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# Fiscal and monetary policy during the pandemic in Canada: a quantitative analysis

**Shutao Cao (Trent University)**
**Yahong Zhang (University of Windsor)**

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# Fiscal and monetary policy during the pandemic in Canada: a quantitative analysis*

Shutao Cao† Yahong Zhang ‡

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**Abstract**

We build a two-agent New Keynesian (TANK) model, augmented with the central bank balance sheet and government budget constraint, to quantify macroeconomic effects of the fiscal and monetary stimulus measures in Canada during the COVID-19 pandemic. The model is calibrated to the Canadian economy, and shock processes are estimated. The model closely replicates the observed dynamics of the economy over the pandemic period. Counterfactual experiments reveal that transfer payments played a key role in cushioning the initial contraction by supporting the consumption of hand-to-mouth (HtM) households, while forward guidance and quantitative easing strengthen these effects through the investment channel and by forestalling a severe deflationary episode. At the same time, the prolonged maintenance of low policy interest rate, in conjunction with large-scale fiscal transfers, contributed substantially to the post-pandemic surge in inflation. We show that an earlier normalization of monetary policy would have significantly reduced post-pandemic inflation at only modest cost to output, suggesting that a more gradual tightening path could have reduced the need for the aggressive interest rate increases that followed.

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†Department of Economics, Trent University, 1600 W Bank Dr, Peterborough, Ontario, Canada, K9L 0G2; E-mail: shutaocao@trentu.ca

‡Department of Economics, University of Windsor, 401 Sunset Ave., Windsor, Ontario, Canada N9B 3P4; E-mail: yzhang@uwindsor.ca.

# 1 Introduction

The COVID-19 pandemic inflicted an unprecedented shock on the Canadian economy. At the peak of the crisis in the second quarter of 2020, real GDP and household consumption each declined by more than 10 percent relative to the preceding quarter. The unemployment rate reached 14 percent in May 2020, with approximately 2.6 million Canadian workers displaced. In response, Canada deployed fiscal and monetary support measures of historic magnitude.

On the fiscal side, Canada's COVID-19 Economic Response Plan reached approximately $350 billion by July 2021, equivalent to roughly 16 percent of 2019 nominal GDP. The stimulus package included a wide range of programs supporting households and businesses. The most significant was the Canada Emergency Response Benefit (CERB), a social transfer program designed to offset pandemic-related income losses. Transfer payments from the federal government to households doubled between 2019Q4 and 2020Q2. To finance the stimulus package, the federal debt-to-GDP ratio rose sharply from 46.4 percent in 2019Q4 to 66.4 percent by 2020Q4.

On the monetary side, the Bank of Canada (BoC) moved swiftly to reduce borrowing costs and restore financial market functioning. In March 2020, the BoC lowered the policy interest rate to its effective zero lower bound. In July 2020, it introduced Extraordinary Forward Guidance (EFG), committing to maintain the policy rate at the zero lower bound (ZLB) until economic slack was eliminated and inflation returned sustainably to the 2-percent target. The EFG program remained in effect until January 2022, keeping the policy rate at the ZLB for seven consecutive quarters, from 2020Q2 through 2021Q4.

With the policy rate at the ZLB, the BoC also implemented quantitative easing (QE) for the first time in its history. QE involved large-scale purchases of Government of Canada securities and other long-term assets from financial institutions in the secondary market, financed by increases in settlement balances held by financial institutions at the BoC. The BoC introduced several asset-purchase programs, the most consequential of these programs was the Government of Canada Bond Purchase Program (GBPP). Beginning in March 2020, the BoC purchased $5 billion of government securities—primarily long-term Government of Canada bonds—on the secondary market each week beginning in March 2020.By mid-2020, the BoC's total assets had grown more than fourfold, reaching approximately $520 billion—about 20 percent of GDP.

These interventions raise important policy questions. The rapid recovery appears to validate the unprecedented scale of the stimulus. Yet Canada's inflation rate rose from 3.1 percent in June 2021 to 8.1 percent just one year later, prompting debate over whether the stimulus programs were excessively large and whether the BoC maintained the policy rate at the ZLB for too long. This paper develops a quantitative macroeconomic framework to address these questions.

Specifically, we build a two-agent New Keynesian (TANK) model, augmented with a banking-sector block à la Gertler and Karadi (2013) and the central bank's balance sheet, to study and quantify the macroeconomic effects of the fiscal and monetary policies implemented during the pandemic. In the model, a fraction of households—hand-to-mouth (HtM) households—are unable to smooth consumption through borrowing and lending. Social transfers are modeled as a reallocation of resources from Ricardian households (who have full asset-market access) to HtM households. QE is modeled following Gertler and Karadi (2013): a moral-hazard problem gives rise to financial constraints on banks, which are crucial for QE to have real effects—in their absence, QE would merely substitute public for private intermediation without affecting aggregate outcomes. Through QE, the central bank purchases long-term government bonds from commercial banks and credits them with reserves (settlement balances at the central bank), thereby relaxing banks' financial constraints and lowering borrowing costs. To capture the effects of the zero lower bound (ZLB), we employ the occasionally-binding-constraint approach developed by Guerrieri and Iacoviello (2015). Under EFG, we model the central bank as committing to maintaining the policy rate at the ZLB for a predetermined number of periods.

We calibrate the model to the Canadian economy. To capture the distinctive nature of pandemic-related disruptions—the simultaneous decline in consumption and labor supply induced by lockdown restrictions, and the rise in financial risk premia driven by heightened uncertainty—we introduce three structural shocks: (i) a forced-saving shock that compresses consumption for both household types; (ii) a labor-disutility shock that reduces labor supply; and (iii) a credit-risk shock that raises the risk premium on bank lending. We use impulse response functions to illustrate qualitatively the mechanisms through which each fiscal and monetary policy instrument operates under these shocks.

We find that although transfers represent a reallocation of resources from Ricardian households to HtM households, they mitigate the sharp declines in output and aggregate consumption because HtM households have a higher propensity to consume. This effect, in turn, reduces deflationary pressures. We also find that QE helps cushion the declines in output and consumption. Unlike fiscal transfers, which further depress investment, QE boosts investment by lowering borrowing costs. The stimulative effects are substantially larger when transfers and QE are implemented jointly. Finally, EFG provides additional stimulus. By keeping the policy rate at the ZLB for a longer period, EFG generates a much larger increase in inflation. As a result, when fiscal stimulus is combined with QE and EFG, the real value of government debt declines.

To quantify effects of policy, we estimate shock profiles for a broad set of disturbances—including pandemic-related shocks (forced saving, labor disutility, and credit risk), policy shocks (transfer payments, QE, and forward guidance), and standard structural shocks (total factor productivity and government spending)—using a two-step procedure that combines time-series estimation with the simulated method of moments. Structural parameters are held fixed at calibrated values. The estimated model closely replicates the observed dynamics of output, consumption, investment, labor input, inflation, and the policy interest rate over the pandemic episode.

Using the estimated model as the baseline, we conduct a series of counterfactual experiments to quantify the contribution of each policy instrument. We find that transfer payments were central to cushioning the 2020 contraction: by directing resources toward HtM households with high marginal propensities to consume, transfers significantly raised real GDP and prevented a severe deflationary episode. Absent the pandemic-era increase in transfers, real GDP in 2020Q2 would have been approximately 2.5 percentage points lower, and the price level would have fallen by more than 8 percent.

Monetary policy accommodation through forward guidance and QE amplified the stabilizing effects of fiscal policy. Forward guidance that kept policy interest rate low raised real GDP by an average of approximately 0.7 percentage points over 2020–2021, primarily through the investment channel. These effects were persistent: elevated output and inflation continued beyond the period during which the rate was held at zero. QE generated qualitatively similar but quantitatively smaller effects, reflecting the more gradual buildup of the central bank's balance sheet.

The maintenance of the policy rate at the ZLB throughout 2021 contributed materially to the post-pandemic inflation surge. If forward guidance were terminated in 2021Q3, inflation would be about 0.71 percentage points lower in that quarter and lower thereafter, with only modest adverse effects on output and welfare. This result suggests that a more gradual and earlier monetary policy tightening could have reduced the need for the aggressive interest rate increases that were subsequently required to bring inflation under control.

**Related literature** Our paper contributes to the literature on how the interaction of monetary and fiscal policy affects price and debt levels. Seminal early works in this field include Leeper (1991), Sims (1994), Woodford (1994), among others. More recently, a number of contributions have analyzed this interaction in the context of the Covid-19 crisis, such as Cochrane (2022), Leeper and Zhou (2021), Bianchi et al. (2020), and Bhattarai et al. (2023). Among these recent papers, Bianchi et al. (2020) focus on the role of unfunded fiscal shocks in inflation and debt dynamics. They estimate a TANK model and find that fiscal trend inflation plays a major role in explaining inflation dynamics. Bhattarai et al. (2023) also uses a TANK model to study the monetary and fiscal policy mix, examining both a monetary regime—where taxes rise to finance transfers—and a fiscal regime—where inflation rises to reduce the government's debt burden. They find that the fiscal regime generates larger and more persistent inflation than the monetary regime. Similarly, our paper employs a TANK model to study the interaction of monetary and fiscal policies during the pandemic. However, a key feature that distinguishes our work from the above-mentioned is the inclusion of QE, a unique and central component of Canada's monetary policy response during this period.

Regarding the interaction of QE and fiscal policy, our paper is directly linked to recent contributions that study unconventional monetary policy and fiscal policy, such as Elenev et al. (2022), Dimakopoulou et al. (2024), Kurovskiy et al. (2022), and Wu and Xie (2025). Elenev et al. (2022) use a New Keynesian model to analyze a rich set of fiscal and monetary policy tools. They find that QE can stimulate higher output, consumption, and investment, ultimately leading to a smaller rise in the debt-to-GDP ratio. Dimakopoulou et al. (2024) examine whether a central bank can stabilize government debt using QE within a representative agent framework. Wu and Xie (2025) develop a tractable New Keynesian model to study four types of monetary and fiscal policies. They show that QE and tax-financed transfers or government spending have similar stimulative effects on the aggregate economy. Our paper is most closely related to Kurovskiy et al. (2022), who integrate the QE framework of Gertler and Karadi (2013) into a TANK model to analyze different types of monetary and fiscal interactions following a large rise in government debt. They show that a QE rule can help stabilize debt without requiring tax increases. Similarly, we incorporate the Gertler and Karadi (2013) framework into a TANK model to analyze monetary and fiscal interactions. The key distinction of our work from Kurovskiy et al. (2022) is its focus on quantifying the effects of the specific monetary and fiscal stimulus measures implemented during the pandemic, including QE, social transfers, and wage subsidies.

Moreover, our paper contributes to the literature exploring the effects of fiscal and monetary programs on the Canadian economy during the pandemic. Fortin (2022) provides a detailed description of the quantitative easing (QE) policy implemented by the Bank of Canada. Koeppl et al. (2024) use the local projections method to estimate the effects of both conventional interest rate policy and unconventional QE policy. Azad et al. (2021) use a structural VAR model to investigate fiscal and monetary policy interactions in Canada for both financial crisis period and COVID-19 period. While the aforementioned papers are primarily descriptive or empirical, our paper's contribution is to provide a quantitative assessment of these pandemic-era fiscal and monetary policies within a unified macroeconomic framework.

The remainder of the paper is organized as follows. Section 2 documents the macroeconomic and policy background. Section 3 presents the model. Section 4 analyzes the transmission mechanisms of fiscal and monetary policy through impulse response functions. Section 5 contains the main quantitative results, including the estimation of shocks and counterfactual policy experiments. Section 6 concludes.

# 2 Macroeconomic policy over the Covid-19 pandemic

## 2.1 Fiscal policy

Government of Canada acted promptly in response to the outbreak of pandemic. From 2020Q2, a broad range of support programs were introduced to support households and businesses. In particular, support measures aimed at individuals included the Canada Emergency Response Benefit (CERB), which provided support to workers who lost their jobs due to COVID-19; the Canada Emergency Student Benefit (CESB) for students; and additional income support programs for families with children, seniors, and vulnerable populations. For businesses, key programs included the Canada Emergency Wage Subsidies (CEWS) and other related programs. Those programs were designed to help employers retain workers and manage operating costs.

As a result of those support programs, transfers payments to households from the federal government increased from 859.6 billion dollars (in 2002 prices, annualized) in 2019q4 to 2,532.5 billion dollars in 2020Q3, a 1.9 times increase (see Figure 1), and it fell back to the pre-pandemic value by 2022q1. Subsidies to businesses also increased substantially, although subsidies are at a much smaller scale relative to transfer payments to households.

Covid-19 reliefs to households and businesses were financed by increased government borrowing. Figure 2 shows that the Government of Canada debt to GDP ratio was 46.4 percent in 2019Q4, and rose to 66.4 percent in 2020Q4. This debt to GDP ratio declined in 2021 and 2022, but was still about 10 percentage points higher than the pre-pandemic level. The general government debt to GDP ratio displayed a similar pattern of changes.

## 2.2 Monetary policy

Bank of Canada (BoC) also rushed to initiate aggressive expansionary policy as the pandemic started. The policy interest rate (target for the overnight rate) was cut to 0.25 percent in March 2020, the effective zero lower bound. In July 2020, the BoC introduced extraordinary forward guidance (EFG) by signaling the policy rate would stay at the ZLB for an extended period until the economic slack is absorbed and inflation returns to the 2 percent target. The EFG program was ended in January 2022. Overall, the policy rate had been remained at ZLB until January 2022, as documented in Figure 3. The pre-pandemic policy interest rate was stable at 1.75 percent. As the pandemic was ending, the central bank started to raise the policy interest rate in February 2022 to control heightened inflation. Policy interest rate reached 5 percent in the second half of 2023.

Along with cutting the policy interest rate, for the first time the BoC implemented QE by introducing a number of asset purchasing programs to lower long-term interest rate and support financial market functioning. These programs involved acquisition of a range of assets, including long-term Government of Canada bonds, corporate bonds, mortgage bonds, commercial paper, and provincial bonds. The objective was to boost asset prices, therefore lowering borrowing costs for households and businesses.[1] Among the programs, the most important one is Government of Canada

[1] During the pandemic, the Bank of Canada established the following seven asset purchase programs: Bankers' Acceptance Purchase Facility (BAPF), Canada Mortgage Bond Purchase Program (CMBP), Corporate Bond Purchase Program (CBPP), Commercial Paper Purchase Program (CPPP), Government of Canada Bond Purchase Program (GBPP), Provincial Bond Purchase Program (PBPP), and Provincial Money Market Purchase Program (PMMP).

