratio is equal across all firms, it is equal to the aggregate capital-labour ratio: $\frac{K_t(j)}{N_t(j)} = \frac{K_t}{N_t} \ \forall j$. Hence real marginal costs, mc_t, are homogeneous across all firms and are equal to:

$$mc_t = w_t^{1-\alpha} \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left(\frac{1}{\alpha}\right)^{\alpha} \frac{r_t^{\alpha}}{A_t}, \tag{9}$$

where $w_t = \frac{W_t}{P_t}$ and $r_t = \frac{R_t}{P_t}$ are the real aggregate wage index and the real rental rate of capital, respectively.

Therefore, real flow profits equal:

$$\Pi_t(j) = \frac{P_t(j)}{P_t} Y_t(j) - mc_t Y_t(j). \tag{10}$$

Prices evolve by a Calvo (1983) mechanism. Only a fraction, $1 - \theta_p$, of intermediate firms can re-optimize price in any given period, which gives rise to sticky prices. The probability an intermediate firm is stuck with a price for one period is θ_p, and for two periods is θ_p^2. Therefore, intermediate firms face a dynamic pricing problem choosing price $P_t(j)$ in period t to maximize the sum of expected discounted profits given price $P_t(j)$, using the stochastic discount factor $\beta^s \frac{u'(C_{t+s})}{u'(C_t)}$ like in Gali (2015):

$$\max_{P_t(j)} \mathrm{E_t} \sum_{s=0}^{\infty} (\beta\theta_p)^s \frac{u'(C_{t+s})}{u'(C_t)} \left(\frac{P_t(j)}{P_{t+s}} \left(\frac{P_t(j)}{P_{t+s}} \right)^{-\epsilon_p} Y_{t+s} - mc_{t+s} \left(\frac{P_t(j)}{P_{t+s}} \right)^{-\epsilon_p} Y_{t+s} \right). \tag{11}$$

The solution says that all firms who can update their price choose the same reset price:

$$P_t^{\#} = \frac{\epsilon_p}{\epsilon_p - 1} \frac{X_{1,t}}{X_{2,t}}, \tag{12}$$

where,

$$X_{1,t} = u'(C_t) mc_t P^{\epsilon_p} Y_t + \theta_p \beta E_t X_{1,t-1}, \tag{13}$$

and

$$X_{2,t} = u'(C_t) P_t^{\epsilon_p - 1} Y_t + \theta_p \beta E_t X_{2,t-1}. \tag{14}$$

Here, $u(\cdot)$ represents the household utility function.

Households and Wage Setting

Analogous to the final goods producer, a competitive labour packer combines the differentiated labour services, $N_t(l)$, $l \in [0,1]$, of households into a homogeneous labour good N_t that is sold to intermediate firms at price W_t, where like the aggregate price index, the aggregate wage index is expressed in the form:

$$W_t = \left(\int_0^1 W_t(l)^{1-\epsilon_w} dl\right)^{\frac{1}{1-\epsilon_w}}. \tag{15}$$

Labour Packer

The labour packer aggregates the labour services of households using the CES technology:

$$N_t = \left(\int_0^1 N_t(l)^{\frac{\epsilon_w-1}{\epsilon_w}} dl\right)^{\frac{\epsilon_w}{\epsilon_w-1}}, \tag{16}$$

where $\epsilon_w > 1$ has the same interpretation as ϵ_p but for wages.

The labour packer chooses $N_t(l)$ to maximize profits subject to the CES technology, which through Dixit-Stiglitz aggregation yields a downward-sloping demand curve for each labour service: $N_t(l) = \left(\frac{W_t(l)}{W_t}\right)^{-\epsilon_w} N_t$.

Households

Households are monopolistically competitive in the supply of heterogeneous labour services. Like prices, nominal wages evolve by the same Calvo mechanism, in function of probability θ_w – hence the presence of sticky wages. This implies that households are heterogeneous in their consumption, saving, and labour decisions. Erceg, Henderson, and Levin (2000) demonstrate that if the utility function is separable in consumption and labour and "there exist state contingent claims that insure households against idiosyncratic wage risk," households are identical in their consumption and saving decisions, and only differ in terms of their supply of labour and posted nominal wage.

Households choose levels of consumption C_t, labour supply $N_t(l)$, one-period nominal bonds B_{t+1}, gross investment I_t, future capital stock K_{t+1}, and choose nominal wage $W_t(l)$, to maximize expected discounted utility. A household's preferences are represented by a standard constant-relative-risk-aversion (CRRA) utility function (equation 17). The optimization problem faced by a household is:

$$\max_{C_t, N_t(l), W_t(l), B_{t+1}, I_t, K_{t+1}} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{*\,1-\sigma}}{1-\sigma} - \frac{N_t(l)^{1+\eta}}{1+\eta} \right) \tag{17}$$

$$\text{s.t.}$$

$$(1+\tau_t^C)C_t + I_t + \frac{B_{t+1}}{P_t} \tag{18}$$

$$= (1-\tau_t^K) r_t K_t + (1-\tau_t^N) w_t N_t(l) + \Pi_t + (1+i_{t-1}) \frac{B_t}{P_t} - Z_t$$

$$K_{t+1} = (1-\delta)K_t + \left[1 + \Psi\left(\frac{I_t}{I_{t-1}}\right)\right] I_t \tag{19}$$

$$N_t(l) = \left(\frac{W_t(l)}{W_t}\right)^{-\epsilon_w} N_t. \tag{20}$$

Composite consumption $C_t^* \equiv C_t + \alpha_G G_t$ is defined as in Leeper et al. (2015): a combination of private and public good consumption. Parameter α_G is the share of government spending consumed by households, or in other words, the share of government spending that is valued as a public good. Thus, α_G can be thought of as the degree of substitutability between private and public good consumption – when $\alpha_G = 1$, private and public goods are perfect substitutes.

Parameter σ is the coefficient of risk aversion or the inverse of the intertemporal elasticity of substitution, η is the coefficient of labour disutility or the inverse of the Frisch labour elasticity.

Equation 19 is consumer l's real flow budget constraint, where τ_t^H is the tax rate with respect to $H = \{C, K, N\}$, and Z_t is lump-sum taxes/transfers from the government. B_t is the nominal stock of bonds, which pay off in period $t+1$ with interest at the nominal rate i_{t-1} known in period $t-1$.

Households invest quantity I_t in physical capital in period t. The physical stock of capital, K_t, accumulates by the law of motion outlined in equation 19. Parameter $\delta \in [0,1]$ is the constant depreciation rate of the physical capital stock, and $\Psi(\cdot)$ is a cost function associated with investment. In this case,

$$\Psi\left(\frac{I_t}{I_{t-1}}\right) = \frac{\psi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 \tag{21}$$

where $\psi > 0$, $\Psi(1) = 0$, $\Psi'(1) = 0$, and $\Psi''(\cdot) > 0$.

The following three Euler equations result from the optimization problem. The first is the bond Euler equation:

$$C_t^{*-\sigma} = \beta \mathrm{E_t}(1 + i_t)(1 + \pi_{t+1})^{-1}\left(\frac{1 + \tau_t^C}{1 + \tau_{t+1}^C}\right) C_{t+1}^{*} \tag{22}$$

where the inflation rate is: $\pi_t = \frac{P_t}{P_{t-1}} - 1$. The second is the capital Euler equation:

$$q_{t-1} = \beta\left(\frac{1 + \tau_{t-1}^C}{1 + \tau_t^C}\right)\left(\frac{C_{t-1}^*}{C_t^*}\right)^{\sigma}\left(q_t(1 - \delta) + (1 - \tau_t^K) r_t\right) \tag{23}$$

where $q_t = \frac{Q_t}{\lambda_t}$ is the Tobin's Q marginal ratio of the Lagrange multipliers Q_t and λ_t, which are associated with equation 19 and 18, respectively. The third is the investment Euler equation:

$$\begin{aligned} q_t - q_{t-1}\frac{\psi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - q_t\psi\left(\frac{I_t}{I_{t-1}} - 1\right)\frac{I_t}{I_{t-1}} \\ + \beta \mathrm{E_t}(1 + \pi_t)\left(\frac{1 + \tau_t^C}{1 + \tau_{t+1}^C}\right)\left(\frac{C_t^*}{C_{t+1}^*}\right)^{\sigma} q_{t+1}\psi\left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2 = 1. \end{aligned} \tag{24}$$

Analogous to intermediate firms, households face a dynamic problem in choosing nominal wage. The result is the following real wage reset equation:

$$w_t^{\#,1+\epsilon_w\eta} = \frac{\epsilon_w}{\epsilon_w - 1}\frac{H_{1,t}}{H_{2,t}} \quad (25)$$

where,

$$H_{1,t} = \psi w_t^{\epsilon_w(1+\eta)} N_t^{1+\eta} + \beta\theta_w \mathrm{E_t}(1+\pi_{t+1})^{\epsilon_w(1+\eta)} H_{1,t+1} \quad (26)$$

and

$$H_{2,t} = \frac{C_t^{*\,-\sigma}}{1+\tau_t^C}(1-\tau_t^N) w_t^{\epsilon_w} N_t + \beta\theta_w \mathrm{E_t}(1+\pi_{t+1})^{\epsilon_w - 1} H_{2,t+1}. \quad (27)$$

Monetary and Fiscal Policy

The monetary authority follows a Taylor-type rule, wherein the nominal interest, i_t, reacts to its lagged value, according to the autoregressive term $\rho_i \in [0,1]$, to current inflation and output according to parameters ϕ_π and ϕ_Y, respectively. The Taylor-type rule in log-linear form is as follows:

$$\hat{\imath}_t = \rho_i \hat{\imath}_{t-1} + (1-\rho_i)\big(\phi_\pi \hat{\pi}_t + \phi_Y \hat{Y}_t\big) + \epsilon_{i,t} \quad (28)$$

where $\epsilon_{i,t} \sim N(0, \sigma_i^2)$ expresses an exogenous monetary policy shock.