Bond Purchase Program (GBPP). Beginning in March 2020, the BoC purchased \$5 billion of government securities—primarily long-term Government of Canada bonds—on the secondary market each week. During the first two quarters of 2020, the BoC's assets increased more than fourfold; reaching approximately \$520 billion which was about 20 percent of GDP. The expansion of total asset of the central bank arose first from mainly short-term government bonds, but was quickly through increased purchases of longer-term government bonds and repos. Figure 4 shows the share of government bonds of over 3 years in total asset, first declined in early 2020, then rose to 44.5% by 2021Q4. The decline of the share of long-term government bonds in early 2020 was associated with the extended term repo facility program in which BoC purchased repos in March and April 2020. The amount of long-term government bonds that the BoC purchased has been rising since the start of the pandemic.

The increased holdings of long-term government bonds were financed by reserve creation. Deposits of banks at the central bank (reserves) were less than 0.4 billion Canadian dollars in 2019Q4. By 2021Q1, reserves spiked to a peak value at 372.2 billion, or 66 percent of total asset of the central bank. Reserves-to-asset ratio has been gradually declining since 2021Q1, and was still substantially above the pre-pandemic level by the end of 2024, as can be seen from Figure 4.

## 2.3 Inflation and GDP

The impact of the pandemic is deep and prolonged. The CPI declined briefly at the start of the pandemic, and quickly picked up in 2021. By January 2022, when the policy interest rate was still at the effective zero lower bound, the 12-month CPI inflation rate reached 5 percent. Despite the central bank's contractionary policy acts in 2022, inflation rate climbed to 8 percent in June 2022 before it started to fall (see Figure 3).

Real GDP plummeted 12 percent in 2020q2 from its trend, and was below the trend in 2020 and 2021. The recovery of real GDP has been moderate. After growths in 2022 and 2023, real GDP declined again in 2024. Both household consumption and business investment experienced a sharper decline in 2020 than real GDP (see Figure 5).

# 3 The model

In this section, we describe the model, which incorporates financial frictions as in Gertler and Karadi (2013) into a standard Two-Agent New Keynesian (TANK) framework. The economy consists of households, firms (wholesale and retail), banks, a central bank, and a fiscal authority.

The model features two types of households: Ricardian households, who optimize intertemporally and can freely borrow and save, and Hand-to-Mouth (HtM) households, who cannot borrow nor save, simply consume all their disposable income (labour income plus government transfers). Both types supply labour to wholesale firms. These firms combine labour and capital to produce intermediate goods. To acquire capital, firms must borrow from banks by issuing capital claims.

Banks' assets consist of these capital claims, long-term government bonds issued by the fiscal authority, and reserves issued by the central bank. The central bank sets the policy rate according to a Taylor rule and can implement unconventional monetary policies by purchasing assets (such as government bonds or capital claims) from commercial banks. The fiscal authority collects taxes from Ricardian households and issues long-term government bonds to finance government spending and transfers to HtM households.

Given our focus on the interaction between fiscal and monetary policy during the pandemic, we will describe the model features related to these policies—the household sector, banking sector, central bank, and fiscal authority—in detail. The more standard components, primarily the firm sector, are detailed in the Appendix.

## 3.1 Households

There are two types of households. Let the share of Hand-to-Mouth (HtM) households be $\omega$, implying the share of Ricardian households is $(1-\omega)$. Ricardian households save by holding bank deposits and pay taxes. HtM households receive transfers from the government. These transfers represent a redistribution of wealth from Ricardian to HtM households.

### 3.1.1 Ricardian households

The household maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^R, l_t^R). \tag{1}$$

where

$$u(c_t^R, l_t^R) = \frac{((c_t^R - \varepsilon_t^{fs}) - h(c_{t-1}^R - \varepsilon_{t-1}^{fs}))^{1-\sigma^c}}{1-\sigma^c} - \chi^R \exp(\varepsilon_t^{l^R}) \frac{(l_t^R)^{1+\varphi}}{1+\varphi}, \tag{2}$$

where $c_t^R$ is consumption, $l_t^R$ is the labour supply, $\sigma^c$ is the coefficient of relative risk aversion, $\varphi$ is the inverse of the Frisch elasticity, $\varepsilon_t^{fs}$ is the forced saving shock,[2] and $\varepsilon_t^{l^R}$ is the shock to labour disutility. Both shocks follow an AR(1) process:

$$\varepsilon_t^{fs} = \rho^{fs}\varepsilon_{t-1}^{fs} + \zeta_t^{fs}, \zeta_t^{fs} \sim i.i.d.\, N(0, \sigma^2_{\zeta^{fs}}),$$

and

$$\varepsilon_t^{l^R} = \rho_1^{l^R}\varepsilon_{t-1}^{l^R} + \zeta_t^{l^R}, \zeta_t^{l^R} \sim i.i.d.\, N(0, \sigma^2_{\zeta^{l^R}}),$$

Each period, the households are subject to the following budget constraint,

$$P_t c_t^R + D_t^R = R_{t-1}^d D_{t-1}^R + (1-\tau^{l^R}) P_t w_t^R l_t^R + P_t \Psi_t - P_t \tau_t^R, \tag{3}$$

where $P_t$ is the price level for consumption goods, $D_t^R$ is the nominal deposits at banks, $R_{t-1}^d$ is the gross return of deposits from $t-1$ to $t$, which is known at $t$, $w_t^R$ is the real wage, $\tau^{l^R}$ is the labour income tax rate. $\Psi_t$ is the real profits from firms and banks (Ricardian households own both of them), and $\tau_t^R$ is the real lump-sum tax.

Define inflation $\pi_t = \frac{P_t}{P_{t-1}}$, and the budget constraint in real terms is

$$c_t^R + d_t^R = R_{t-1}^d \frac{d_{t-1}^R}{\pi_t} + (1-\tau^{l^R}) w_t^R l_t^R + \Psi_t - \tau_t^R. \tag{4}$$

The first-order conditions are as follows.

[2]Following Cardani et al. (2022), we use the forced-savings shock, denoted by $\varepsilon_t^{fs}$, to represent the impact of the pandemic on consumption. We assume $\varepsilon_t^{fs} = 0$ prior to the COVID-19 pandemic, with a negative value reflecting a reduction in consumption demand. A forced-savings shock differs from a standard consumption demand shock. For a standard demand shock, habit persistence generates a hump-shaped consumption response, causing the effects to persist even after the shock vanishes. In contrast, the impact of a forced-savings shock on consumption dissipates as soon as the shock itself ends. Therefore, once the pandemic ended, consumption was expected to return immediately to its pre-shock level. This feature makes the forced-savings shock more suitable for capturing the transitory nature of the pandemic.

$c_t^R$ :

$$\left((c_t^R - \varepsilon_t^{fs}) - h(c_{t-1}^R - \varepsilon_{t-1}^{fs})\right)^{-\sigma^c} - \beta h \mathrm{E}_t \left((c_{t+1}^R - \varepsilon_{t+1}^{fs}) - h(c_t^R - \varepsilon_t^{fs})\right)^{-\sigma^c} = \lambda_t^R, \tag{5}$$

where $\lambda_t^R$ is the Lagrange multiplier.

$d_t$:

$$\lambda_t^R = \beta \mathrm{E}_t \lambda_{t+1}^R \frac{R_t^d}{\pi_{t+1}}. \tag{6}$$

$l_t^R$ :

$$u_l'(c_t^R, l_t^R) + \lambda_t^R (1 - \tau^{l^R}) w_t^R = 0, \tag{7}$$

where $u_l'(c_t^R, l_t^R) = -\chi^R \exp(\varepsilon_t^{l^R})(l_t^R)^{\varphi}$.

### 3.1.2 Hand-to-Mouth households

The HtM households consume $c_t^H$, and supply labour $l_t^H$, also are subject to a forced saving shock $\varepsilon_t^{fs}$ and labour disutility shock $\varepsilon_t^{l^H}$. The utility function is given by

$$u(c_t^H, l_t^H) = \frac{(c_t^H - \varepsilon_t^{fs})^{1-\sigma^c}}{1-\sigma^c} - \chi^H \exp(\varepsilon_t^{l^H}) \frac{(l_t^H)^{1+\varphi}}{1+\varphi}, \tag{8}$$

where

$$\varepsilon_t^{l^H} = \rho_1^{l^H} \varepsilon_{t-1}^{l^H} + \zeta_t^{l^H}, \zeta_t^{l^H} \sim i.i.d.\, N(0, \sigma_{\zeta^{l^H}}^2).$$

The HtM households do not have access to borrowing and saving, and they do not pay labour income tax either. The budget constraint is as follows.

$$c_t^H = w_t^H l_t^H + tr_t^H, \tag{9}$$

where $w_t^H l_t^H$ is labour income and $tr_t^H$ is government transfers. The first-order condition for consumption $c_t^H$ is

$$(c_t^H - \varepsilon_t^{fs})^{-\sigma^c} = \lambda_t^H, \tag{10}$$

where $\lambda_t^H$ is the Lagrange multiplier.And the first-order necessary condition for labor supply is

$$\chi^H \exp(\varepsilon_t^{l^H})(l_t^H)^{\varphi} = \lambda_t^H w_t^H. \tag{11}$$

## 3.2 Banks

During the pandemic, a key component of the Bank of Canada's (BoC) quantitative easing (QE) operations involved purchasing long-term government bonds from commercial banks. These purchases were conducted by crediting banks' settlement balance accounts held at the BoC.

We model the banking sector following the approach of Gertler and Karadi (2013), which incorporates a moral hazard problem that makes banks financially constrained. This friction is amplified during a crisis. These constraints are essential for QE to affect banks' lending spreads; otherwise, QE would merely substitute private intermediation with public intermediation without reducing borrowing costs. By relaxing these financial constraints, QE results in lower borrowing spreads from the banking sector.

Before detailing the banks' problem, we first briefly describe the modeling of long-term government bonds.

### 3.2.1 Long-term government bonds

To model the long-term government debt, we follow Woodford (2001) and Sims and Wu (2021) to treat it as a perpetual bond with a decreasing coupon payment. In this way, we can track the long-term bond as one-period bond. To be specific, for one dollar of issuance of such long-term bonds at time $t$, the coupon payment at $t+1$ would be one dollar, and at $t+2$ would be $\kappa$ dollar, where $0 < \kappa < 1$, and at $t+3$ would be $\kappa^2$ dollar, and so on. Assuming the market price of the long-term bonds issued at time $t$ is $q_t^b$, with this decaying structure, bonds issued in $t-1$ would be $\kappa q_t^b$, and bonds issued at $t-2$ would be $\kappa^2 q_t^b$ and so on. The return of the long-term bonds from $t$ to $t+1$, $R_{b,t}$, thus can be expressed as

$$R_{b,t} = E_t \frac{1 + \kappa q_t^b}{q_{t-1}^b}, \tag{12}$$

where $q_{t-1}^b$ is the purchase price at $t-1$,the numerator is the sum of the coupon payment and the market price for the bonds issued at $t-1$, and $\kappa$ is the decay parameter for the long term bond. The value of $\kappa$ will be calibrated later to match the length of the maturity of the long-term bonds.

#### 3.2.2 Banks' problem

There are a continuum of measure 1 of banks. We assume that in each period, a fraction of $\sigma$ of banks survived and $1-\sigma$ of banks exit, replaced by new banks. The purpose of making such an assumption is to prevent the banks from accumulating enough funds to self-finance. In what follows, we first describe the problem for an individual bank and then describe the banking sector's problem at the aggregate level.

For a typical bank $j$, the optimization problem is as follows. At the beginning of period $t$, bank $j$ needs to decide how much to lend to firms and government by using nominal deposits from Ricardian households $D^b_{jt}$, where $\int D^b_{jt}dj = D^b_t = (1-\omega)D^R_t$, and its own net worth $N_{jt}$ (in nominal term). This means that the bank needs to decide how much capital claims and long-term government bonds to purchase. Since the central bank can also hold those assets, we use $s^{k,b}_t$, and $B^b_t$ for the capital claims and bonds held by the banks and $s^{k,cb}_t$ and $B^{cb}_t$ for the ones held by the central bank. Banks also hold reserves, which is the settlement balances at the central bank, $RE_t$. The flow of funds condition is

$$q^b_t B^b_{jt} + P_t q^k_t s^{k,b}_{jt} + RE_{jt} = N_{jt} + D^b_{jt}, \tag{13}$$

where $q^b_t$ is the market price of bonds. Writing equation (13) in real terms, we have

$$q^b_t b^b_{jt} + q^k_t s^{k,b}_{jt} + re_{jt} = n_{jt} + d^b_{jt}, \tag{14}$$

where $b^b_{jt} = \frac{B^b_{jt}}{P_t}$, $re_{jt} = \frac{RE_{jt}}{P_t}$, and $n_{jt} = \frac{N_{jt}}{P_t}$. Net worth is accumulated by retained earnings – the difference between the returns of the assets and the costs of deposits. Thus, at the beginning of $t+1$ (the end of period $t$), the net worth for bank $j$ can be expressed as

$$N_{jt+1} = R_{b,t+1} q^b_t B^b_{jt} + R_{k,t+1} q^k_t P_t s^{k,b}_{jt} + R^{re}_t RE_{jt} - R^d_t D^b_{jt}. \tag{15}$$

Note that both $R_{b,t+1}$ and $R_{k,t+1}$ are not known in the beginning of period $t$; while $R^{re}_t$ and $R^d_t$ are known. Substitute equation (13) into equation (15), we have the law of motion for net worth

$$N_{jt+1} = (R_{b,t+1} - R_t^d) q_t^b B_t^b + (R_{k,t+1} - R_t^d) q_t^k P_t s_t^{k,b} + (R_t^{re} - R_t^d) RE_{jt} + R_t^d N_{jt}. \tag{16}$$

Equation (16) shows that the growth of net worth relies on the excess return of assets held by banks. Writing equation (16) in real terms, we have

$$n_{jt+1} = (R_{b,t+1} - R_t^d) \frac{q_t^b b_{jt}^b}{\pi_{t+1}} + (R_{k,t+1} - R_t^d) \frac{q_t^k s_{jt}^{k,b}}{\pi_{t+1}} + (R_t^{re} - R_t^d) \frac{re_{jt}}{\pi_{t+1}} + R_t^d \frac{n_{jt}}{\pi_{t+1}}. \tag{17}$$

Since banks only pay dividends after they exit, the objective of the bank is to maximize the discounted value of future net worth $n_{jt}$:

$$\max E_t \sum_{i=1}^{\infty} (1-\sigma) \sigma^{i-1} \Delta_{t,t+i} n_{jt+i}, \tag{18}$$

where $\Delta_{t,t+i} \equiv \beta^i \lambda_{t+i}^R / \lambda_t^R$ is the stochastic discount factor since we assume that the banks are owned by the Ricardian households. Writing Equation (18) recursively, we have

$$V_{jt} = \max E_t \Delta_{t,t+1} \left[ (1-\sigma) n_{jt+1} + \sigma V_{jt+1} \right]. \tag{19}$$

To introduce financial frictions, we assume that bankers have the incentive to divert funds at the end of each period. The fraction of the funds can be diverted is different across the different type of assets held by the banks. Denote the diversion rates for capital claims, government bonds and reserves as $\kappa_t^K$, $\kappa_t^B$, and $\kappa_t^{RE}$. Following Gertler and Karadi (2013) we further assume that $\kappa_t^K > \kappa_t^B > \kappa_t^{RE}$ – it is easier for bankers to divert funds from their holdings of private capital claims than from their holding of government bonds and reserves, with diverting funds from reserves being the most unlikely. Given the diversion risks, for depositors to be willing to deposit funds at banks, the following incentive constraint needs to hold

$$V_{jt} \geq \kappa_t^K q_t^k s_{jt}^{k,b} + \kappa_t^B q_t^b b_{jt}^b + \kappa_t^{RE} re_{jt}. \tag{20}$$

Equation (20) is the key equation to understand the role of QE – QE relaxes the incentive constraint.

This is because when conducting QE, the central bank purchases either private assets $s^{k,b}_{jt}$ or long-term government bonds $b^b_{jt}$ from bank $j$ and in return the central bank credit the banks with reserves. Given the diversion rates difference, QE lowers the value of the right-hand of the Equation (20). As a result, the incentive constraint is less likely to bind. And because of this, bank $j$ can attract more deposits, improve the balance-sheet position and charge borrowers at a lower rate.

Bank $j$'s problem is to choose $s^{k,b}_{jt}$, $B^b_{jt}$ and $RE_{jt}$ to maximize the discounted value of net worth equation (19), subject to the flow of funds condition equation (14), the law of motion for net worth equation (17), and the incentive constraint equation (20).

Denote $\Delta^B = \frac{\kappa^B_t}{\kappa^K_t}$ and $\Delta^{RE} = \frac{\kappa^{RE}_t}{\kappa^K_t}$ and define bank's leverage as

$$\phi_t = \frac{q^k_t s^{k,b}_{jt} + \Delta^b q^b_t b^b_{jt} + \Delta^{re} re_{jt}}{n_{jt}} = \frac{a^{adj}_{tj}}{n_{jt}},$$

where $a^{adj}_{tj} = q^k_t s^{k,b}_{jt} + \Delta^b q^b_t b^b_{jt} + \Delta^{re} re_{jt}$ is the assets adjusted by diversion rates. Later on, we assume that $\Delta^{RE} = 0$, and $\phi_t = \frac{q^k_t s^{k,b}_{jt} + \Delta^b q^b_t b^b_{jt}}{n_{jt}}$. To solve the problem, following Gertler and Kiyotaki (2010), we use the undetermined coefficients method (see derivation details in the Appendix) – we guess that the bank's value function is a linear function of net worth

$$V_{jt} = \mu_{n,t} n_{jt}, \tag{21}$$

where $\mu_{n,t}$ can be thought of as the expected discounted marginal gain of having one more unit of net worth. The first-order condition with respect to $s^{k,b}_{jt}$ gives

$$E_t \Delta_{t,t+1}[((1-\sigma) + \sigma\mu_{n,t+1})\frac{(R_{k,t+1} - R^d_t)}{\pi_{t+1}}] = \lambda_{bank}\kappa^K_t, \tag{22}$$

where $\lambda_{bank}$ is the multiplier on the incentive constraint. Note that $R^d_t$ is known at time $t$, while $R_{k,t+1}$ is not known since $R_{k,t+1} = \frac{mpk_{t+1} + (1-\delta)q^k_{t+1}}{q^k_t}$. The first order condition with respect to $B^b_t$ is

$$E_t \Delta_{t,t+1}[((1-\sigma) + \sigma\mu_{n,t+1})\frac{R_{b,t+1} - R^d_t}{\pi_{t+1}}] = \lambda_{bank}\kappa^K_t \Delta^B. \tag{23}$$

Similarly, the first order condition with respect to $re_{jt}$ is

$$E_t\Delta_{t,t+1}[((1-\sigma)+\sigma\mu_{n,t+1})\frac{R_{t+1}^{RE}-R_t^d}{\pi_{t+1}}]=\lambda_{bank}\kappa_t^K\Delta^{RE}. \tag{24}$$

Given the above equations and the definition of $\phi_t$, we can rewrite equation (17) as

$$n_{jt+1}=\{\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}\phi_t+\frac{R_t^d}{\pi_{t+1}}\}n_{jt}. \tag{25}$$

To capture the rise in credit risk during the pandemic, we further assume that $\kappa_t^K=\kappa^K\exp(\varepsilon_t^\kappa)$, where $\varepsilon_t^\kappa$ is the credit risk shock, following an AR(1) process:

$$\varepsilon_t^\kappa=\rho_1^\kappa\varepsilon_{t-1}^\kappa+\zeta_t^\kappa,\zeta_t^\kappa\sim i.i.d.\,N(0,\sigma_{\zeta^\kappa}^2).$$

#### 3.2.3 Aggregation in the banking sector

Given that the leverage ratio $\phi_t$ is independent of individual bank-specific factors, if all existing banks survived, the law of motion of aggregate net worth would be:

$$n_{t+1}=\int n_{jt+1}dj=\{(R_{t+1}^A-R_t^d)\phi_t+R_t^d\}n_t$$

where $R_{t+1}^A=R_{b,t+1}\frac{q_t^bb_t^b}{q_t^bb_t^b+q_t^ks_t^{k,b}+re_t}+R_{k,t+1}\frac{q_t^ks_t^{k,b}}{q_t^bb_t^b+q_t^ks_t^{k,b}+re_t}+R_t^{re}\frac{re_t}{q_t^bb_t^b+q_t^ks_t^{k,b}+re_t}$. Also, $\int(q_t^bb_{jt}^b+q_t^ks_{jt}^{k,b}+re_{jt})dj=\int(n_{jt}+d_{jt}^R)dj$ gives us

$$q_t^bb_t^b+q_t^ks_t^{k,b}+re_t=n_t+d_t^R.$$

Aggregating also gives us

$$\phi_t=\frac{q_t^ks_t^{k,b}+\Delta^bq_t^bb_t^b+\Delta^{re}re_t}{n_t}.$$

With the assumption of $\Delta^{RE}=0$, we have $\phi_t=\frac{q_t^ks_t^{k,b}+\Delta^bq_t^bb_t^b}{n_t}$, and $a_t^{adj}=\int a_{tj}^{adj}dj=q_t^ks_t^{k,b}+\Delta^bq_t^bb_t^b$.

However, given that only a fraction $\sigma$ of the banks survive, at the aggregate level, the total net worth consists $n_{t+1}^e$, the net worth for the surviving banks (existing banks), and $n_{t+1}^n$,the net worth for the newly entered banks:

$$n_{t+1} = n^e_{t+1} + n^n_{t+1} = \sigma[(R^A_{t+1} - R^d_t)\phi_t + R^d_t]n_t + n^n_{t+1},$$

Following Gertler and Karadi (2011), we assume that the patient households receive the wealth of the exiting banks and transfer a small fraction $\omega^b$ of the received wealth as "start up" funds to the newly-entered banks.[3] That is $n^n_{t+1} = \omega^b a^{adj}_t$.

## 3.3 Central bank: interest rate rule and unconventional monetary policy

### 3.3.1 Interest rate rule

In normal time, the central bank implements a simple Taylor rule:

$$\frac{R^n_t}{R^n_{ss}} = (\frac{R^n_{t-1}}{R^n_{ss}})^{\rho^r}((\frac{\pi_t}{\pi_{ss}})^{\rho^\pi}(\frac{y_t}{y_{t-1}})^{\rho^y})^{1-\rho^r}e^{\zeta^m_t}. \tag{26}$$

That is, the central bank adjusts the nominal interest rate $R^n_t$ in response to deviations of inflation $\pi_t$ from its steady-state value $\pi_{ss}$ and output $y_t$ from its previous quarter $y_{t-1}$. $\zeta^m_t$ is a monetary policy shock that follows $\zeta^m_t \sim i.i.d.\ N(0, \sigma^2_{\zeta^m})$. In addition, $\rho_\pi$, $\rho_y$ and $\rho_r$ are policy coefficients chosen by the central bank. In addition, the nominal interest rate is subject to the ZLB constraint:

$$R^n_t = \max\{1, R^n_t\}$$

Note that we also assume that

$$R^n_t = R^d_t = R^{re}_t.$$

### 3.3.2 Unconventional policy: quantitative easing and forward guidance

While during the Pandemic, in addition to adjusting the nominal interest rate, the central bank uses QE and EFG to further stimulate the economy. In the interest of parsimony, we assume that the central bank's liability includes only reserve $RE_t$ (including bank note to the model would not change

[3] $\omega$ is set in order to have a stationary aggregate net worth for the banking sector. In the calibration, it is a very small number, 0.0013.

Table 1: Central Bank's Balance Sheet

| Assets | Liabilities |
|---|---|
| Government bond $b_t^{cb}$ | Settlement account (reserves) $re_t$ |
| Financial assets $s_t^{k,cb}$ | |

the main message because during the pandemic there was no significant change in banknote).[4] Assets held by the central bank include government bonds $b_t^{cb}$ and other financial assets $s_t^{k,cb}$. The balance sheet of the central bank (CB) is as follows.

**QE.** We model QE as that the central bank purchase the government bonds and other financial assets from commercial banks by creating settlement balances (reserves). As stated in the previous section, since the banks are financially constrained, QE relaxes banks' incentive constraint.

$$q_t^k s_t^{k,cb} + q_t^b b_t^{cb} = re_t, \tag{27}$$

with

$$s_t^{k,cb} = \varphi_t^k s_t$$

and

$$b_t^{cb} = \varphi_t^b b_t,$$

where $\varphi_t^k$ and $\varphi_t^b$ are the fractions of capital claims and long-term government bonds purchased by the central bank.

We assumed $\varphi_t^k$ and $\varphi_t^b$ follow AR(1) processes below:

$$\varphi_t^k = \rho^{\varphi,k}\varphi_{t-1}^k + \zeta_t^{\varphi,k}, \zeta_t^{\varphi,k} \sim i.i.d.\, N(0, \sigma^2_{\zeta^{\varphi,k}}),$$

and

$$\varphi_t^b = \rho^{\varphi,b}\varphi_{t-1}^b + \zeta_t^{\varphi,b}, \zeta_t^{\varphi,b} \sim i.i.d.\, N(0, \sigma^2_{\zeta^{\varphi,b}}).$$

We assume that the for any profits or loss incurred to the central bank are transferred (or covered) by the treasury. Let $Tr_t^{cb}$ be the nominal transfer from the central bank to treasury and it is given by

[4] Note that although the reserve requirement for the Bank of Canada is zero, we can think of the settlement balances as reserves. During the pandemic, the Bank of Canada "Settlement balances increased more than 1,500-fold—from \$250 million before the pandemic (0.2% of the Bank's balance sheet) to a high of \$403 billion (about 69.8% of the Bank's balance sheet) — in just under 12 months" – Chu et al. (2022).

the following equation

$$Tr_t^{cb} = P_t re_t + R_{kt} q_{t-1}^k P_{t-1} s_{t-1}^{k,cb} + R_{bt} q_{t-1}^b P_{t-1} b_{t-1}^{cb} - q_t^k P_t s_t^{k,cb} - q_t^b P_t b_t^{cb} - R_{t-1}^{re} P_{t-1} re_{t-1}. \quad (28)$$

Then in real terms, we have

$$tr_t^{cb} = re_t + R_{kt} q_{t-1}^k s_{t-1}^{k,cb}/\pi_t + R_{bt} q_{t-1}^b b_{t-1}^{cb}/\pi_t - q_t^k s_t^{k,cb} - q_t^b b_t^{cb} - R_{t-1}^{re} re_{t-1}/\pi_t. \quad (29)$$

That is, the central bank's resource is the settlement account (reserves) that it just created, the return on the bonds bought by the central bank in the previous period. The central bank uses the resources to pay for the purchase of new security including the ones issued by the private sector $s_t^{k,cb}$ and by the government $q_t^b b_t^{cb}$, and pay the interest rate on reserves held by the commercial banks.

Substituting equation (27) to equation (29), we can obtain

$$tr_t^{cb} = (R_{kt} - R_{t-1}^{re}) q_{t-1}^k s_{t-1}^{k,cb}/\pi_t + (R_{bt} - R_{t-1}^{re}) q_{t-1}^b b_{t-1}^{cb}/\pi_t. \quad (30)$$

**EFG.** To model EFG, we follow Sim and Wu (2021) by model the EFG as a shock to the policy rate in equation (26). That is, we assume that under EFG, the central bank maintain the policy rate at the ZLB for a pre-determined period of time, and we use a negative shock to the policy rate if the ZLB is over before the pre-determined period.