On the revenue side, the government collects tax revenue from private consumption, labour income, capital gains, and can levy lump-sum taxes or issue lump-sum transfers. The government can also accumulate debt using one-period nominal bonds, B_t^G, which must be paid off in period $t+1$ with interest at rate i_{t-1}. The government's real flow budget constraint is as follows:

$$G_t + (1+\pi_t)^{-1}(1+i_{t-1})b_t^G$$
$$= \tau_t^C C_t + \tau_t^N w_t N_t + (1+\pi_t)^{-1} b_{t+1}^G + Z_t \tag{29}$$

where $b_t^G = \frac{B_t^G}{P_{t-1}}$ as in Sims and Wolff (forthcoming, 2017).

Fiscal policy is governed by the following fiscal rules:

$$\hat{G}_t = \rho_G \hat{G}_{t-1} - (1-\rho_G)\gamma_G \hat{b}_t^{GY} + \epsilon_{G,t}, \tag{30}$$

$$\hat{Z}_t = \rho_Z \hat{Z}_{t-1} + (1-\rho_Z)\gamma_Z \hat{b}_t^{GY} + \epsilon_{Z,t}, \tag{31}$$

$$\hat{\tau}_t^C = \rho_C \hat{\tau}_{t-1}^C + (1-\rho_C)\gamma_C \hat{b}_t^{GY}, \tag{32}$$

$$\hat{\tau}_t^N = \rho_N \hat{\tau}_{t-1}^N + (1-\rho_N)\gamma_N \hat{b}_t^{GY}, \tag{33}$$

$$\hat{\tau}_t^K = \rho_K \hat{\tau}_{t-1}^K + (1-\rho_K)\gamma_K \hat{b}_t^{GY} \tag{34}$$

where $\rho_J \in [0,1]$ for $J = \{G, Z, C, N, K\}$, $\epsilon_{S,t} \sim N(0, \sigma_J^2)$ for $S = \{G, Z\}$ are exogenous shocks to government spending and lump-sum taxes, respectively, and the real debt-output ratio is given by: $b_t^{GY} = \frac{(1+\pi_t)^{-1} b_t^G}{Y_t}$.

Equations 30–34, say that fiscal instrument J responds to its lagged value according to the autoregressive term ρ_J, and to the real debt-output ratio with probability $1-\rho_J$, according to parameter γ_J, which governs the degree of responsiveness of the instrument to the real debt-output ratio.

The full set of equilibrium conditions in log-deviations from steady state can be found in appendix A.

3. PARAMETERIZATION AND PRIOR ANALYSIS

Calibration

Under both regimes, the following parameters (table 1) hold fixed values. As in Leeper et al. (2015), the discount factor, β, is set to 0.99, the capital income share in production, α, is set to 0.33, and the depreciation rate of capital, δ, is set to 0.025 – implying an annual depreciation rate of 10 percent. The risk aversion coefficient, σ, and the inverse Frisch labour elasticity, η, are set to 1 so that preferences over consumption and labour are logarithmic as in Lucas (1987). The elasticities of substitution for intermediate goods and labour varieties, ϵ_p and ϵ_w, are set to 5, which imply 25 percent markups, within the range of estimates of existing literature (Kryvtsov & Midrigan, 2011). The investment adjustment cost parameter, ψ, is set to 6 as in Torres (2015), who writes about the integration of investment adjustment costs into DSGE models.

Parameter	Calibrated Value
β, discount factor	0.990
σ, coefficient of risk aversion	1.000
η, inverse Frisch labour elasticity	1.000
δ, capital depreciation rate	0.025
ϵ_p, goods elasticity of substitution	5.000
ϵ_w, labour elasticity of substitution	5.000
α, share of capital in production	0.330
ψ, investment adjustment cost	6.000
$\frac{C}{Y}$, steady-state consumption-output	0.548
$\frac{G}{Y}$, steady-state spending-output	0.227
$\frac{B^G}{Y}$, steady-state debt-output	0.936
$\frac{Z}{Y}$, steady-state transfers-output	0.006
$\frac{K}{Y}$, steady-state capital-output	0.222
w, steady-state wage	20.115
i, steady-state interest rate	0.020
r, steady-state capital return	0.027
τ^C, steady-state consumption tax	0.110
τ^N, steady-state labour tax	0.260
τ^K, steady-state capital tax	0.075

Table 1: Fixed parameters set using mean Canadian data over the period of 1997:1-2016:4, and estimates from existing literature.

Steady-state variables are constructed using real, seasonally adjusted at annual rates, mean Canadian data over the period of 1997:1 – 2016:4, within the confines of the available average wage data. Thus, one period in the model is treated as one fiscal quarter. The steady-state consumption-output ratio is approximately 0.548; government-spending-to-output ratio is 0.227; the government-debt-to-output ratio is 0.936; the ratio of lump-sum taxes/transfers to output is 0.006; and the capital-stock-to-output ratio is set to 0.222. The steady state real wage is set to 20.11, which is equal to the average hourly wage in Canada over the sample period. The steady-state quarterly capital rental rate is set to 2.27 percent – the average annual return rate of the TSX divided by four. As for the nominal interest rate, its steady-state value is simply set to the approximate average Bank Rate (the Bank of Canada's interest rate) of 2 percent. With respect to the steady-state distortionary tax rates, the labour rate is set to 26 percent, which is the federal income tax rate of the middle tax bracket; the consumption rate is set to 11 percent, which is the average GST plus HST over all provinces; lastly, the capital rate is set at 7.5 percent, which was chosen given that the capital gains tax rate of the middle bracket is 15 percent and only 50 percent of capital gains are taxable. Lastly, some steady-state variables were derived from the model. The investment-output ratio was derived from the aggregate resource constraint and is equal to: $1 - \frac{C}{Y} - \frac{G}{Y}$. The labour-output ratio, $\left(\frac{\alpha}{1-\alpha}\frac{w}{r}\right)^{-\alpha}$, was derived from the production function and the optimal capital-labour ratio equation. The investment-capital ratio is from the law of motion for capital and is equal to δ. Finally, the composite-consumption-to-output ratio is set to equal: $\frac{C}{Y} + 0.5\frac{G}{Y}$. The data sources are referenced in appendix B.

<u>Prior Distributions</u>

Prior distributions are mostly the same as in Leeper et al. (2015), which are closely related to those in Zubairy (2014), and Traum and Yang (2015). Instead of specifying a prior mean and a standard deviation for α_G, I set the lower and upper bounds to 0.1 and 1, respectively. I choose 0.1 instead of 0 as the lower bound of α_G because it is unlikely that no government spending in Canada is viewed as a public good. Table 2 lists the set of priors that satisfy the Blanchard-Kahn determinacy conditions. Indeterminacy occurs when values ϕ_π and γ_J are

Policy Regimes

The monetary-fiscal policy regimes are distinguished in my choice of priors. In regime

Parameter		Prior	
	distribution	mean	std.
θ_w, wage stickiness	beta	0.500	0.200
θ_p, price stickiness	beta	0.500	0.200
α_G, substitutability of private/public consumption	uniform		
ρ_A, technology	beta	0.500	0.150
ρ_i, monetary policy	beta	0.500	0.200
σ_A, technology	inv. gam.	0.100	1.000
σ_i, monetary policy	inv. gam.	0.100	1.000
σ_G, spending	inv. gam.	0.100	1.000
σ_Z, transfers	inv. gam.	0.100	1.000
γ_J, debt response for $J = \{G, Z, C, N, K\}$, regime M	normal	0.150	0.100
γ_J, debt response for $J = \{G, Z, C, N, K\}$, regime F	normal	0.000	0.001
ρ_J, persistence for $J = \{G, Z, C, N, K\}$	beta	0.500	0.150
ϕ_π, interest rate response to inflation, regime M	normal	1.500	0.200
ϕ_π, interest rate response to inflation, regime F	normal	0.500	0.150
ϕ_Y, interest rate response to output	normal	0.125	0.050

Table 2: Prior distributions

M, the prior mean for the nominal interest rate's response to inflation, ϕ_π, is greater than in F – reflecting a more active monetary policy. In regime F, not only is the prior mean of ϕ_π lower – reflecting a more passive monetary policy – the prior means of the parameters governing the response of fiscal instruments to the debt-output ratio are set to 0 as opposed to 0.15, and the standard deviations are set lower, at 0.001 as opposed to 0.1. Thus, regime M reflects active monetary policy paired with passive fiscal policy, and regime F reflects passive monetary policy paired with active fiscal policy.

Prior Predictive Analysis

In the spirit of Geweke (2010), Faust and Gupta (2010), and Leeper et al. (2015), I use prior predictive analysis as a preliminary measure to elucidate which features of the model give rise to which characteristics of the results, and a range of possible multipliers that the model can produce.

Since the emphasis of this paper is on the difference in multipliers produced under regime M and regime F, I examine two broad parameter specifications that reflect the extremes of either regime. The first specification is an extreme version of regime M, where monetary policy is highly active ($\phi_\pi = 6$) and fiscal policy is highly passive ($\gamma_J = 0.6$). The second specification is an extreme version of regime F, where monetary policy is highly passive ($\phi_\pi = 0.125$) and fiscal policy is simply active ($\gamma_J = 0$). The remaining parameters are set to the prior means in table 2, except for α_G, which is set to its lower bound, 0.1. I also set α_G to 0.5 to isolate the effects of increased substitutability of private and public consumption.

As a means of calibrating the prior predictive analysis, I first analyze the model using the prior means of regime M and regime F. Table 3 summarizes all four sets of parameter specifications. Table 4 reports the mean impact, 4-quarter, 10-quarter, 25-quarter, and cumulative multipliers of output, composite-consumption, investment, and labour supply to a 10 percent increase in government spending, under all 4 parameter specifications.

The cumulative multiplier is equal to the sum of each quarters' multiplier from impact to the 25fth quarter.

Parameter specification	Policy parameters	
	ϕ_π	γ_J
Regime M (active MP, passive FP)	1.500	0.150
Regime F (passive MP, active FP)	0.500	0.000
Extreme M (highly active MP, highly passive FP)	6.00	0.600
Extreme F (highly passive MP, active) FP	0.125	0.000

Table 3: Summary of parameter specifications

Output Multiplier					
Parameter specification	Impact	4 qtrs	10 qtrs	25 qtrs	Cml
Regime M (active MP, passive FP)	0.146	-0.014	-0.003	-6.04E-05	0.117
Regime F (passive MP, active FP)	0.260	0.059	0.017	2.22E-03	0.811
Highly active MP, highly passive FP	0.109	-0.022	-0.001	-4.77E-05	0.053
Highly passive MP, active FP	0.236	0.039	0.006	1.77E-04	0.558
Composite-Consumption Multiplier					
	Impact	4 qtrs	10 qtrs	25 qtrs	Cml
Regime M (active MP, passive FP)	-0.080	-0.043	-0.010	3.58E-05	-0.388
Regime F (passive MP, active FP)	0.067	0.041	0.030	0.004	0.586
Highly active MP, highly passive FP	-0.131	-0.058	-0.006	2.60E-05	-0.483
Highly passive MP, active FP	0.036	0.016	0.011	3.46E-04	0.218
Investment Multiplier					
	Impact	4 qtrs	10 qtrs	25 qtrs	Cml
Regime M (active MP, passive FP)	-0.023	-0.026	0.019	-3.94E-04	-0.021
Regime F (passive MP, active FP)	0.053	0.028	-0.014	-0.002	0.065
Highly active MP, highly passive FP	-0.037	-0.010	0.013	-2.93E-04	-0.017
Highly passive MP, active FP	0.037	0.012	-0.010	-2.31E-04	0.023
Labour Multiplier					
	Impact	4 qtrs	10 qtrs	25 qtrs	Cml
Regime M (active MP, passive FP)	0.218	-0.011	0.002	-1.37E-04	0.270
Regime F (passive MP, active FP)	0.389	0.071	0.010	0.002	0.983
Highly active MP, highly passive FP	0.163	-0.021	0.003	-1.04E-04	0.155
Highly passive MP, active FP	0.353	0.048	0.002	1.13E-04	0.734

Table 4: Prior predictive multipliers over four parameter specifications.

Prior predictive analysis produces two main observations. The first observation concerns fiscal policy, and is discussed in the following two sub-sections.

When fiscal policy is active ($\gamma_J = 0$), regardless of monetary policy specifications, the model produces unambiguously larger multipliers than under passive fiscal policy ($\gamma_J > 0$). Impact and cumulative multipliers are larger for all variables when fiscal policy is active rather than passive. Consumption and investment are only crowded out on impact, and in total, when fiscal policy is passive.

The second observation concerns monetary policy, and is discussed in the third sub-section. Holding fiscal policy constant, a moderate response of the nominal interest rate to inflation (passive monetary policy) – as a medium between a highly active or a highly passive response – produces the largest and most persistent multipliers.

The Effects of Passive Fiscal Policy

Figure 1 show impulse-responses of key variables to exogenous government spending shocks, under regime M and regime F priors, and under the two extreme policy specifications.

When fiscal policy is passive (as in regime M) or highly passive (as in the extreme version of regime M), government spending is financed by borrowing, lump-sum taxes, and distortionary taxes. The real debt-output ratio rises in a hump-shape as the government spending shock increases on impact and then decays. Lump-sum taxes and distortionary tax rates rise and fall with the real debt-output ratio, bringing the ratio back to steady state in approximately 12 quarters under regime M, and in 5 quarters when monetary policy is highly active and fiscal policy is highly passive.

On impact of the government spending shock, the real rental rate of capital rises above its steady state level due to a higher marginal product of capital, signaling positive future composite-consumption growth. Higher expected future tax rates on consumption and capital gains also contribute to the higher rental rate.

Through its positive effect on the real rental rate of capital, government spending puts upward pressure on real marginal costs. Since price stickiness is 10 percent, 90 percent of firms raise price in response to higher marginal costs; hence, inflation rises. The intermediate firms that cannot raise price in response to higher real marginal costs, increase output to maintain markups and thus demand more labour. In regime M and in its extreme counterpart, government spending increases output overall, with respective cumulative multipliers: 0.117 and 0.053.

Increased government spending implies higher future lump-sum taxes and higher government debt, which in turn, implies rising distortionary tax rates. Rising current and expected future taxes create negative wealth effects. First, higher lump-sum taxes and a higher labour tax rate directly reduce households' after-tax income. Second, higher inflation has a negative effect on real wages. Third, wage effects are exacerbated by a feedback loop of negative substitution effects – wages decrease as labour supply increases, and the rental rate of capital increases with the rising marginal product of capital. Labour supply increases in response to a government spending shock because diminishing real wages imply compressed labour markups, particularly because nominal wages are moderately sticky ($\theta_w = 0.5$). The cumulative labour multiplier is 0.27 under regime M, and 0.155 when monetary policy is highly active and fiscal policy is highly passive.

When α_G is increased to 0.5, increases in the rental rate of capital, inflation, and labour supply are diminished.

In response to increased inflation and output, the nominal interest rate rises, which puts negative pressure on current consumption – since a higher nominal interest rate implies a higher opportunity cost of consuming in the present – while stimulating future consumption growth through bond purchases.

Negative wealth effects, a higher nominal interest rate, and a higher capital rental rate (or return on investment) causes consumption to fall on impact. Under regime M and under its extreme counterpart, composite-consumption falls by less than the fall in consumption because 10 percent of the increase in government spending is consumed by households, in accordance with the parameter α_G that set equal to 0.1. Under regime M, the composite-consumption multiplier is -0.08 on impact, and -0.388 in total over 25 quarters. Under highly active monetary policy and highly passive fiscal policy, consumption is more strongly crowded out, with an impact composite-consumption multiplier of -0.131, and a cumulative multiplier of -0.483. When α_G equals 0.5 instead 0.1, increased government spending reduces consumption by more, and composite-consumption by less, since private and public consumption become stronger substitutes as α_G is increased.

Households return consumption smoothly to steady state after around 16 quarters, as real wages rise, and at the cost of reduced investment. The impact multiplier of investment is -0.023 under regime M, and -0.037 under the more extreme version of regime M. The fluctuations in investment are tempered by investment adjustment costs, which offset the degree of investment crowding-out.

The Effects of Active Fiscal Policy

Since $\gamma_J = 0$ when fiscal policy is active, government spending, lump-sum taxes, and distortionary taxes do not react to the real debt-output ratio.

As with passive fiscal policy, the real rental rate of capital increases on impact of the government spending shock. The increase in the real rental rate of capital is greater when fiscal policy is active rather than passive because the relative increase in the marginal product of capital is larger when fiscal policy is active. As a result, the increase in marginal costs are greater when fiscal policy is active; the increase of marginal costs in regime F is almost double that in regime M. Therefore, inflation and output rise comparatively more. Higher output implies higher demand for labour and capital.

As a result of the substantially larger increases in output and inflation, the real debt-output ratio falls below steady state on impact instead of rising.

Again, government spending produces negative wealth effects; however, the negative effects of taxation are absent when fiscal policy is active rather than passive. The negative wealth effects are attributed to reduced wages from relatively larger increases in inflation and labour supply, and a smaller increase in the real rental rate of capital. However, after 4 quarters, in both regime F and the regime with highly passive monetary policy and active fiscal policy, the aggregate real wage index rises momentarily above steady state as labour supply and inflation fall back to steady state.

In sharp contrast with the results under passive fiscal policy, composite-consumption is persistently above steady state for 25 quarters under regime F, and for approximately 21 quarters with highly passive monetary policy and active fiscal policy. With passive fiscal policy, composite-consumption returns to steady state in approximately 15 quarters. Consumption increases instead of falling because there are no negative tax-effects.

The cumulative multipliers for output and labour under regime F are: 0.811 and 0.983, respectively, which are notably higher than under the parameter specifications with