## 3.4 Fiscal authority

The government issue long-term bonds, make transfers to the HtM households $\omega tr_{Ht}$, collect lump-sum tax $(1-\omega)\tau_t$ from the Ricardian households, and purchase goods $g_t$. Define $\tau_t^{agg} = (1-\omega)\,\tau_t$ and $tr_{Ht}^{agg} = \omega tr_{Ht}$. And taking account of $L_t^R = (1-\omega) l_t^R$, and $L_t^H = \omega l_t^H$. The budget constraint for the government in nominal terms is

$$(1 + \kappa q_t^b) B_{t-1} + P_t g_t + P_t tr_{Ht}^{agg} = P_t \tau_t^{agg} + P_t tr_t^{cb} + \tau^{l^R} P_t w_t L_{Rt} + \tau^{l^H} P_t w_t L_{Ht} + q_t^b B_t.$$

Writing it in real terms, we have

$$(1+\kappa q_t^b)\frac{b_{t-1}}{\pi_t} + g_t + tr_{Ht}^{agg} = \tau_t^{agg} + tr_t^{cb} + \tau^{l^R} w_t L_{Rt} + \tau^{l^H} w_t L_{Ht} + q_t^b b_t.$$

The government spending $g_t$ follows an AR(1) process:

$$\log g_t = (1-\rho_g)\log g_{ss} + \rho_g \log g_{t-1} + \varepsilon_t^g, \qquad \varepsilon_t^g \sim i.i.d.N(0, \sigma_{\varepsilon^g}^2).$$

And we assume that labour income tax rates follow

$$\tau_t^{l^R} = (\frac{q_{t-1}^b b_{t-1}}{q_{ss}^b b_{ss}})^{\phi^{lR}} \tau_{ss}^{l^R}. \tag{31}$$

Denote the aggregate lump-sum tax as $\tau_t^{agg} = (1-\omega)\ \tau_t$. We assume that $\tau_t^{agg}$ is given by the following equation

$$\tau_t^{agg} = (\frac{q_{t-1}^b b_{t-1}}{q_{ss}^b b_{ss}})^{\phi^{tax}} \tau_{ss}^{agg}. \tag{32}$$

**Transfers.** As stated earlier, we assume that only HtM households receive transfers. Denote total transfers $tr_{Ht}^{agg} = \omega tr_{Ht}$, assume that $tr_{Ht}^{agg}$ follows

$$\frac{tr_{Ht}^{agg}}{tr_{Hss}^{agg}} = (\frac{tr_{Ht-1}^{agg}}{tr_{Hss}^{agg}})^{\rho^{tr}}((\frac{y_t}{y_{ss}})^{\rho^{y,tr}})^{1-\rho tr}\zeta_t^{tr}, \tag{33}$$

where $\zeta_t^{tr} \sim i.i.d.\ N(0, \sigma_{\zeta^{tr}}^2)$. We also assume that $\rho^{y,tr} < 0$, so that the government transfers rise when output falls below the steady-state value.

## 3.5 Market clearing and aggregation

Capital claims market clears:

$$s_t^k = s_t^{k,b} + s_t^{k,cb},$$

and bond market clears:

$$b_t = b_t^b + b_t^{cb}.$$

Resource constraint:

$$C_t^R + C_t^H + g_t + i_t + 0.5\chi^k(\frac{i_t}{i_{t-1}} - 1)^2 = y_t, \tag{34}$$

where $C_t^R = (1-\omega)c_{Rt}$, and $C_t^H = \omega c_{Ht}$.

# 4 Calibration

In this section, we calibrate the model to the Canadian economy. We first detail how we choose the model parameters, and then we conduct simulations and use impulse response functions to show how various fiscal and monetary policies affect key macroeconomic variables; in particular, we focus on the policies' impact on output, consumption, investment, inflation, and government debt.

## 4.1 Parameters values

The parameters are calibrated to the Canadian economy wherever possible, and for some parameters the values are borrowed from the related literature. Tables 2 and 3 below display the parameter values.

The model is calibrated at a quarterly frequency. We set the discount factor for Ricardian households to 0.995, which corresponds to an annualized interest rate of 2%—close to the pre-pandemic average. Bhattarai et al. (2023) use the employment share of retail, transportation and warehousing and leisure and hospitality to pin down the share of the HtM households. We follow their approach to set $\omega$, the share of HtM household to 0.28, based on the share of employment in the similar sector in the Labour Force Survey (LFS) from 2011 to 2019. The relative utility weight of labour is set to 3.73 for Ricardian households and 5.0 for HtM households, implying steady-state labour supplies of 0.3 and 0.27, respectively. Following Gertler and Karadi (2013), we set the inverse Frisch elasticity of labour supply to 0.3 and the habit persistence parameter to 0.815. Finally, the coefficient of relative risk aversion ($\sigma^c$) is set to 1.01, approximating a log utility function.

For the production sector, the labour share parameters for Ricardian and HtM households in the production function, $\alpha$ and $\theta$, are set to 0.415 and 0.159, respectively. These values are calculated based on: (1) the share of labour in the cost of producing intermediate goods, which is 0.574 according to productivity data (Statistics Canada Table 36-10-0208); and (2) the share of HtM employment in the Labour Force Survey (LFS) from 2011 to 2019, which is 0.277.

For the remaining parameters—including the capital depreciation rate ($\delta^k$), the Calvo pricing parameter ($\nu$), the investment adjustment cost parameter ($\chi^k$), and the elasticity of substitution ($\varepsilon$)—we use values typical in the literature. Specifically, we set $\delta^k$ to 0.025 as in Smets and Wouters (2007), implying an annual depreciation rate of 10%. We set $\nu$ to 0.8 following Gertler and Karadi (2013), implying that prices change every five quarters. The parameter $\chi^k$ is set to 5.5 as in Smets and Wouters (2007), which implies an elasticity of investment with respect to the price of capital of 0.18. Finally, $\varepsilon$ is set to 11, a standard value that implies an average markup of 10%.

For financial intermediaries, most parameter values are set following Gertler and Karadi (2013). We select values for three key parameters to match steady-state targets. The diversion rate for capital claims ($\kappa^k$) is set to 0.35; the survival rate of banks ($\sigma$) is set to 0.972; and the proportional transfer to newly-entered banks ($\omega^b$) is set to 0.0013. These values are chosen to match three steady-state targets: an annualized spread of long-term government bonds of 100 basis points; an average bank leverage ratio of 6.2, calculated as the ratio of total assets to net worth for Chartered Canadian banks; and an average bank life horizon of 10 years. Finally, the diversion rate difference between capital claims and government bonds is set to 0.5, as in Gertler and Karadi (2013).

Table 3 displays the parameters related to the central bank and government. The parameters for the Taylor rule are taken from Gertler and Karadi (2013): the interest rate smoothing parameter $\rho$ is set to 0.8, while the response parameters to inflation and output, $\rho_\pi$ and $\rho_y$, are set to 1.5 and 0.05, respectively. For the government, the coupon decay parameter, $\kappa$, is calibrated to 0.975, implying that the duration of the long-term bonds is ten years. Based on National Income Accounts and National Balance Sheet, the government spending-to-GDP ratio and government debt-to-GDP ratio are set to 0.2 and 0.285, respectively. The parameters in the transfer response rule, $\rho^{tr}$ and $\rho^{y,tr}$, are set to 0.9762 and $-6.0$, based on the author's calculations. The tax adjustment parameter, $\phi^{\text{tax}}$, is set to 0.1. Labour income tax rate for both Ricardian is set to 0.25. Finally, both the steady-state transfers-to-GDP ratio is set to 0.01, based on the Canadian data.

## 4.2 Model mechanism

In this section, we present the model simulations, focusing on the transmission mechanisms through which the policy measures affect the economy. Our simulation strategy proceeds in two steps. First, we employ a combination of shocks to generate large declines in key macroeconomic variables—

Table 2: Parameter Values I

| Parameter | Value | Description | Source/Target |
|---|---|---|---|
| Households | | | |
| $\omega$ | 0.28 | Fraction of hand-to-mouth households | Labor Force Survey |
| $\beta$ | 0.995 | Discount factor of Ricardian households | Annual interest rate of 2% |
| $\chi^H$ | 5.0 | Weight of labour in preference, HtM | $l^H_{ss} = 0.27$ |
| $\chi^R$ | 3.73 | Weight of labour in preference, Ricardian | $l^R_{ss} = 0.3$ |
| $\varphi$ | 0.3 | Inverse of Frisch elasticity | Gertler and Karadi (2013) |
| $h$ | 0.815 | Habit persistence | Gertler and Karadi (2013) |
| $\sigma^c$ | 1.01 | Coefficient of relative risk aversion | Close to log utility |
| Goods Producers | | | |
| $\delta^k$ | 0.025 | Depreciation rate of capital | Smets and Wouters (2007) |
| $\theta$ | 0.159 | Labour share of HtM households | Labor Force Survey |
| $\alpha$ | 0.415 | Labour share of Ricardian households | Labor Force Survey |
| $\nu$ | 0.80 | Calvo pricing parameter | Gertler and Karadi (2013) |
| $\chi^k$ | 5.5 | Investment adjustment cost parameter | Smets and Wouters (2007) |
| $\varepsilon$ | 11.0 | Elasticity of substitution for retailers | Standard in literature |
| Financial Intermediaries | | | |
| $\sigma$ | 0.972 | Survival rate of banks | see text |
| $\kappa^k$ | 0.35 | Diversion rate for capital claims | see text |
| $\omega^b$ | 0.0013 | Proportional transfer to new banks | see text |
| $\Delta^b$ | 0.5 | Diversion rate difference | Gertler and Karadi (2013) |

Table 3: Parameter Values II

| Parameter | Value | Description | Source/Target |
|---|---|---|---|
| Central Bank | | | |
| $\rho^r$ | 0.8 | Interest rate smoothing in Taylor rule | Gertler and Karadi (2013) |
| $\rho^\pi$ | 1.5 | Response to inflation in Taylor rule | Gertler and Karadi (2013) |
| $\rho^y$ | 0.05 | Response to output in Taylor rule | Gertler and Karadi (2013) |
| Government | | | |
| $\kappa$ | 0.975 | Coupon decay parameter | 10-year bond maturity |
| $g/y$ | 0.2 | Government spending to GDP ratio | National Income Accounts |
| bond$/y$ | 0.285 | Government bonds to GDP ratio | National Balance Sheet |
| $\rho^{tr}$ | 0.9762 | Parameter in transfers rule | Canadian data |
| $\rho^{y,tr}$ | -6.0 | Parameter in transfers rule | Canadian data |
| $\phi^{\text{tax}}$ | 0.9 | Tax adjustment parameter | |
| $\tau^{l^R}$ | 0.25 | Labour income tax rate, Ricardian | Canadian data |
| transfer$/y$ | 0.01 | Transfers to GDP ratio | Canadian Data |

GDP, consumption, and investment—so that the baseline model economy approximates the observed contractions at the peak of the pandemic. We then introduce the policy interventions and compare the model's responses under these policies with those in the baseline case.

#### 4.2.1 Baseline: the impact of the pandemic

To generate the baseline scenario, we employ a combination of shocks: a forced-savings shock and a labour-disutility shock that affect both household types (targeting consumption and labour supply, respectively), and a credit-risk shock to banks' diversion rates that influences firms' borrowing costs and, in turn, investment. All three shocks are assumed to follow AR(1) processes with a persistence parameter of 0.9. The sizes of the shocks at time 0 are reported in Table 4.

Table 4: Shocks Used to Generate Pandemic

| Forced-savings shocks | Labour disutility shocks | Diversion rate shocks |
|---|---|---|
| -0.09 | 0.06 | 0.22 |

Figure 6 shows that under this combination of shocks, the peak declines in aggregate output, consumption, and investment are approximately 10%, 16%, and 12%, respectively, broadly matching the observed declines in the data. However, the model overpredicts the fall in inflation, generating deflation of about 8%. The simultaneous declines in output and inflation cause the nominal interest rate to hit the ZLB and remain there for the following seven quarters. Both Ricardian and HtM households experience substantial reductions in consumption and labour supply.

In addition, the pandemic-induced credit-risk shock tightens banks' incentive constraints, raising spreads on both long-term government bonds and capital claims. The resulting increase in borrowing costs leads to declines in the prices of government bonds and capital claims.

The transfer-to-GDP ratio rises even in the absence of the pandemic stimulus package. This occurs because $\rho^y < 0$ in the transfer rule,

$$\frac{tr^{agg}_{Ht}}{tr^{agg}_{Hss}} = \left(\frac{tr^{agg}_{Ht-1}}{tr^{agg}_{Hss}}\right)^{\rho^{tr}} \left(\left(\frac{y_t}{y_{ss}}\right)^{\rho^y}\right)^{1-\rho^{tr}} \zeta^{tr}_t,$$

which implies that transfers increase when GDP falls below its steady-state level. To finance this increase, the government issues additional bonds, leading to a rise in the government debt-to-GDP ratio. The newly issued bonds are absorbed primarily by banks, as reflected in the increase in their bond holdings, while a smaller share is absorbed by the central bank, whose bond holdings rise only modestly.

#### 4.2.2 Fiscal policy: transfers

Figure 7 illustrates the impact of transfers by comparing an economy with a pandemic transfer program to the baseline scenario. We assume a shock persistence of 0.9 and introduce a transfer shock at time $t$ such that the transfers-to-GDP ratio rises to approximately 2 percent when the pandemic hits—about twice its steady-state level. Because transfers represent a redistribution of income from Ricardian to HtM households, their effects differ significantly across the two groups. HtM households, who receive the transfers, experience an increase in consumption when the program is in place. As a result, their welfare improves.

The effect is the opposite for Ricardian households, whose consumption and welfare decline under the transfer program owing to the increased tax burden. The transfer program also mitigates the decline in inflation. Because HtM households have a higher marginal propensity to consume, the increase in their consumption helps stabilize aggregate demand, thereby dampening the disinflationary pressures associated with the pandemic.

Overall, transfers raise aggregate consumption at the cost of lower investment. This trade-off helps mitigate the initial decline in output but eventually results in a larger output loss. To finance the transfers, the fiscal authority issues additional long-term government bonds, which are primarily absorbed by banks, leading to an increase in their bond holdings. Banks hold slightly fewer bonds initially relative to the baseline because the early rise in transfers is financed mainly through higher labour-income and lump-sum taxes on Ricardian households.

#### 4.2.3 Monetary policy: QE and FG

Figure 8 compares the baseline economy with one in which the central bank conducts QE. Note that in this section, QE refers only to the central bank's purchases of long-term government bonds. We assume a shock persistence of 0.9 and introduce a QE shock at time $t$ such that the cumulative increase in the ratio of long-term government bonds held by the central bank (CB) to GDP reaches about 20 percent over the first two quarters. This magnitude is broadly consistent with the size of the

QE program implemented by the Bank of Canada during the pandemic. The QE program mitigates the declines in output, consumption, and investment, and it also leads to a substantially smaller drop in inflation.

The key transmission mechanism is the same as in Gertler and Karadi (2013) and Sims and Wu (2021). Because of financial frictions, banks face binding incentive (financial) constraints, and QE relaxes these constraints. As a result, the central bank's purchase of long-term government bonds does not simply represent a one-for-one substitution of public for private intermediation. Instead, it increases total demand for long-term government debt and raises its price. As banks become less constrained, the spreads on both long-term government bonds and capital claims decline.

Since the primary effect of QE operates through lower borrowing costs, it boosts investment more than consumption. Overall, under QE, both output and inflation are higher, which shortens the duration for which the nominal interest rate remains at the zero lower bound (ZLB). Furthermore, different from transfer policy, QE raises the welfare of both household types.

Figure 9 compares the baseline economy with one in which the central bank implements forward guidance (FG). In the baseline case, the ZLB binds for seven quarters. Under FG, we assume that the central bank commits to maintaining the policy rate at the ZLB for eight quarters — one quarter longer. We find that the additional monetary easing from extending the ZLB period is highly inflationary, while the stimulative effects on output, consumption, and investment are minimal.

#### 4.2.4 Interaction of the fiscal and monetary policies

To fully understand the impact of the COVID-19 stimulus package on the economy, it is essential to study the joint effects of fiscal and monetary policies. Figure 10 compares three economies: (i) fiscal transfers only (blue line); (ii) transfers combined with QE (red line); and (iii) transfers combined with QE and FG (orange dotted line).

Comparing the transfers-only case with the transfers-plus-QE case, the key difference lies in the balance sheets of commercial banks. Under transfers only, commercial banks absorb most of the increase in government debt generated by the pandemic transfers, leading to a rise in the share of government bonds in their total assets. Under QE, by contrast, the central bank absorbs the majority of the increase in long-term government debt. This is reflected in a substantial decline in the share of bonds held by commercial banks and a corresponding increase in their reserve balances (settlement balances at the central bank).

The resulting expansion in reserves relaxes banks' incentive constraints and lowers the spreads on long-term government bonds and capital claims. As a consequence, investment increases, and the welfare of both household types rises when QE is combined with transfers. Overall, the transfers-plus-QE policy mix is also more inflationary.

The orange dotted line represents the case in which the monetary authority implements both QE and FG while the fiscal authority implements transfers. In this scenario, FG becomes more stimulative when combined with transfers and QE. In particular, the economy experiences significantly higher inflation under the full policy mix, reflecting the stronger aggregate stimulus when all three policies are present.

Another important result is that QE and FG reduce the government debt-to-GDP ratio relative to the transfers-only case. This occurs because the stronger mitigation of the decline in inflation under QE and FG lowers the real value of government debt.

# 5 Quantifying policy effects

An important exercise is to quantify the contribution of the aforementioned fiscal and monetary policies to output, consumption, and inflation during and after the pandemic. While the impulse response functions in the previous section illustrate the transmission mechanisms of these policies, they are not well suited to addressing this quantitative question. A standard approach in the literature is to treat policy changes as shocks and quantify their contribution using a full-information Bayesian estimation of the model, followed by shock decomposition. This standard method, however, requires linearizing the model around its steady state. It is reliable only when shocks are not too large and when there are no occasionally binding constraints such as the ZLB.[5] The unusually large COVID-19 shock and the presence of the ZLB in our model therefore make the standard log-linearization approach unreliable. [6]

Thus, in this paper, we adopt an alternative approach to estimating the model. We then use the estimates to conduct counterfactuals to quantify the policy effects. The details are as follows.

[5] When shocks are large, linearization can provide a poor approximation; the ZLB introduces a global nonlinearity.

[6] Recent attempts in the literature to overcome this issue include Cardani et al. (2022), who use a heteroskedastic Kalman filter to estimate a standard multi-sector, medium-scale DSGE model and study the impact of COVID-19, Ferroni et al. (2024), who estimate the standard model parameters using the pre-COVID sample and the COVID shock parameters using data from 2020Q2, the peak of the pandemic.

## 5.1 Estimating shock profiles

We focus on the period 2020Q1–2022Q4, which encompasses both the pandemic and the subsequent recovery phases. We assume that, over this time, the Canadian economy is primarily driven by pandemic-related shocks—namely forced-saving, labor-disutility, and credit-risk shocks—along with the associated fiscal and monetary support measures. Compared to Section 4, we allow for a broader set of shocks. Specifically, we classify shocks into three groups: (1) policy shocks, including quantitative easing (QE) shocks to long-term government bonds, and transfer shocks; (2) pandemic-related shocks, including forced-saving shocks, labor-disutility shocks, and credit-risk shocks; and (3) standard macroeconomic shocks, including total factor productivity (TFP) shocks and government spending shocks. We assume that all structural parameters remain fixed at their calibrated values and instead focus on estimating the time profiles of the shocks. The estimation proceeds in two steps.

In the first step, we estimate the shock processes using individual time-series data corresponding to these shocks: fraction of long-term government bonds held by the central bank ($\varphi_t^b$), transfer payments ($tr_{Ht}^{agg}$), government spending ($g_t$), and total factor productivity ($A_t$). For each shock, we estimate the specified shock process using quarterly data from 2000q1 to 2024q4. Data sources are described in Appendix E. Unlike the specification in Section 4, shocks to transfer payments are assumed here to follow an AR(1) process. We obtain estimates of the serial correlation coefficients, reported in Table 5, as well as the estimated innovation terms for the period 2020Q1–2022Q4. The resulting shock series, shown in Figure 11, are fed into the model as policy and technology shocks over the pandemic period.

Table 5: Serial correlation coefficient estimates on individual time series

| Parameter | Value | Variable | Data |
|---|---|---|---|
| $\rho_1^{\varphi,b}$ | 1.625 | $\varphi_t^b$ | share of government bonds over 3 years held by CB in total gov bond |
| $\rho_2^{\varphi,b}$ | -0.650 | $\varphi_t^b$ | share of government bonds over 3 years held by CB in total gov bond |
| $\rho^{tr}$ | 0.940 | $\ln(tr_t^H)$ | Log transfer payments |
| $\rho_g$ | 0.686 | $\ln(g_t)$ | Log Government purchases |
| $\rho_A$ | 0.931 | $\ln(A_t)$ | Log Business-sector multifactor productivity |

In the second step, we estimate the pandemic-related shocks. We feed the estimated shocks to technology, government spending, quantitative easing, and transfer payments into the model and then use the simulated method of moments (SMM) to estimate the shock processes for forced saving, labor disutility for Ricardian households, labor disutility for hand-to-mouth (HtM) households, and credit risk (the diversion rate). Each of these shocks is assumed to follow an AR(1) process.[7] In addition, we estimate shocks to the policy interest rate, which are assumed to be i.i.d. The parameter set in the SMM estimation includes three serial correlation coefficients, 24 innovation terms for the AR(1) shocks (six for each process), and eight policy interest rate shocks. The six innovation terms for each AR(1) process correspond to the six quarters from 2020Q1 to 2021Q2, which we interpret as the period during which shocks were primarily pandemic-related. The eight policy rate shocks correspond to the eight quarters from 2020Q1 to 2021Q4, during which the policy interest rate remained at the effective lower bound despite rising inflation.

In the SMM estimation, we match model-generated dynamics of the following variables for 10 quarters to their empirical counterparts observed during 2020q1–2022q2: aggregate consumption, aggregate investment, hours worked by Ricardian households, hours worked by HtM households, inflation rate, and policy interest rate. Restricting the matching window to 10 quarters allows us to estimate the serial correlation coefficients while limiting the influence of shocks unrelated to the pandemic, which may have played a more prominent role after 2022q2. Figure 12 presents the estimated shock profiles for forced-saving, labour disutility, and credit risk.[8] Forced saving can be interpreted as an adverse demand shock associated with Covid-19 lockdowns and drops sharply at the onset of the pandemic. Labor-disutility shocks are positive in early 2020, contributing to the observed declines in employment.

The estimated shocks to the policy interest rate in the Taylor rule (not shown) are negative in all eight quarters from 2020Q1 to 2021Q4, with their absolute magnitude increasing modestly toward 2021. These shocks keep the policy interest rate at zero throughout 2020 and 2021, even as aggregate output and inflation rise markedly. The monetary policy shocks capture the forward guidance embedded in monetary policy communications during the Covid-19 period and are consistent with the central bank's assessment that inflationary pressures in 2021 were transitory.

The model economy incorporating all estimated shocks (the baseline model) generates dynamics

[7] We restrict the coefficients of serial correlation for labor-disutility shocks to be equal across the two household types.

[8] The estimated serial correlation coefficients for credit risk, forced saving, and labor disutility are $\rho^{\kappa} = 0.579$, $\rho^{fs} = 0.617$, and $\rho^{l^R} = 0.622$, respectively.

that closely match those observed in the data, as shown in Figure 13. Although GDP is not directly targeted in the estimation, the model-generated GDP series aligns well with the data. The estimated shocks are concentrated in 2020 and 2021, during which the model tracks the observed movements in aggregate variables closely. Even though no additional shocks are imposed after 2021, the model continues to generate post-2021 dynamics that resemble the patterns observed in the data.

## 5.2 Policy effects

In assessing the effects of fiscal and monetary policies, we take as the baseline the full model incorporating all policy and structural shocks, as this specification replicates the observed dynamics of the economy during the pandemic reasonably well. Starting from this baseline, we shut down individual policy instruments or consider counterfactual policy paths in order to quantify the effects of specific policies.

**Transfer payments.** Starting from the full model, we eliminate shocks to transfer payments while holding their level fixed at the steady-state value. The resulting outcomes are labeled "No TR" in Figure 14. To quantify the effects of transfer payments, we compute the gap for each variable as the difference between the series simulated under the full model and the corresponding series simulated in the absence of transfer payments. These gaps therefore represent the contribution of transfer payments to macroeconomic outcomes. Figure 15 reports these gaps, together with those obtained under other policy experiments.

Overall, higher transfer payments raise real GDP in both 2020 and 2021. The effects are most pronounced in the first half of 2020, with transfer multipliers of 2.46 and 1.94 in 2020Q2 and 2020Q3, respectively. Absent the increase in transfer payments, real GDP in 2020Q2 would have been approximately 2.5 percentage points lower. In 2021, the impact on real GDP remains positive but diminishes as transfer payments gradually return toward their pre-pandemic levels.

In the model, transfer payments are directed exclusively to hand-to-mouth households. Consequently, their effect on real GDP operates primarily through increased consumption by these households, as illustrated in Figure 16. In 2020Q2, consumption by hand-to-mouth households is approximately 18 percentage points higher than in the counterfactual without higher transfer payments. At the same time, transfer payments reduce hours worked by hand-to-mouth households while increasing hours worked by Ricardian households. In welfare terms, measured by the household value function, transfer payments improve welfare for hand-to-mouth households but reduce welfare for Ricardian households.

To summarize the overall effects of transfer payments under alternative monetary policy regimes, we define the cumulative transfer multiplier as

$$M = \frac{\sum_{s=0}^{T} \beta^s (Y_0 - Y_1^i)}{\sum_{s=0}^{T} (tr_s^H)},$$

where $T$ denotes the number of quarters, $Y_0$ is real GDP in the full model with all policies and shocks, and $Y_1^i$ is real GDP in the counterfactual economy without transfer payments under monetary policy scenario $i$. We consider four monetary policy scenarios: quantitative easing combined with forward guidance ("QE+FG"), forward guidance only ("FG"), quantitative easing only ("QE"), and neither quantitative easing nor forward guidance ("No QE & FG").

The resulting cumulative transfer multipliers are reported in Table 6. In all scenarios, the multiplier is larger in 2020 than in 2021, reflecting the severity of the initial pandemic shock. Moreover, transfer multipliers are substantially larger when transfer payments are combined with forward guidance that keeps the policy interest rate low for an extended period.

Table 6: Transfer Multipliers

| | QE + FG | FG | QE | No QE & FG |
|---|---|---|---|---|
| Two-year cumulative multiplier (2020q1-2021q4) | 1.413 | 1.413 | 0.427 | 0.512 |
| Three-quarter cumulative multiplier (2020q1-2020q3) | 2.184 | 2.184 | 1.428 | 1.500 |

Transfer payments during the pandemic are strongly inflationary in 2020. Had transfer payments been held at their 2019 levels, the economy would have experienced a pronounced deflation, with the consumer price index falling by more than 8 percent in 2020Q2. As transfer payments recede in 2021, their inflationary impact correspondingly weakens. Nevertheless, in the absence of increased transfer payments in 2020, the inflation rate in 2021 would have been approximately 0.7 percentage points lower than in the baseline model.

**Forward guidance and quantitative easing.** The Bank of Canada maintained the policy interest rate at the effective zero lower bound throughout the pandemic until 2022Q1, even as inflation began to rise above its trend in 2021Q2. To replicate this policy stance, we introduce monetary policy shocks in the Taylor rule that keep the policy rate at zero during 2020 and 2021. These shocks capture the forward guidance conveyed through the central bank's monetary policy communications over the pandemic period.

In the full model with Taylor-rule shocks, the policy interest rate remains at the zero lower bound from 2020Q2 to 2021Q4.[9] In contrast, when these shocks are shut down, the policy rate remains at the zero lower bound only until 2021Q2 and subsequently rises to 0.47 percent in 2021Q3 and 0.93 percent in 2021Q4. Policy rates thereafter continue to exceed those in the full-model economy.