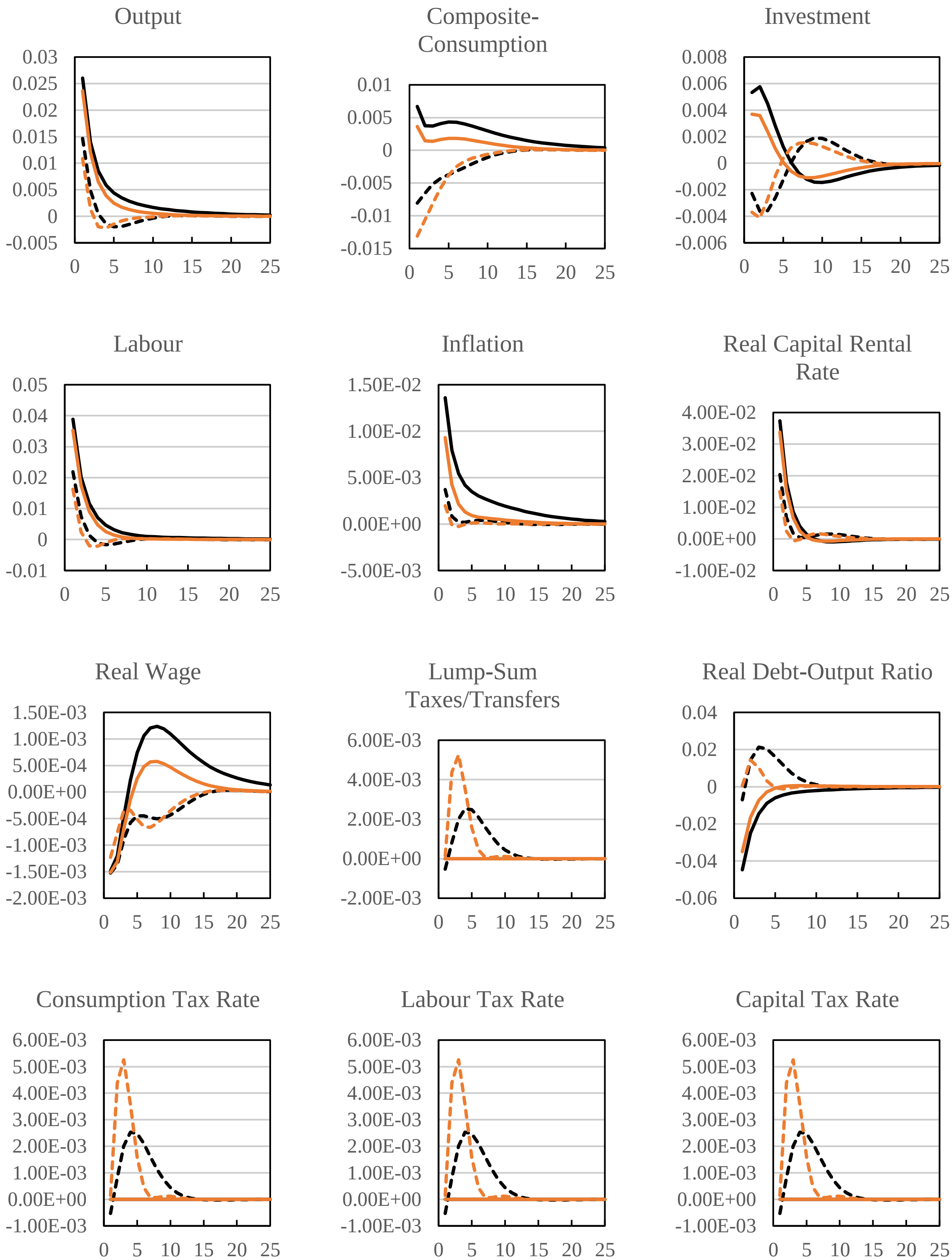

Figure 1: Impulse-responses for endogenous variables to an exogenous government spending shock. Dotted lines indicate responses under regimes with passive FP. Solid lines indicate responses under regimes with active FP. Black lines indicate responses under table 2 priors, and orange lines indicate responses under the extreme regime specifications.

passive fiscal policy. The cumulative multipliers produced under the extreme version of regime F are also notably large, though smaller than in regime F.

A higher rental rate of capital implies higher investment, and thus a positive investment multiplier on impact and a growing capital stock. Though, investment falls below steady state after 6 quarters in regime F, and after 5 quarters in the extreme version of regime F. The fall in investment is the cost of smoothing consumption back to steady state. Overall, increased government spending crowds in investment, with cumulative multipliers of 0.065 for regime F, and 0.023 for regime F's extreme counterpart.

Overall, higher α_G implies higher composite-consumption, lower private consumption, higher real wages, and a diminished impact-effect on the rest of the variables, in response to an increase in government spending, under all parameter specifications.

The Effects of Monetary Policy

The second observation discovered in the prior predictive analysis is: coupled with active fiscal policy, a moderate response of the nominal interest rate to inflation (passive monetary policy) – as a medium between a highly active or a highly passive response – produces the largest and most persistent multipliers. This observation arises from the differences between the multipliers produced under regime F and regime F's extreme counterpart. Since the activeness of fiscal policy is constant between regime F and its extreme counterpart ($\gamma_J = 0$), only the differences in monetary policy can account for the multiplier effect differences between the regimes. In regime F, monetary policy is passive ($\phi_\pi = 0.5$). In the extreme version of regime F, monetary policy is highly passive ($\phi_\pi = 0.125$). I observe larger and more persistent multiplier effects when monetary policy is passive rather than highly passive. Hence, multiplier magnitudes – on impact, after 25 quarters, and in total – are the highest under regime F for all variables of interest. The model with highly passive monetary policy and active fiscal policy produces the second largest and most persistent multipliers; the model with highly active monetary policy and highly passive fiscal policy produces the smallest and least persistent multipliers, and the largest crowding-out effects.

Therefore, the more fiscal policy is concerned with debt stabilization – the lesser are the positive effects of government spending, and the larger are the crowding-out effects. As for monetary policy, a moderate response of the nominal interest rate to inflation yields the largest multipliers, assuming fiscal policy is active.

Implications for Policy Coordination

To summarize, first, multipliers are larger and more persistent when fiscal policy is active rather than passive, that is, when government debt accumulation is tolerated and acts as the primary financier of government expenses. Second, when fiscal policy is active, a monetary policy that is not overly passive or active, is associated with larger multipliers and lesser crowding-out effects. Therefore, to maximize multiplier effects and minimize the crowding out of consumption and investment, my calibrated model recommends regime F – a combination of moderate inflation-stabilizing monetary policy, and fiscal policy with a relatively low propensity to stabilize debt. At the core, prior predictive analysis concludes that the optimal combination of policy behaviours reflects a balance between inflation and debt stabilization.

4. DATA AND ESTIMATES

Data

Now I turn to an exercise in Bayesian estimation to examine the varying effects of debt-financed government spending, under the two distinct monetary-fiscal regimes, in the context of the Canadian economy.

I estimate the model using four Canadian times series (observables) from the sample period of 1976:2–2017:2. The four observables are: consumption, investment, inflation, and the nominal interest rate. This combination of observables is recommended by Iskrev (2014) based on two optimal information criterion. The first selects variables to satisfy “a rank condition for identification of the free model parameters.” The second criterion evaluates combinations of variables based on which convoluted distribution “is closest to the convoluted singular system of all observables.” The combination of consumption, investment, inflation, and the nominal interest is selected as the most informative, on average, given a model with at least 24 parameters.

The time series used for the observables are transformed into log-deviations from steady state using a one-sided Hodrick-Prescott filter as recommended by Pfeifer (2013). The data sources are referenced in appendix B.

I also estimate over two sub-samples: the period before the Great Recession, 1976:2-2007:2, and the period after it, 2011:4-2017:2. This additional analysis reveals that the two different subsets of Canadian data influence policy behaviour distinctly, which sparks a discussion on the effectiveness of government spending in environments of varying economic activity.

As in the prior predictive analysis, my findings recommend a generalized optimal coordination of monetary policy and fiscal policy that maximizes the positive effects of Canadian government spending, and minimizes the crowding out of consumption and investment; though, with additional consideration to the characteristics of the environment in which the government spending is made.

Posterior Distributions

Table 5 reports the posterior estimates for the entire sample period. Although the prior distributions were made diffuse in the spirit of approaching the size and sign of multipliers agonistically, the data are sufficiently informative such that the posterior distributions are tightly spaced around their means. Posterior estimates vary substantively in size between regime M and regime F, though mostly retain the same signs.

Under regime M, a large share of government spending is consumed by households, with a value of α_G of 0.979, as opposed to 0.127 in regime F.

Nominal rigidities are greater in regime F than regime M, particularly wage stickiness, whose mean nears unity. Regime-F price and wage stickiness are similar to those of Leeper et al. (2015), while regime-M price and wage stickiness are far lower. Nominal rigidities in regime M are similar to those of Smets and Wouters (2007) who find mean price stickiness of 0.66, and mean wage stickiness of 0.58. High levels of nominal rigidities imply relatively flat inflation and wage Philips curves (Leeper et al., 2015).

Between the regimes, policy parameters differ notably. Monetary policy parameters reflect a strong preference for low inflation in regime M, and a stronger preference for output stabilization in regime M than in regime F, though with a mean coefficient ϕ_Y that is lower than the prior mean. Regime-F posterior estimates reflect far more passive monetary policy than regime M. As for the fiscal rule parameters, their distributions are tightly centered around zero in regime F, while generally greater and positive in regime M. Notably, the mean of the parameter governing lump-sum taxes/transfers, γ_Z, is negative in either regime, suggesting that lump-sum taxes are not levied on households when the debt-output ratio rises but rather households receive lump-sum transfers.

				1976:2–2017:2
Parameter	Regime M		Regime F	
	mean	90% C.I.	mean	90% C.I.
θ_w, wage stickiness	0.283	[0.192, 0.384]	0.949	[0.942, 0.957]
θ_p, price stickiness	0.620	[0.596, 0.647]	0.712	[0.687, 0.730]
α_G, substitutability of spending	0.980	[0.942, 1.010]	0.127	[0.102, 0.153]
ρ_A, technology	0.165	[0.117, 0.210]	0.165	[0.109, 0.233]
ρ_i, monetary policy	0.055	[0.023, 0.086]	0.047	[0.013, 0.083]
ρ_G, spending	0.728	[0.677, 0.765]	0.872	[0.830, 0.909]
ρ_Z, transfers	0.579	[0.537, 0.636]	0.852	[0.805, 0.897]
ρ_C, consumption	0.314	[0.204, 0.400]	0.534	[0.443, 0.692]
ρ_N, labour	0.340	[0.253, 0.403]	0.575	[0.517, 0.638]
ρ_K, capital	0.190	[0.151, 0.233]	0.503	[0.385, 0.647]
σ_A, technology	0.022	[0.018, 0.026]	0.062	[0.053, 0.071]
σ_i, monetary policy	0.015	[0.014, 0.017]	0.042	[0.013, 0.016]
σ_G, spending	0.024	[0.021, 0.026]	0.068	[0.058, 0.077]
σ_Z, transfers	7.546	[6.981, 8.006]	6.267	[5.276, 7.088]
γ_G, spending response to debt	0.300	[0.272, 0.327]	0.0001	[-0.0006, 0.0009]
γ_Z, transfer response to debt	-0.170	[-0.204, -0.123]	-0.0001	[-0.0007, 0.0005]
γ_C, consumption tax response to debt	0.129	[0.110, 0.149]	0.0000	[-0.0008, 0.0010]
γ_N, labour tax response to debt	0.050	[0.036, 0.061]	0.0024	[0.0015, 0.0031]
γ_K, capital tax response to debt	0.084	[0.064, 0.103]	0.0006	[-0.0004, 0.0019]
ϕ_π, interest rate response to inflation	1.858	[1.806, 1.902]	0.763	[0.642, 0.865]
ϕ_Y, interest rate response to output	0.114	[0.098, 0.137]	0.025	[0.015, 0.037]

Table 5: Posterior distributions for the period of 1976:2-2017:2 under regime M and regime F.

5. RESULTS

Multipliers

To understand the potential aggregate effects of government projects like the NIP, I first compare my model's estimated multipliers under both regimes, over the whole sample period to develop a general perspective on Canadian multiplier effects, and then over the two sub-sample periods to determine the role of the economic environment on multipliers and policy behaviour. Second, I discuss the transmission mechanisms of government spending shocks with reference to the impulse-responses in figure 2. I analyze the fiscal financing and monetary policy behaviour behind the transmission of government spending shocks, and how they relate to the posterior parameter estimates.

Table 6 summarizes output, consumption, investment, and labour supply multipliers under either regime, over the full sample, and over the two sub-samples. The table reports multipliers on impact, after 4 quarters, after 10 quarters, after 25 quarters, and cumulative multipliers over a 25-quarter period.

Multipliers Over the Full Sample Period

First, I dicsuss the multiplier effects over the full sample, followed by a discussion of the differences observed between the sub-samples.

Under regime M, a 2.3 percent government spending shock leads to negative, less-than-one cumulative multipliers for all variables of interest. Impact multipliers are negative across all variables, except for composite-consumption, whose multiplier is narrowly greater than zero. The largest impact is on private consumption at -0.399, which indicates a fall in consumption that is approximately 40 percent of the size of the increase in government spending.

In regime F, a 6.8 percent increase in government spending leads to distinct multipliers to regime M. On impact, output increases by an amount that is 19.8 percent of the government spending shock; in the same terms, composite consumption falls by 2.9 percent, investment increases by 8.8, and labour supply increases by 29.5 percent.

After four quarters, all multipliers in regime M remain negative but some are greater than on impact. After 10 quarters, all regime-M multipliers are of essentially negligible size. In comparison, the effects of a government spending shock persist for over 25

Output Multiplier					
Sample period	Impact	4 qtrs	10 qtrs	25 qtrs	Cml
1976:2–2017:2 (full sample period)	M: -0.004	M: -0.050	M: -0.030	M: -3.99E-05	M: -0.479
	F: 0.198	F: 0.142	F: 0.061	F: 0.021	F: 1.770
1976:2–2007:2 (pre-Great-Recession)	M: -0.002	M: -0.041	M: -0.019	M: -2.65E-04	M: -0.327
	F: 0.185	F: 0.115	F: 0.041	F: 0.016	F: 1.320
2011:4–2017:2 (post-Great-Recession)	M: 0.132	M: 0.005	M: -0.004	M: -3.83E-04	M: 0.180
	F: 0.244	F: 0.226	F: 0.122	F: 0.055	F: 3.170
Composite-Consumption Multiplier					
Sample period	Impact	4 qtrs	10 qtrs	25 qtrs	Cml
1976:2–2017:2 (full sample period)	M: 0.004	M: -0.055	M: -0.054	M: -2.4E-04	M: -0.716
	F: -0.030	F: -0.004	F: 0.013	F: 0.019	F: 0.327
1976:2–2007:2 (pre-Great-Recession)	M: 9.24E-04	M: -0.052	M: -0.036	M: 6.40E-04	M: -0.502
	F: -0.030	F: -0.006	F: 0.013	F: 0.019	F: 0.239
2011:4–2017:2 (post-Great-Recession)	M: -0.083	M: -0.024	M: -0.010	M: -2.94E-04	M: -0.305
	F: 0.033	F: 0.071	F: 0.055	F: 0.034	F: 1.310
Investment Multiplier					
Sample period	Impact	4 qtrs	10 qtrs	25 qtrs	Cml
1976:2–2017:2 (full sample period)	M: -0.053	M: -0.066	M: 0.030	M: 6.66E-04	M: -0.078
	F: 0.088	F: 0.066	F: -0.024	F: -0.002	F: 0.138
1976:2–2007:2 (pre-Great-Recession)	M: -0.002	M: -0.048	M: -0.013	M: 6.41E-05	M: -0.317
	F: 0.072	F: 0.046	F: -0.020	F: 2.99E-04	F: 0.155
2011:4–2017:2 (post-Great-Recession)	M: -0.024	M: -0.043	M: 0.021	M: -5.04E-05	M: - 0.048
	F: 0.134	F: 0.133	F: -0.031	F: -0.004	F: 0.386
Labour Multiplier					
Sample period	Impact	4 qtrs	10 qtrs	25 qtrs	Cml
1976:2–2017:2 (full sample period)	M: -0.006	M: -0.052	M: -0.015	M: -1.44E-04	M: -0.363
	F: 0.296	F: 0.181	F: 0.059	F: 0.021	F: 2.010
1976:2–2007:2 (pre-Great-Recession)	M: -0.002	M: -0.048	M: -0.013	M: 6.41E-05	M: -0.317
	F: 0.277	F: 0.147	F: 0.040	F: 0.016	F: 1.590
2011:4–2017:2 (post-Great-Recession)	M: 0.197	M: 0.019	M: 0.012	M: -1.59E-04	M: 0.465
	F: 0.365	F: 0.286	F: 0.115	F: 0.055	F: 3.460

Table 6: Estimated multipliers over all sample periods, under regime M and regime F.

quarters under regime F.

The cumulative effects of increased government spending are positive for all variables under regime F. Notably, the cumulative output and labour multipliers are greater than one – 1.77 and 2.01, respectively. In contrast, none of the cumulative multipliers in the prior predictive analysis were greater than one in either regime, which suggests that the Canadian data push the results toward larger multiplier effects.

In summary of the full sample estimation, government spending, under regime M, produces negative, less-than-one cumulative multipliers for all variables of interest, crowds out consumption and investment on impact, and exhibits lower shock-persistence than regime F. Under regime F, government spending produces positive cumulative multipliers for all variables of interest, crowds out consumption on impact while crowding in investment, and exhibits greater-than-one cumulative multipliers for output and labour supply.

My results mirror those of Leeper et al. (2015) who also find larger and more persistent multipliers in regime F than regime M, though impacts are smaller and less persistent in my analysis. Multipliers are not directly comparable between Leeper et al. and my analysis as Leeper et al. calculate present-value multipliers where the ratio is discounted by the model-implied real interest rate; however, the differences in multiplier calculation methods do not affect the signs of multipliers, thus it is still useful to compare our results.

In Leeper et al, the short-term output multipliers are similar between the two regimes, with the same initial impact of approximately 1.35. After 25 quarters, the mean cumulative output multiplier is 0.7 in regime M and 1.730 in regime F. In my analysis, the impact multiplier of output is -0.004 in regime M, and 0.198 in regime F, and the mean cumulative multiplier is -0.479 in regime M and 1.77 in regime F. Zubairy (2014), who estimates her model over 1968:1–2008:4, finds results akin to those of Leeper et al., with a median impact output multiplier of 1.070, and a median present-value output multiplier of 0.720 after 20 quarters. In contrast, Fatás and Mihov (2001), and Blanchard and Perotti (2002), who employ VAR analysis, find less-than-one impact multipliers, as I have; though, their samples cover U.S. data over the 1960s to the 1990s while Leeper et al. cover the period of 1955:1–2014:2, and I use Canadian data over the period of 1976:2–2017:2.

On impact, the present-value consumption multipliers in Leeper et al. are on average: 0.24 and 0.2, with respect to regime M and regime F; after 25 quarters, they are: 0.23 and 0.26. In my analysis, consumption is crowded out on impact in either regime, and the effects are far less persistent. The present-value investment multipliers in Leeper et al. are negative in regime M (between a range of -1.4 and -0.8) but are more often positive in regime F (between a range of -0.2 and 0.3), as in my own findings.

Given almost identical priors, multiplier effects are mostly similar between Leeper et al.'s model U.S. economy and my own model Canadian economy with one notable difference – the effect of government spending on consumption. Unlike in Leeper et al., consumption is strongly crowded out in my model under regime M, with a cumulative multiplier of -0.76. I attribute this difference in our results to the exclusion of non-savers in my model and their inclusion in Leeper et al., as their presence artificially increases consumption multipliers by imposing a share of consumers who consume all their disposable income in each period.

Multipliers Over the Sub-Sample Periods

Before the Great Recession, multipliers are almost identical to those of the full sample estimation under both regimes. The only noteworthy differences concern the cumulative composite-consumption and investment multipliers under regime M, which reflect greater crowding-out effects than in the full sample estimation.

On the other hand, multipliers and impulse-responses vary greatly between the estimation over the post-Great-Recession period and the estimation over the full sample period. Under regime M, cumulative output and labour multipliers are positive, unlike in the full sample and pre-Great-Recession estimations, and impact and 4-quarter multipliers for output and labour are relatively large and positive. The 4-quarter output and labour mean multipliers are 0.132 and 0.197, respectively. The crowding out of consumption and investment is lesser in the post-Great-Recession period, with respective cumulative multipliers: -0.305 and -0.048, compared to -0.502 and -0.317 in the pre-Great-Recession period.

A surprising difference between the post-Great-Recession estimation and the full sample estimation is the effect of a government spending shock on cumulative multipliers in regime F. The cumulative multipliers for output, composite-consumption, and labour supply are all greater than one; the output and labour multipliers are greater than three. Furthermore, regime F, in the post-Great-Recession period, is the only environment in which composite-consumption multipliers are exclusively positive.

Generally, the effects of a government spending shock are larger and more persistent under regime F than under regime M. Over the full sample period, the effects of a government spending shock are slightly more persistent in regime F than regime M with respect to output, consumption, investment, and labour but are much more persistent with respect to the capital tax rate, the labour tax rate, and the government debt-output ratio. Although the effects on the capital and labour tax rates are essentially negligible in regime F, the debt-output ratio remains 4 percent above its steady-state value even after

100 quarters (25 years). In regime M, the debt-output ratio returns to steady state after approximately 22 quarters.

Overall, in the post-Great-Recession period, the impacts of shocks are larger than over the full sample period, under both regimes, and are particularly large under regime F.