As shown in Figure 15 for the case labeled "FG", forward guidance raises real GDP by an average of 0.7 percentage points over 2020–2021. This increase reflects stronger aggregate demand, driven by higher consumption and, more importantly, by increased investment. In contrast to transfer payments, the output effects of forward guidance operate primarily through the investment channel, reflecting the sustained reduction in borrowing costs associated with the zero policy rate.

Low policy interest rates led to a mitigated deflation in 2020. In the absence of the policy rate shocks, the inflation would have been on average 1.32 percentage points lower than the economy experienced in 2020-2021. In the full model, the inflation reaches the peak of 1.85% in 2021q4, while it would have been only 0.46% in the absence of shocks to the policy rate.[10]

Forward guidance also mitigates deflationary pressures in 2020. In the absence of policy rate shocks, inflation would have been, on average, 1.32 percentage points lower over 2020–2021. In the full model, inflation peaks at 1.85 percent in 2021Q4, whereas it would have reached only 0.46 percent without policy rate shocks.[11]

The effects of policy rate shocks are persistent. Even after 2021Q4, when no additional monetary policy shocks are imposed, both real GDP and inflation remain elevated relative to the counterfactual economy without forward guidance, reflecting the endogenous propagation of earlier monetary accommodation.

Quantitative easing in the model generates effects qualitatively similar to those of forward guidance, though quantitatively smaller. This difference reflects the gradual expansion of the central

[9] In the full model, the policy interest rate increases modestly to 0.25 percent in 2021Q4.

[10] It is noted that inflation rate in the model is the deviation from the trend inflation in percentage points. The trend inflation rose to around 3% in 2021 and 2022.

[11] Inflation in the model is measured as deviations from trend inflation, expressed in percentage points. Trend inflation rises to approximately 3 percent in 2021 and 2022.

bank's holdings of long-term government bonds. At the onset of the pandemic, quantitative easing was not the dominant policy response. Instead, the share of long-term government bonds held by the central bank increased steadily and reached its peak in 2021Q3 (see Figure 11), by which time most pandemic-related shocks had largely dissipated.

Forward guidance thus kept the policy interest rate at the effective zero lower bound despite the substantial increase in inflation during 2021. To assess the consequences of delayed monetary policy normalization, we conduct a counterfactual experiment in which forward guidance and quantitative easing are terminated in 2021Q3, when inflation was already well above its trend. The results indicate that, had forward guidance ended in 2021Q3, inflation in that quarter would have been 0.71 percentage points lower, with inflation remaining lower in subsequent periods (Figure 18). By contrast, terminating forward guidance two quarters earlier has only modest effects on output and welfare. This exercise suggests that an earlier and more gradual increase in the policy interest rate could have reduced the need for subsequent aggressive tightening, thereby smoothing the path of monetary policy normalization.

The policy effects of transfer payments and monetary policy are summarized in Tables 7 and 8. Alternative welfare measures are consumption-equivalent (CE) for both types of households. All policies have benefited the hand-to-mouth households, while the Ricardian households' welfare was worsen off.

Table 7: Model outcomes in 2020Q2 (percentage-point deviations)

| Scenario | Output ($y$) | Consumption ($c$) | Investment ($i_k$) | Inflation ($\pi$) | CE (R) | CE (H) |
|---|---|---|---|---|---|---|
| Baseline | -12.705 | -14.282 | -15.179 | -3.116 | -0.392 | 0.891 |
| No QE | -12.807 | -14.425 | -15.283 | -3.485 | -0.390 | 0.877 |
| No FG | -13.071 | -14.845 | -15.468 | -4.344 | -0.385 | 0.846 |
| No TR | -15.456 | -19.947 | -14.958 | -8.913 | 0.072 | -0.096 |

Table 8: Average model outcomes over the first 6 quarters (percentage-point deviations)

| Scenario | Output ($y$) | Consumption ($c$) | Investment ($i_k$) | Inflation ($\pi$) | CE (R) | CE (H) |
|---|---|---|---|---|---|---|
| Baseline | -3.460 | -5.406 | -1.996 | -1.693 | -0.161 | 0.485 |
| No QE | -3.601 | -5.548 | -2.235 | -1.990 | -0.162 | 0.472 |
| No FG | -4.087 | -6.221 | -2.742 | -3.041 | -0.159 | 0.429 |
| No TR | -4.466 | -7.772 | -1.426 | -3.688 | 0.082 | -0.001 |

# 6 Conclusion

We developed a theoretical framework that embeds a banking-sector block à la Gertler and Karadi (2013) into a two-agent New Keynesian (TANK) model, and we conduct a series of counterfactual exercises to evaluate the macroeconomic contribution of each policy component. Our analysis yields four main findings.

First, transfer payments played a dominant role in cushioning the initial pandemic contraction. By redirecting resources toward hand-to-mouth (HtM) households, transfers substantially raised aggregate consumption and real output. In the absence of transfers, real GDP in 2020Q2 would have been approximately 2.5 percentage points lower and the price level would have fallen by more than 8 percent.

Second, monetary policy accommodation amplified the stabilizing effects of fiscal policy through complementary channels. Forward guidance—which committed the Bank of Canada to maintaining the policy rate at the effective zero lower bound throughout 2020 and 2021—raised real GDP by an average of approximately 0.7 percentage points over the pandemic period, mainly through the investment channel by reducing borrowing costs. QE generated quantitatively small effects on output and inflation, reflecting the more gradual buildup of the central bank's long-term bond holdings.

Third, the prolonged maintenance of the policy rate at the ZLB throughout 2021 contributed materially to the post-pandemic inflation surge. In the baseline estimated model, inflation in 2021Q4 reaches 1.85 percentage points above its trend; in the absence of monetary policy shocks, it would have been only 0.46 percentage points above the trend.

Fourth, an earlier normalization of monetary policy would have been effective at curbing inflation at relatively low output cost. Had forward guidance been terminated in 2021Q3—when inflation had already risen well above the trend—inflation in that quarter would have been approximately 0.71 percentage points lower, with durable reductions in subsequent periods. This result suggests that a more gradual tightening path could have contained post-pandemic inflation without requiring the aggressive interest rate increases that was subsequently implemented.

Taken together, our findings highlight the powerful complementarity between fiscal transfers and monetary accommodation during the pandemic, while also pointing to the inflationary costs of maintaining policy rates at the ZLB beyond the period of maximum economic distress. Extensions that allow for endogenous monetary policy normalization rules, richer heterogeneity in household balance sheets, or open-economy channels represent promising directions for future research.

# References

Azad, N. F., Serletis, A., and Xu, L. (2021). Covid-19 and monetary–fiscal policy interactions in canada. *The Quarterly Review of Economics and Finance*, 81:376–384.

Bhattarai, S., Lee, J. W., and Yang, C. (2023). Redistribution and the monetary-fiscal policy mix. *Quantitative Economics*, 14(3):817–853.

Bianchi, F., Faccini, R., and Melosi, L. (2020). Monetary and fiscal policies in times of large debt: Unity is strength. Technical report, National Bureau of Economic Research.

Cardani, R., Croitorov, O., Giovannini, M., Pfeiffer, P., Ratto, M., and Vogel, L. (2022). The euro area's pandemic recession: A dsge-based interpretation. *Journal of Economic Dynamics and Control*, 143:104512.

Chu, P., Johnson, G., Kinnear, S., McGuinness, K., and McNeely, M. (2022). Settlement balances deconstructed. Technical report, Bank of Canada.

Cochrane, J. H. (2022). Inflation past, present and future: Fiscal shocks, fed response, and fiscal limits. Technical report, National Bureau of Economic Research.

Dimakopoulou, V., Economides, G., Philippopoulos, A., and Vassilatos, V. (2024). Can central banks do the unpleasant job that governments should do? *European Economic Review*, page 104728.

Elenev, V., Landvoigt, T., Shultz, P., and Van Nieuwerburgh, S. (2022). Can monetary policy create fiscal capacity? *Available at SSRN 3896402*.

Fortin, M. (2022). The fiscal impact of quantitative easing. *Canadian Public Policy*, 48(4):490–502.

Gertler, M. and Karadi, P. (2013). Qe 1 vs. 2 vs. 3...: A framework for analyzing large-scale asset purchases as a monetary policy tool. *International Journal of Central Banking*, 9(S1):5–53.

Gertler, M. and Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. In *Handbook of monetary economics*, volume 3, pages 547–599. Elsevier.

Guerrieri, L. and Iacoviello, M. (2015). Occbin: A toolkit for solving dynamic models with occasionally binding constraints easily. *Journal of Monetary Economics*, 70:22–38.

Koeppl, T. V., Kronick, J., and McNeil, J. (2024). Using functional shocks to assess conventional and unconventional monetary policy in canada. *Canadian Journal of Economics / Revue canadienne d'économique*, 57(4):1314–1336.

Kurovskiy, G., Lambertini, L., and Tsiaras, S. (2022). Active and passive (un) conventional monetary and fiscal policies for debt stability.

Leeper, E. M. (1991). Equilibria under 'active'and 'passive'monetary and fiscal policies. *Journal of monetary Economics*, 27(1):129–147.

Leeper, E. M. and Zhou, X. (2021). Inflation's role in optimal monetary-fiscal policy. *Journal of Monetary Economics*, 124:1–18.

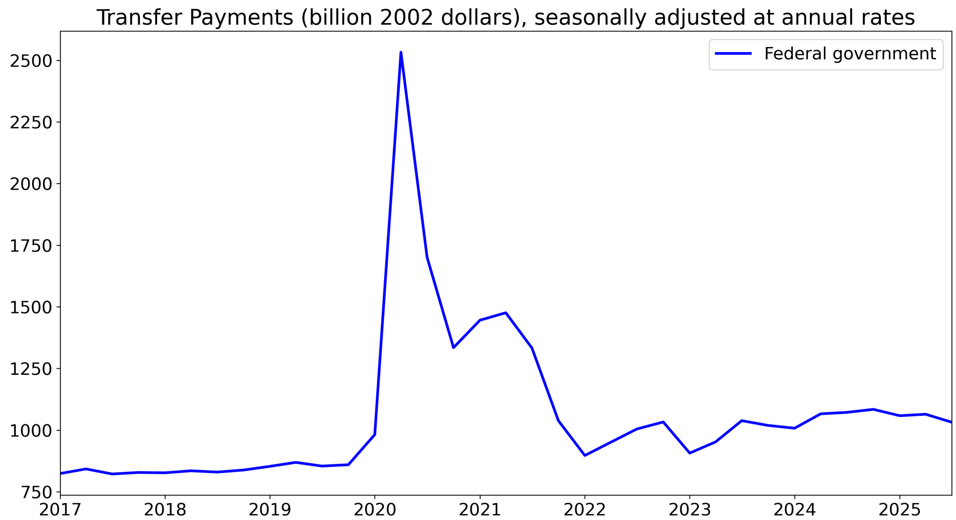
Sims, C. A. (1994). A simple model for study of the determination of the price level and the interaction of monetary and fiscal policy. *Economic theory*, 4:381–399.

Sims, E. and Wu, J. C. (2021). Evaluating central banks' tool kit: Past, present, and future. *Journal of Monetary Economics*, 118:135–160.

Woodford, M. (1994). Monetary policy and price level determinacy in a cash-in-advance economy. *Economic theory*, 4:345–380.

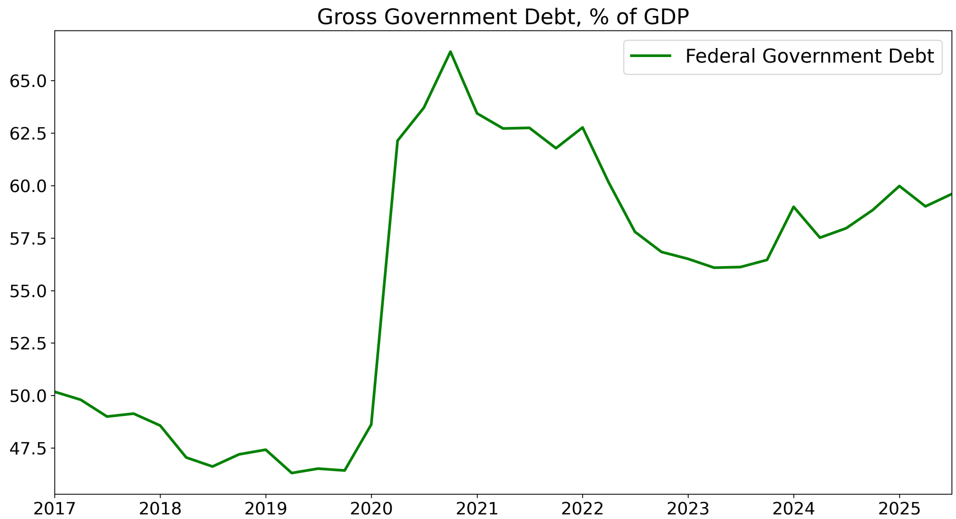
Wu, J. C. and Xie, Y. (2025). Unconventional monetary and fiscal policy. *Review of Economic Dynamics*, 56:101259.

# A Figures



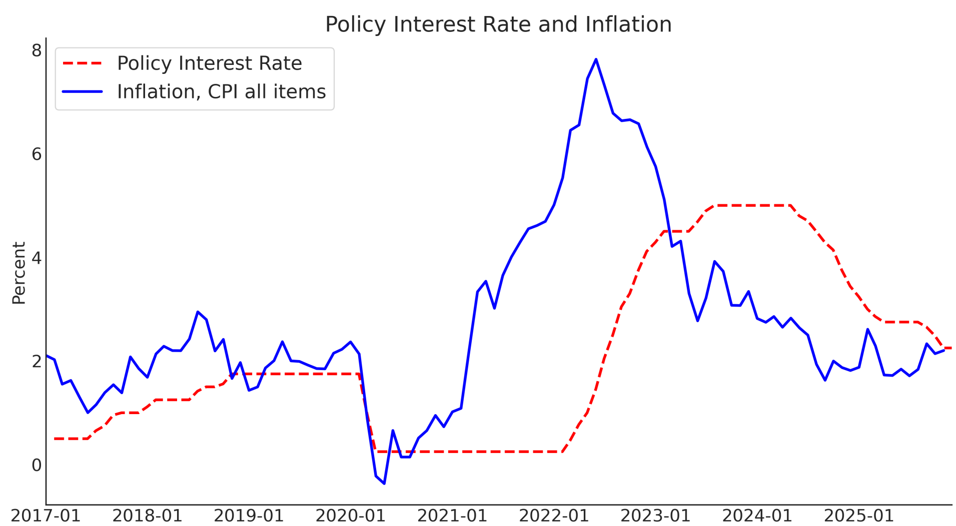

Data source: Transfer payments: Statistics Canada Table 36100477 “Revenue, expenditure and budgetary balance - General governments”, series “Current transfers to households” from the Federal General Government.