Transmission Mechanisms in the Two Regimes

Regime M

To interpret the multipliers produced by the model and their implications, I examine the transmission mechanisms of the government spending shocks under the two regimes and over the three samples. Figure 2 shows impulse-responses of key variables under each monetary-fiscal policy regime, and over the 4 sample periods.

Over the full sample period, regime M, which combines active monetary policy with passive fiscal policy, has the influence of dampening the effects of government spending shocks in magnitude and in persistence. Increased government spending is, in part, financed by increased borrowing, which leads to a rising real debt-output ratio (with a peak approximate increase of 1.2 percent). In response, fiscal instruments react swiftly to stabilize the debt-output ratio over time, which falls back to its steady state after around 22 quarters. Distortionary tax rates rise with the concave time-path of the debt-output ratio, while the government issues lump-sum transfers to households that dampen the negative wealth effects produced by the government spending shock. Of the three distortionary tax rates, the consumption tax rate rises the most (with a peak approximate increase of 2 percentage points).

Like in the prior predictive analysis, higher current and expected future tax rates imply negative wealth effects which reduce consumption on impact. However, since the estimated parameter governing the degree of substitutability between public and private consumption, α_G, is so high (0.980 at the mean), composite-consumption does not jump down remarkably on impact, as goods consumption does, but rather declines gradually as the government spending shock decays. Consumption smoothly returns to steady state at the cost of reduced investment.

Initially, the real rental rate of capital is below steady state because of a reduced marginal product of capital, thus signaling negative composite-consumption growth. A falling real rental rate of capital implies the crowding-out of investment, and a falling capital stock. As expected future tax rates on consumption and capital gains increase, and as the marginal product of capital rises – the real rental rate of capital becomes positive, signaling positive composite-consumption growth. Investment increases momentarily with the higher rental rate to smooth household consumption until returning to steady state levels.

Unlike in the prior predictive analysis, government spending reduces marginal costs through a lower real rental rate of capital, rather than increasing them. Since posterior price stickiness ($\theta_p = 0.620$) is greater than the prior of 0.5, lower marginal costs result in output reductions in excess of the fall in inflation. Since firms produce less output, they demand less labour. As the real rental rate of capital rises, output returns to steady state and inflation becomes positive.

On impact, real wages rise slightly rather than fall like in the calibrated model. The modest increase in real wages can be attributed to the decrease in inflation and a small decrease in labour supply. After the initial effects, real wages fall with the rise in inflation, the increase in the marginal product of capital, and the rise in the rental rate of

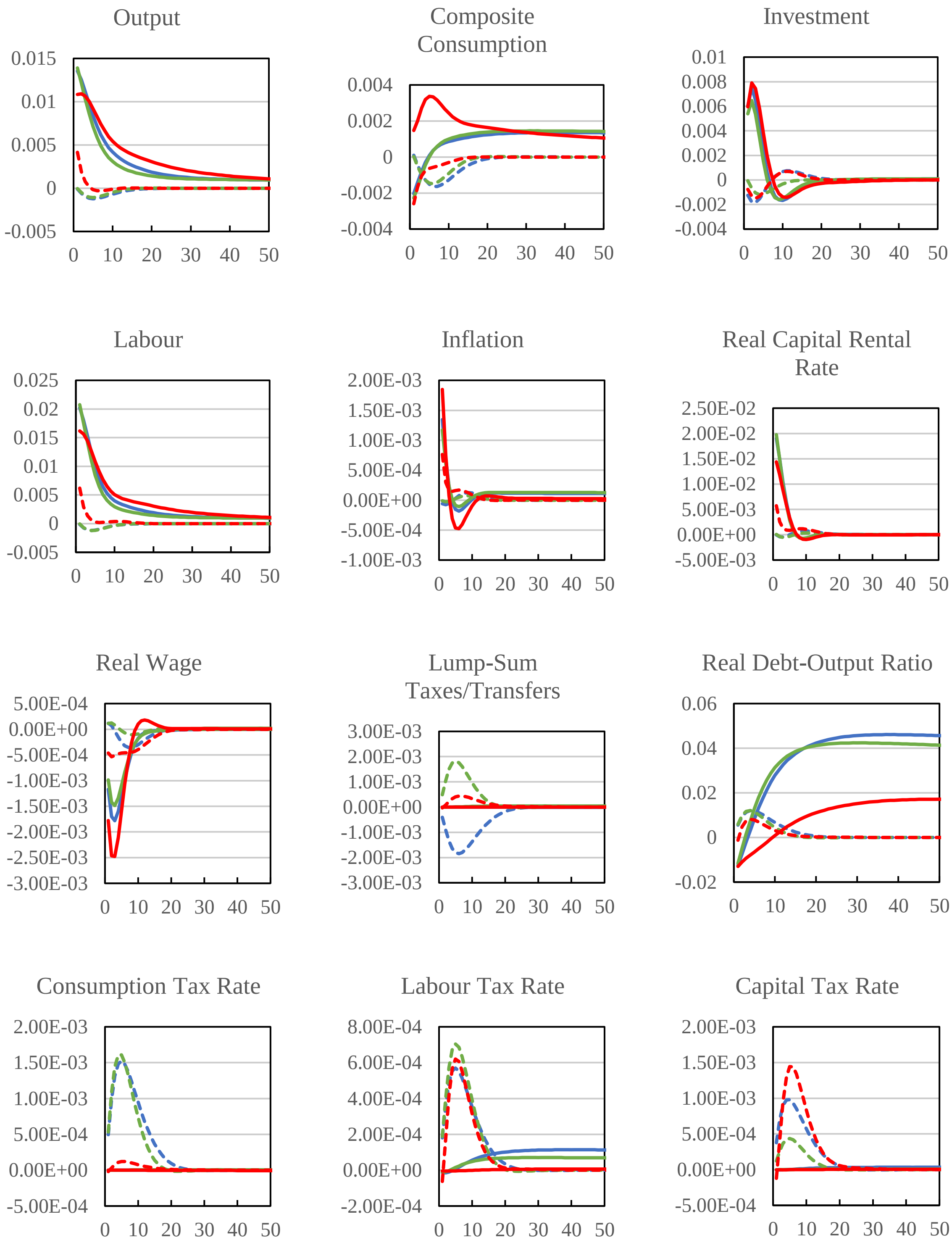

Figure 2: Impulse-responses for endogenous variables to an exogenous government spending shock. Dotted lines indicate regime M responses, and solid lines indicate regime F responses. Blue line indicates the full-sample (1976:2-2017:2) response, green line indicates the pre-Great-Recession (1976:2-2007:2) response, and the red line indicates the post-Great-Recession (2011q4-2017:2) response.

capital. Labour supply falls to meet demand as the substitution effect of decreased wages implies a lower opportunity cost of leisure $(1 - N_t)$.

In response to falling inflation and output, the nominal interest rate decreases, thereby lessening the reduction in current consumption, and quickly stabilizing inflation.

To summarize, a government spending shock, under strict debt and inflation stabilization (regime M), generates negative multipliers, and results in a swift return of the economy to equilibrium. The transmission mechanism described above can be attributed to the following parameter posterior estimates. Distortionary tax rates react to rising debt because the posterior distributions of parameters γ_C, γ_N, and γ_K are tightly centered around positive means. This implies that distortionary taxes always rise in response to an increasing debt-output ratio. As for monetary policy, the nominal interest rate's response to inflation (ϕ_π) is by a factor of 1.858 (at the mean), which is 24 percent higher than the prior mean. Furthermore, the posterior estimate of the nominal interest rate's response to output (ϕ_Y) is also strictly positive with a mean of 0.114. Estimated regime M is stricter on inflation than regime F but slightly less strict on debt than implied by the priors. The result is regime M multipliers that are negative and less persistent than in regime F.

Regime M in the Post-Great-Recession Period

While the estimation over the pre-Great-Recession period is almost identical to the full sample estimation, there are striking differences with respect to the estimation over the post-Great-Recession period. On impact, output, labour, and inflation rise as government spending increases, instead of falling like in the full sample estimation. This is in part due to lower estimated price stickiness in the post-Great-Recession period than in the full sample (with respective mean values: 0.590 and 0.620), and due to much higher estimated wages stickiness (with respective mean values: 0.707 and 0.283).

Instead of falling on impact, the real rental rate of capital rises with the marginal product of capital, thereby increasing the marginal costs of firms. Higher marginal costs in the post-Great-Recession period imply higher inflation than in the full sample because prices are less sticky, that is, a greater share of firms than in the full sample can raise their price to maintain markups. The firms who cannot raise their price, increase output.

Households increase labour supply to compensate for their compressed wage markups, hence the real aggregate wage index falls as labour supply and distortionary tax rates rise.

The fiscal financing behaviour is mostly similar between the post-Great-Recession and full sample estimations, although, consumption taxation is less utilized and lump-taxes are levied in place of transfer payments. Furthermore, the rise and fall of distortionary tax rates is gradual over the post-Great-Recession period while sharper and quicker over the full sample.

The nominal interest rate increases in response to rising inflation and output, which further decreases current consumption as in the full sample estimation.

For reference, the posterior parameter distributions for the pre-and-post-Great-Recession periods can be found in appendix C.

Regime F

As demonstrated in the multipliers section of the paper, the effects of government spending shocks differ greatly between regime M and regime F. Regime F, which combines passive monetary policy with active fiscal policy, produces larger multipliers and more persistent shock effects. In contrast to regime M, debt accumulation is tolerated in regime F. Following a government spending shock, the debt-output ratio remains approximately 4 percent above its steady state value after 25 years. Fiscal financing is mostly done through borrowing, while distortionary and lump-sum taxation are seldom used.

Unlike in regime M, the mean value of α_G is much lower at 0.127, thus composite-consumption does not gradually fall but rather jumps down immediately due to small increases in lump-sum taxes, labour taxes, capital taxes, and the nominal interest rate, which reacts to rising inflation and output. The consumption tax rate is virtually unaffected.

Due to a higher marginal product of capital, the real rental rate of capital rises by 0.02 percent on impact, which signals positive consumption growth. The positive real rental rate of capital stimulates investment, hence investment impact multipliers are positive under regime F.