Figure 1: Transfer Payments



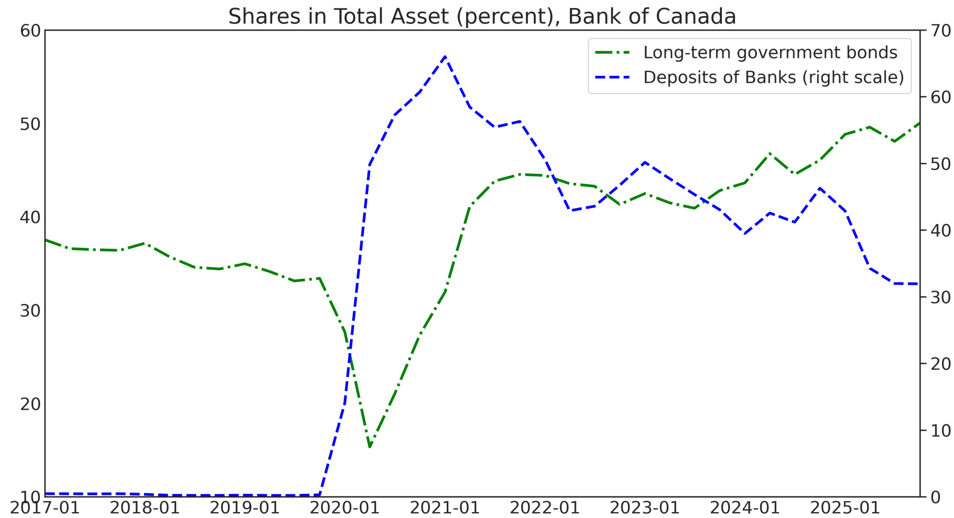

Data source: Federal government debt to GDP ratio: Statistics Canada Table 38100237 "Financial indicators of general government sector, national balance sheet accounts", series "Federal general government gross debt to gross domestic product (GDP)". GDP: Statistics Canada Table 36100104 "Gross domestic product, expenditure-based, Canada, quarterly", series "Gross domestic product at market prices" in current prices.

Figure 2: Government Debt



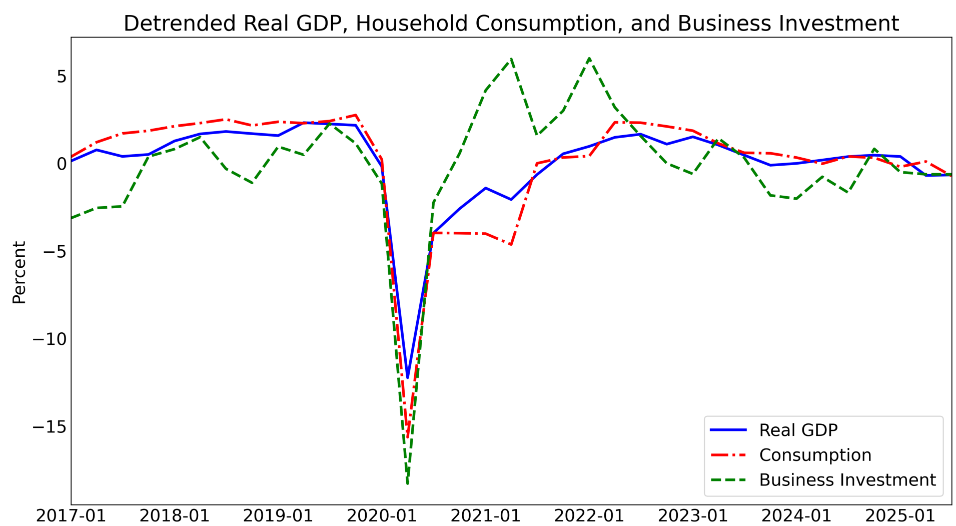

Data source: Policy interest rate: Statistics Canada Table 10100139 "Bank of Canada, money market and other interest rates", series "Target rate". Inflation rate is calculated as 12-month percent change in the series "All-items" in Statistics Canada Table 18100004 "Consumer Price Index by product group, monthly, percentage change, not seasonally adjusted, Canada, provinces, Whitehorse, Yellowknife and Iqaluit".

Figure 3: Policy rates and inflation since 2017




Data source: Statistics Canada Table 10100108 "Bank of Canada, assets and liabilities, at month-end". Long-term government bonds: the total amount of series "Government Of Canada, Bonds, Over 3 Years To 5 Years", "Government Of Canada, Bonds, 5 Years To 10 Years", and "Government Of Canada, Bonds, Over 10 Years". Reserves: series "Canadian Dollar Deposits, Members Of Payments Canada". Total asset: series "Total Assets".

Figure 4: Long-term Government Bonds and Reserves held by Bank of Canada




Data source: Statistics Canada Table 36100104 "Gross domestic product, expenditure-based, Canada, quarterly". Household consumption: series "Household final consumption expenditure" in chained (2017) dollars. Business investment: series "Business gross fixed capital formation" in chained (2017) dollars. Real GDP: series "Gross domestic product at market prices" in chained (2017) dollars.