Marginal costs rise due to a higher real rental rate of capital; thus, prices and output rise, in function of the degree of price stickiness.

Like in the prior predictive analysis, the larger negative wealth effects observed under regime F over regime M are not due to increased taxes but rather to larger increases in inflation and labour supply, that are particular to an environment of relatively lower price stickiness ($\theta_p = 0.712$) and extreme wage stickiness ($\theta_w = 0.950$). Since wages are very sticky, labour supply increases substantially (by 2 percent on impact) in response to lower wages.

Lastly, the nominal interest rate rises in response to rising inflation and output, though its response is relatively small when compared to its response in regime M since, $\phi_\pi =$

0.736 and $\phi_Y = 0.025$ in regime F, while $\phi_\pi = 01.858$ and $\phi_Y = 0.114$ in regime M.

Regime F in the Post-Great-Recession Period

Again, the estimates over the pre-Great-Recession period are similar to those of over the full sample period. However, there is a remarkable difference between the post-Great-Recession period and the full sample period estimations. Consumption remains persistently above steady state after a small decrease on impact, and composite-consumption exhibits exclusively positive multipliers. Both consumption and composite-consumption remain above steady state for 50 years. This can be attributed to high government spending persistence ($\rho_G = 0.924$), high tolerance for debt accumulation and extremely low taxes. The rest of the transmission mechanism in the post-Great-Recession period is similar to that of the full sample period.

An interesting footnote of the posterior analysis is, the distribution for ϕ_Y is negative over the post-Great-Recession period, which means the nominal interest rate decreases with output. This may be a reflection of the strong stimulating monetary policy that followed the Financial Crisis of 2008, where the Bank of Canada lowered the Bank Rate near zero, where it was held throughout the Canadian economy's recovery and thereafter, regardless of increases in inflation and output.

Implications for Policy Coordination

When confronted with Canadian data, my model produces larger and more persistent shock-effects when compared to the calibrated model, under both regime M and regime F. However, like in the prior predictive analysis, passive monetary policy coupled with active fiscal policy (regime F) produces the largest and most persistent multiplier effects and does not crowd out consumption or investment in any of the three sample estimations. Therefore, I conclude that, in order to maximize the multiplier effects and minimize the crowding-out effects produced by increased government spending, the optimal combination of monetary policy and fiscal policy would resemble regime F – moderate inflation-stabilization (in the neighbourhood of $\phi_\pi = 0.763$) and loosely restricted debt accumulation (in the neighbourhood of $\gamma_J = 0.001$).

However, the effectiveness of government spending can vary substantially depending on prevailing policy behaviour, and the economic environment in which the spending is made.

If fiscal rules are strict and monetary policy is historically hawkish, my model predicts that increases in government spending will affect all aspect of the economy negatively, particularly consumption, as distortionary tax rates will react strongly to the accumulation of debt and the policy nominal interest rate will react strongly to changes in inflation and output.

I observe remarkable differences between the estimations over the pre-and-post-Great-Recession periods under either regime. These differences imply that the effectiveness of government spending is, in part, dependent on the economic environment – which, for example, may be characterized by the degree of price and wage stickiness, the history of consumption and investment growth, or the reactiveness of the Bank of Canada's Bank Rate to inflation. For instance, if the nominal interest rate is historically highly reactive to inflation and output growth over a given period of time, increases in government spending may have weak or even negative multiplier effects. Another example is, if prices are particularly reactive to changes in marginal costs (low price stickiness), increased government spending will likely raise inflation, which will have negative effects on real wages and consumption, particularly if monetary policy is active.

The key differences in the Canadian economy between the pre-and-post-Great-Recession periods are represented in table 7, where, in percentage terms, columns 2 and 3 are the average quarterly growth rates of consumption and investment, respectively, and columns 4 and 5 are the average nominal interest rate (Bank Rate) and inflation rate, respectively. In brackets are the standard deviations, which are also in percentage terms.

The variables in table 7 are the ones used as observables in the Bayesian estimation, therefore, the remarkable differences in multipliers between the pre-and-post-Great-Recession estimations can be attributed to the differences in these four variables.

Sample period				Variable (quarterly %)
	cons. growth	inv. growth	int. rate	infl. rate
1976:2–2007:2 (pre-Great-Recession)	0.70	0.90	7.80	1.05
	(0.72)	(2.06)	(3.89)	(0.86)
2011:4–2017:2 (post-Great-Recession)	0.60	0.03	1.05	0.35
	(0.48)	(2.34)	(1.15)	(0.46)

Table 7: Summary of key differences between pre-and-post-Great-Recession Canada

Consumption growth, and particularly investment growth, are greater in the pre-Great-Recession period than in the post-Great-Recession period. The average Bank Rate during the pre-Great-Recession period is more than seven times that over the post-Great-Recession period, and the inflation rate is exactly three times higher in the former period over the latter period. It appears that increases in government spending are more effective when the economy is relatively depressed and when the average nominal interest rate is low, which would explain why I observe greater multipliers in the post-Great-Recession period, regardless of regime specification.

This insight is consistent with Owyang, Ramey, and Zubairy’s (2013) who find that government spending multipliers in Canada are countercyclical – output multipliers are greater in periods of high unemployment like in the aftermath of the Great Recession.

To conclude, it is important for the government of Canada to have a complete understanding of the reactiveness of the Bank of Canada to changes in inflation and output, and of prevailing macroeconomic economic trends, as both may influence the multiplier effects of large investment projects like the NIP.

6. CONCLUSION

In conclusion, this paper finds that Canadian government spending multipliers are larger and more persistent when monetary policy is passive and fiscal policy is active (regime F), rather than, when monetary policy is active and fiscal policy is passive (regime M). Over the full sample (1976:2–2017:2), and under regime M, increased government spending decreases output, crowds out private consumption and investment, and reduces labour supply. Under regime F, increased government spending increases output, consumption, investment, and labour supply.

Furthermore, I find that the characteristics of the economic environment, in which government investments are made, have strong influences on the impact and persistence of the investments. In the post-Great-Recession period (2011:4–2017:2), where economic growth is depressed relative to the pre-Great-Recession period (1976:2–2007:2), government spending multipliers are notably larger and more persistent, under either regime, particularly under regime F.

Therefore, my findings imply that the success of large investment projects in Canada like the NIP is more likely under three conditions. First, under the condition that the Bank of Canada can tolerate some above-trend inflation; second, government-debt accumulation is loosely restricted; third, the economy is in a relatively depressed state, as

Canadian multipliers may be countercyclical (Owyang, Ramey, & Zubairy, 2013). In other words, multiplier effects may be larger, in magnitude and persistence, when debt-stabilization is lenient, inflation-stabilization is moderate, and economic growth is relatively low.

While my research helps explain the general aggregate effects of Canadian government spending under different monetary-fiscal regimes and in opposing economic environments, it would be useful to apply the same methods to local economies to examine the effects of individual investments so as to construct a more complete representation of Canadian multiplier effects.

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APPENDICES

A. Equilibrium Conditions of the Log-Linearized DSGE Model

Rates are expressed in absolute deviations from steady state, while all other variables are expressed in log-deviations from steady state. Variables without time-subscripts refer to steady state values.

A.1 Household Optimality Conditions

$$\frac{C^*}{Y}\hat{C}_t^* = \frac{C}{Y}\hat{C}_t + \alpha_G \frac{G}{Y}\hat{G}_t \tag{35}$$

$$\hat{C}_{t+1}^* - \hat{C}_t^* = \frac{1}{\sigma}(\hat{\tau}_t^C - \hat{\tau}_{t+1}^C + \hat{\imath}_t - \hat{\pi}_{t+1}) \tag{36}$$

$$\begin{aligned}&(1-\delta)\hat{q}_{t+1} - \hat{q}_t \\ &= \hat{\tau}_{t+1}^C - \hat{\tau}_t^C + \sigma\left(\hat{C}_{t+1}^* - \hat{C}_t^*\right) + \hat{\tau}_{t+1}^K - (1-\tau^K)\hat{r}_{t+1}\end{aligned} \tag{37}$$

$$\hat{q}_t = \psi(\hat{I}_t - \hat{I}_{t-1} - \beta\left(\hat{I}_{t+1} - \hat{I}_t\right)) \tag{38}$$

$$\hat{K}_{t+1} = (1-\delta)\hat{K}_t + \frac{I}{Y}\hat{I}_t \tag{39}$$

$$\hat{Y}_t = \frac{C}{Y}\hat{C}_t + \frac{I}{Y}\hat{I}_t + \frac{G}{Y}\hat{G}_t \tag{40}$$

Equation 35 is the definition of composite consumption; equation 36 is the bond Euler equation (or new Keynesian IS curve); equation 37 is the capital Euler equation; equation 38 is the investment Euler equation; equation 39 is the law of motion for capital; and equation 40 is the aggregate resource constraint.

A.2 Firm Optimality Conditions

$$\hat{W}_t - \hat{r}_t = \hat{K}_t - \hat{N}_t \tag{41}$$

$$\widehat{mc}_t = (1-\alpha)\hat{w}_t + \alpha\hat{r}_t - \alpha\hat{A}_t \tag{42}$$

$$\hat{Y}_t = \hat{A}_t + \alpha \hat{K}_t + (1-\alpha)\hat{N}_t \tag{43}$$

Equation 41 represents the optimal mix of capital and labour in production; equation 42 defines real marginal costs; and equation 43 is the production function.

A.3 Price and Wage Dynamics

$$\hat{\pi}_t = \frac{(1-\theta_p)(1-\theta_p\beta)}{\theta_p}\widehat{mc}_t + \beta\hat{\pi}_{t+1} \tag{44}$$

$$\pi_t^W = \frac{(1-\theta_w)(1-\theta_w\beta)}{\theta_w(1+\epsilon_w\eta)}\left(\hat{F}_t + \frac{\hat{\tau}_t^N}{1-\tau^N} + \frac{\hat{\tau}_t^C}{1-\tau^C} + \beta\hat{\pi}_{t+1}^W\right) \tag{45}$$

$$\hat{F}_t = \hat{X}_t - \widehat{w}_t \tag{46}$$

$$\hat{X}_t = \eta\hat{N}_t + \sigma\hat{C}_t^* \tag{47}$$

$$\hat{\pi}_t^W = \widehat{w}_t - \widehat{w}_{t-1} + \hat{\pi}_t \tag{48}$$

Equation 44 is the new Keynesian Phillips curve; equation 45 is the wage Phillips curve; equation 46 is the first component of the wage Phillips curve and equations 47 is the second; equation 48 represents wage dispersion.

A.4 Monetary Policy and Government

$$\hat{\imath}_t = \rho_i\hat{\imath}_{t-1} + (1-\rho_i)(\phi_\pi\hat{\pi}_t + \phi_Y\hat{Y}_t) + \epsilon_{i,t} \tag{49}$$

$$\frac{G}{Y}\hat{G}_t + \frac{b^G}{Y}\left(\hat{\imath}_{t-1} - i\hat{\pi}_t + (1+i)\hat{b}_t^G - \hat{b}_{t+1}^G\right)$$

$$= \frac{C}{Y}\left(\hat{\tau}_t^C + \tau^C\hat{C}_t\right) + w\frac{N}{Y}\left(\hat{\tau}_t^N + \tau^N\widehat{w}_t + \tau^N\hat{N}_t\right) + \frac{K}{Y}(r\hat{\tau}_t^K \tag{50}$$

$$+ \tau^K r\hat{K}_t) + \frac{Z}{Y}\hat{Z}_t$$

$$\hat{b}_t^{GY} = \hat{b}_t^G - \hat{\pi}_t - \hat{Y}_t \tag{51}$$

Equation 49 represents the Taylor rule; equation 50 is the government's real budget constraint; and equation 51 is the definition of the real debt-output ratio.

A.5 Exogenous Processes and Fiscal Rules

$$\hat{A}_t = \rho_a \hat{A}_{t-1} + \epsilon_{a,t} \tag{52}$$

$$\hat{G}_t = \rho_G \hat{G}_{t-1} - (1 - \rho_G)\gamma_G \hat{b}_t^{GY} + \epsilon_{G,t} \tag{53}$$

$$\hat{Z}_t = \rho_Z \hat{Z}_{t-1} + (1 - \rho_Z)\gamma_Z \hat{b}_t^{GY} + \epsilon_{Z,t} \tag{54}$$

$$\hat{\tau}_t^C = \rho_C \hat{\tau}_{t-1}^C + (1 - \rho_C)\gamma_C \hat{b}_t^{GY} \tag{55}$$

$$\hat{\tau}_t^N = \rho_N \hat{\tau}_{t-1}^N + (1 - \rho_N)\gamma_N \hat{b}_t^{GY} \tag{56}$$

$$\hat{\tau}_t^K = \rho_K \hat{\tau}_{t-1}^K + (1 - \rho_K)\gamma_K \hat{b}_t^{GY} \tag{57}$$

Equations 52 describes the productivity shock process; and equations 53–47 describe the fiscal rules.

B. Data Descriptions

The following data are from the Canadian socioeconomic database from Statistics Canada (CANSIM) unless specified otherwise.

Output: is defined as expenditure-based final domestic demand (Table 380-0064).

Consumtion: is defined as household final consumption expenditure (Table 380-0064).

Investment: is defined as gross fixed capital formation (Table 380-0064).

Labour supply: is defined as total actual hours worked in all industries (Table 282-0092).

Government spending: is defined as general governments final consumption expenditure (Table 380-0064).

Government lump-sum taxes/transfers: are defined other current transfers from households (Table 380-0080).

Government debt: is defined as domestic debt (Table 378-1000)

Wage: is defined as average hourly wage rate for total employees (Table 282-0151).

Nominal interest rate: is defined as the Bank Rate (Table 176-0043).

B1. Steady State Variables

The steady-state ratios are simply the ratios of the averages of either variable, for example, $\frac{C}{Y}$ equals average consumption over average output, as they are defined above.

All data concerning steady-state tax rates are sourced from the Government of Canada website. The steady-state labour tax rate is defined as the middle-bracket federal tax rate: 26 percent. The steady-state consumption tax rate is defined as the average GST plus HST over all provinces: 11 percent. The steady-state capital gains tax rate is set to 7.5 percent, as the middle bracket capital gains tax is 15 percent but only 50 percent of capital gains are taxable.

The steady-state capital rental rate (or return on investment) is set to the average annual return of the TSX divided by four, $\tau^K = \frac{0.980}{4} = 2.27$ percent.

B2. Observables

First, I log-transform consumption and investment, while leaving the nominal interest rate and inflation unchanged. Second, I extract the long-term trend from each variable using a one-sided Hodrick-Prescott Filter. Lastly, I achieve parity between the observable data and the DSGE model's variables by expressing consumption and investment as log-deviations (percentage deviations) from their long-term trends, and the nominal interest rate and inflation as absolute deviations from their long-term trends.

C. <u>Posterior Distributions of Sub-Sample Estimations</u>

C1. Pre-Great-Recession Period

	1976:2–2007:2

Parameter	Regime M		Regime F	
	mean	90% C.I.	mean	90% C.I.
θ_w, wage stickiness	0.357	[0.241, 0.491]	0.946	[0.935, 0.954]
θ_p, price stickiness	0.656	[0.617, 0.692]	0.736	[0.703, 0.775]
α_G, substitutability of spending	0.976	[0.940, 1.010]	0.164	[0.100, 0.231]
ρ_A, technology	0.110	[0.062, 0.163]	0.167	[0.073, 0.260]
ρ_i, monetary policy	0.058	[0.006, 0.133]	0.095	[0.023, 0.160]
ρ_G, spending	0.729	[0.694, 0.775]	0.835	[0.783, 0.879]
ρ_Z, transfers	0.498	[0.440, 0.562]	0.643	[0.451, 0.828]
ρ_C, consumption	0.366	[0.366, 0.287]	0.508	[0.328, 0.708]
ρ_N, labour	0.519	[0.343, 0.668]	0.450	[0.265, 0.636]
ρ_K, capital	0.475	[0.333, 0.605]	0.511	[0.294, 0.753]
σ_A, technology	0.030	[0.022, 0.040]	0.071	[0.055, 0.090]
σ_i, monetary policy	0.017	[0.014, 0.019]	0.016	[0.014, 0.018]
σ_G, spending	0.026	[0.022, 0.029]	0.075	[0.063, 0.087]
σ_Z, transfers	14.058	[13.195, 14.840]	13.883	[9.638, 18.977]
γ_G, spending response to debt	0.318	[0.276, 0.375]	0.000	[-0.0012, 0.0012]
γ_Z, transfer response to debt	0.162	[0.085, 0.1213]	0.0012	[-0.0001, 0.0029]
γ_C, consumption tax response to debt	0.366	[0.119, 0.174]	0.0002	[-0.0011, 0.0016]
γ_N, labour tax response to debt	0.068	[0.056, 0.087]	0.0017	[0.0002, 0.0032]
γ_K, capital tax response to debt	0.042	[0.064, 0.103]	0.0002	[-0.0010, 0.0011]
ϕ_π, interest rate response to inflation	2.040	[1.785, 2.333]	0.678	[0.480, 0.827]
ϕ_Y, interest rate response to output	0.125	[0.108, 0.153]	0.0386	[0.020, 0.064]

Table 8: Posterior distributions for the period of 1976:2-2007:2 under regime M and regime F.

C2. Post-Great-Recession Period

				1976:2–2017:2
Parameter	Regime M		Regime F	
	mean	90% C.I.	mean	90% C.I.
θ_w, wage stickiness	0.707	[0.402, 0.884]	0.968	[0.952, 0.986]
θ_p, price stickiness	0.590	[0.514, 0.680]	0.582	[0.490, 0.655]
α_G, substitutability of spending	0.158	[0.100, 0.219]	0.154	[0.101, 0.221]
ρ_A, technology	0.317	[0.033, 0.545]	0.148	[0.041, 0.247]
ρ_i, monetary policy	0.244	[0.073, 0.445]	0.282	[0.149, 0.465]
ρ_G, spending	0.556	[0.381, 0.728]	0.924	[0.880, 0.976]
ρ_Z, transfers	0.752	[0.590, 0.919]	0.628	[0.348, 0.895]
ρ_C, consumption	0.472	[0.253, 0.717]	0.414	[0.222, 0.639]
ρ_N, labour	0.539	[0.350, 0.740]	0.479	[0.246, 0.683]
ρ_K, capital	0.528	[0.288, 0.728]	0.480	[0.241, 0.751]

σ_A, technology	0.022	[0.018, 0.026]	0.062	[0.053, 0.071]
σ_i, monetary policy	0.015	[0.014, 0.017]	0.042	[0.013, 0.016]
σ_G, spending	0.024	[0.021, 0.026]	0.068	[0.058, 0.077]
σ_Z, transfers	7.546	[6.981, 8.006]	6.267	[5.276, 7.088]
γ_G, spending response to debt	0.175	[0.064, 0.313]	-0.0007	[-0.0027, 0.0008]
γ_Z, transfer response to debt	0.124	[-0.053, -0.327]	0.0002	[-0.0014, 0.0018]
γ_C, consumption tax response to debt	0.010	[-0.050, 0.063]	-0.0003	[-0.0018, 0.0012]
γ_N, labour tax response to debt	0.099	[0.046, 0.171]	0.0004	[-0.0012, 0.0018]
γ_K, capital tax response to debt	0.221	[0.116, 0.310]	0.0001	[-0.0017, 0.0016]
ϕ_π, interest rate response to inflation	1.478	[1.291, 1.734]	1.035	[0.811, 1.287]
ϕ_Y, interest rate response to output	0.155	[0.060, 0.236]	-0.014	[-0.029, -0.002]

Table 9: Posterior distributions for the period of 1976:2-2017:2 under regime M and regime F.