Figure 5: Declines in Real GDP, Investment, and Consumption during the Pandemic

Figure 6: Baseline

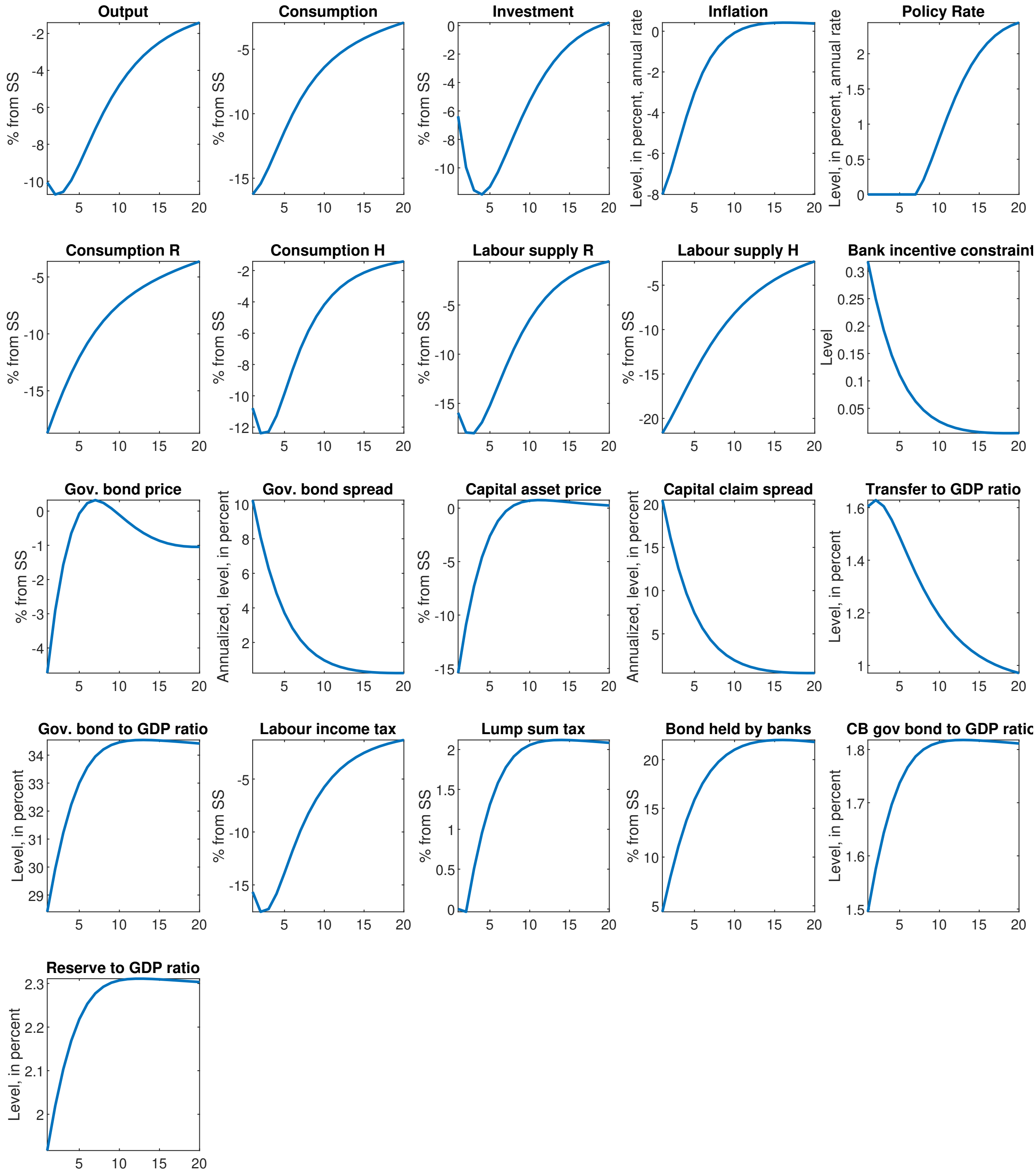


Figure 7: Effect of Transfers

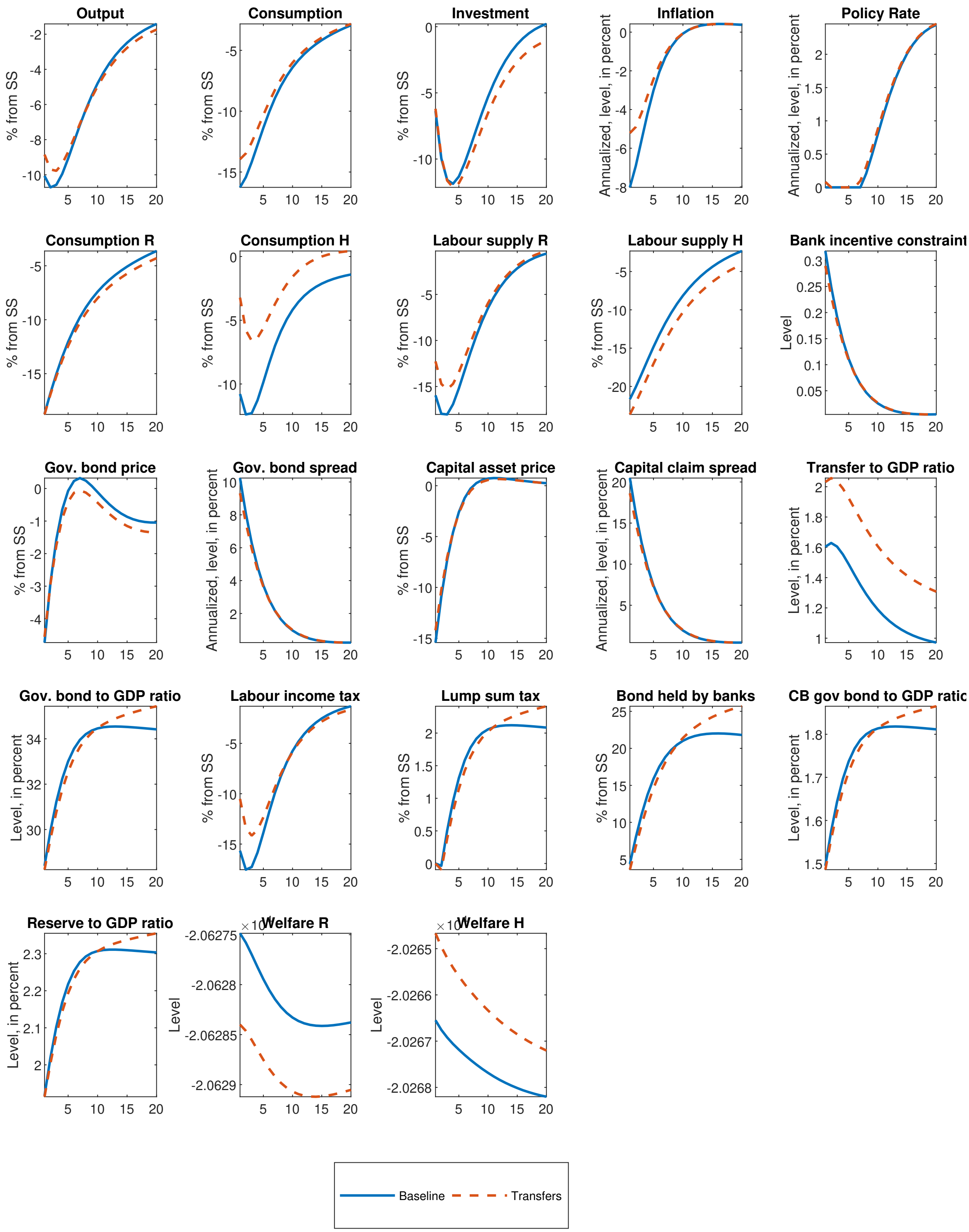


Figure 8: Effect of QE

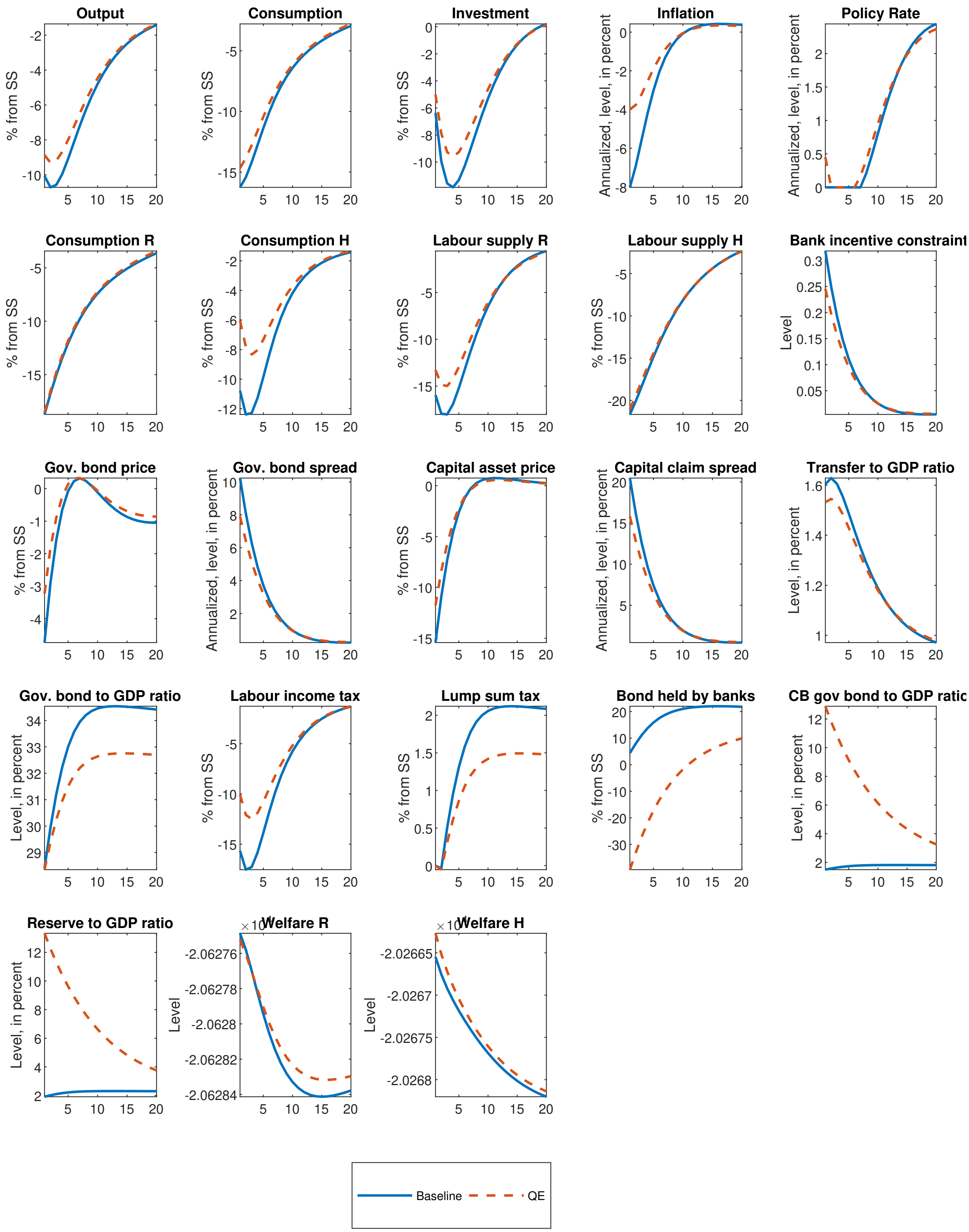


Figure 9: Effect of FG

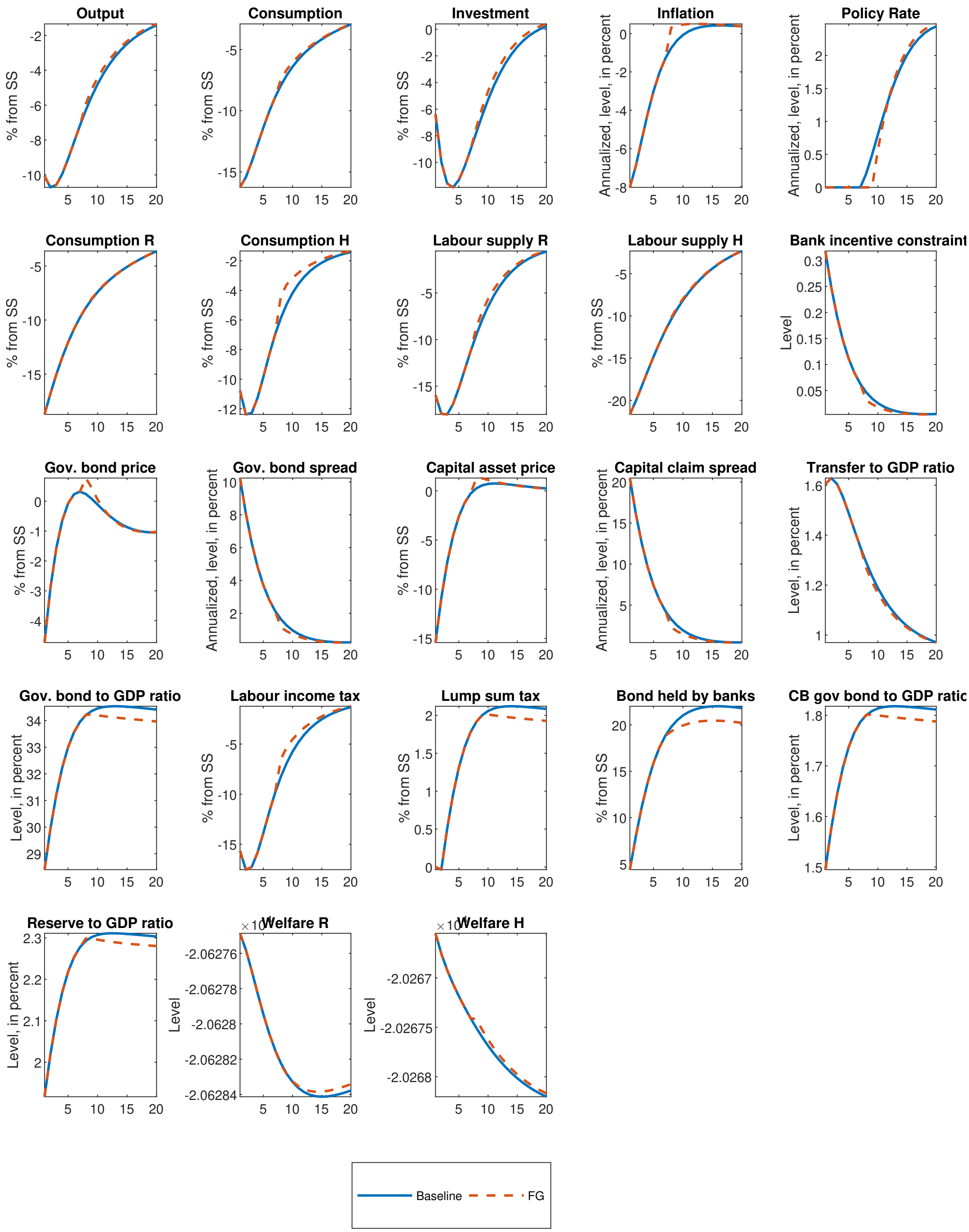


Figure 10: Transfer, QE, and FG

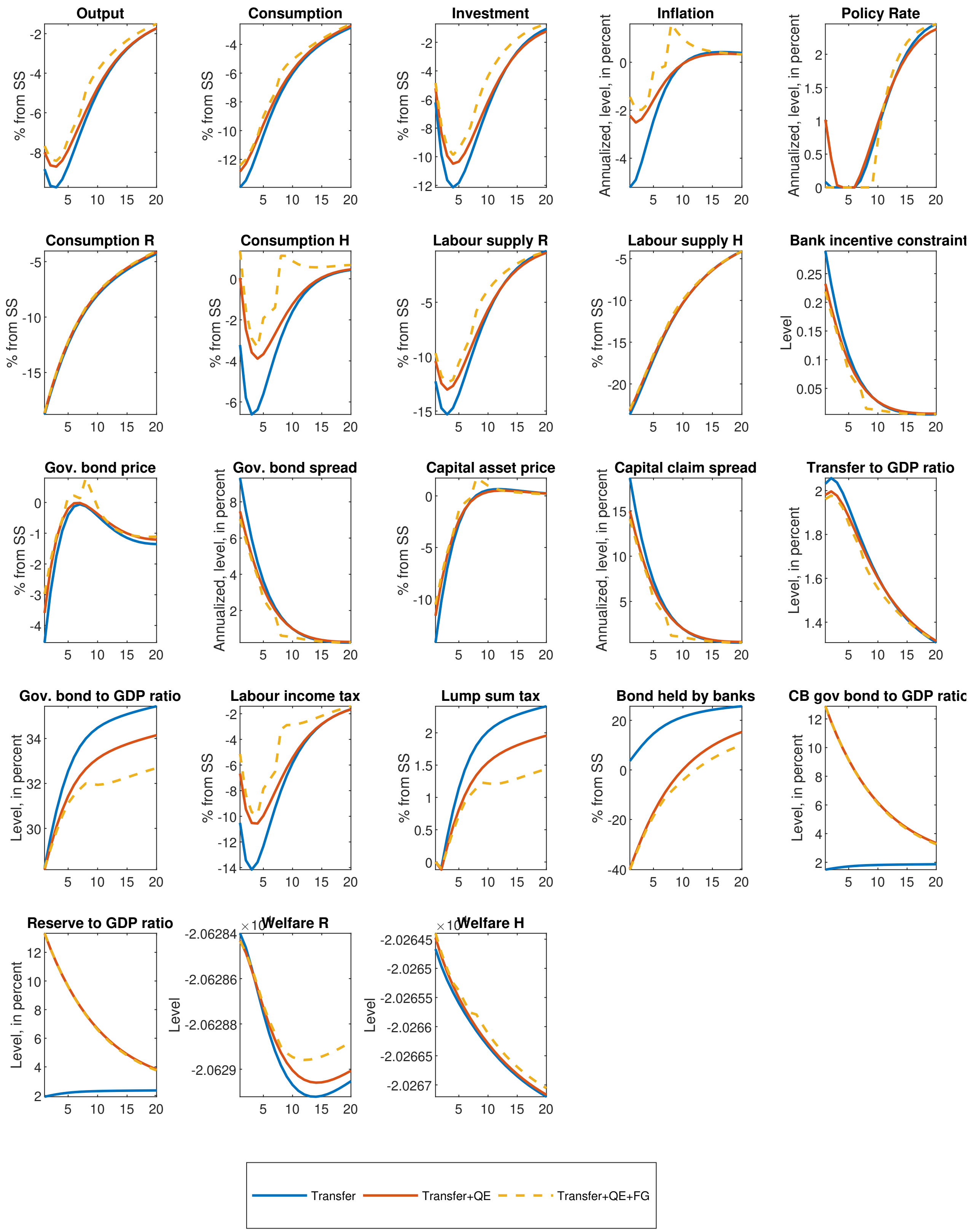


Figure 11: Macroeconomic Policy and Technology Shock

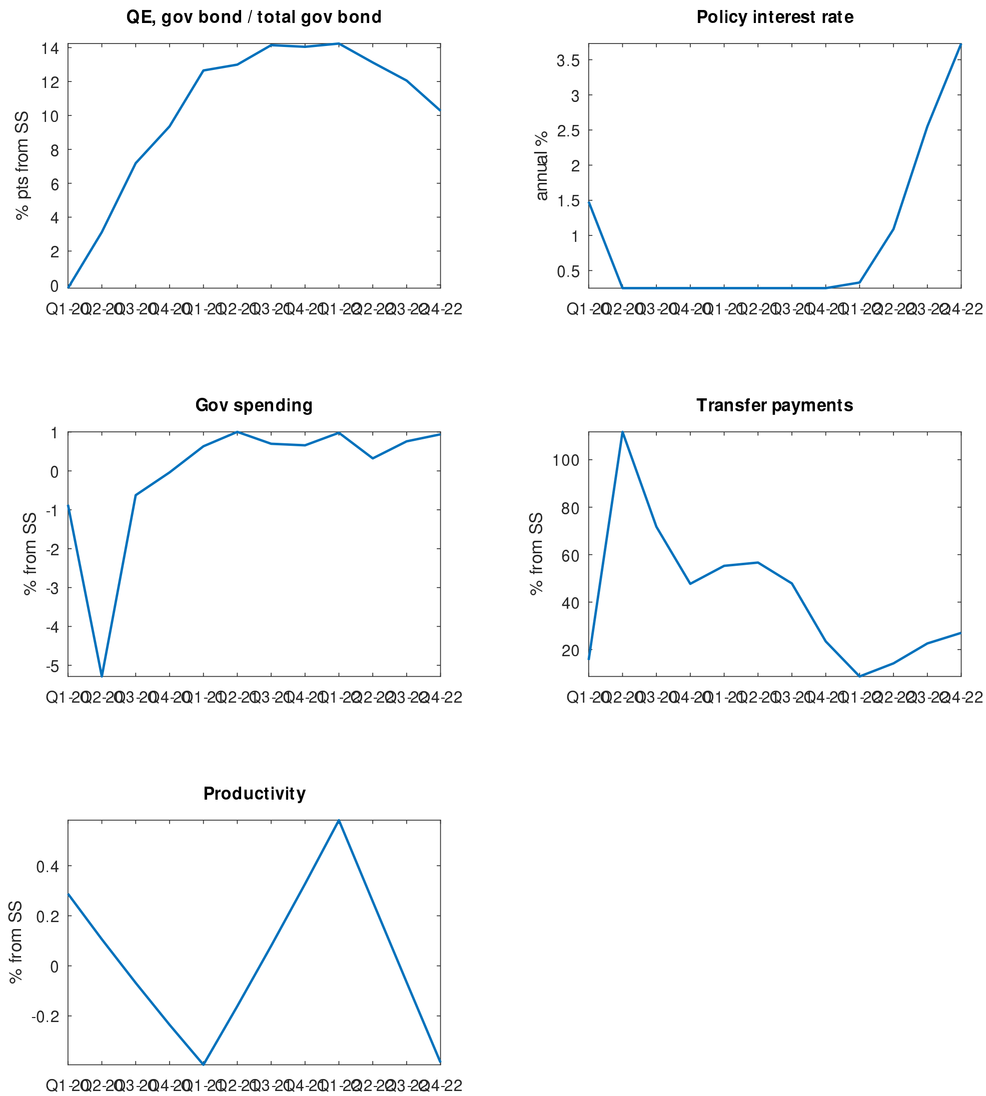


Figure 12: Shock series – pandemic-related

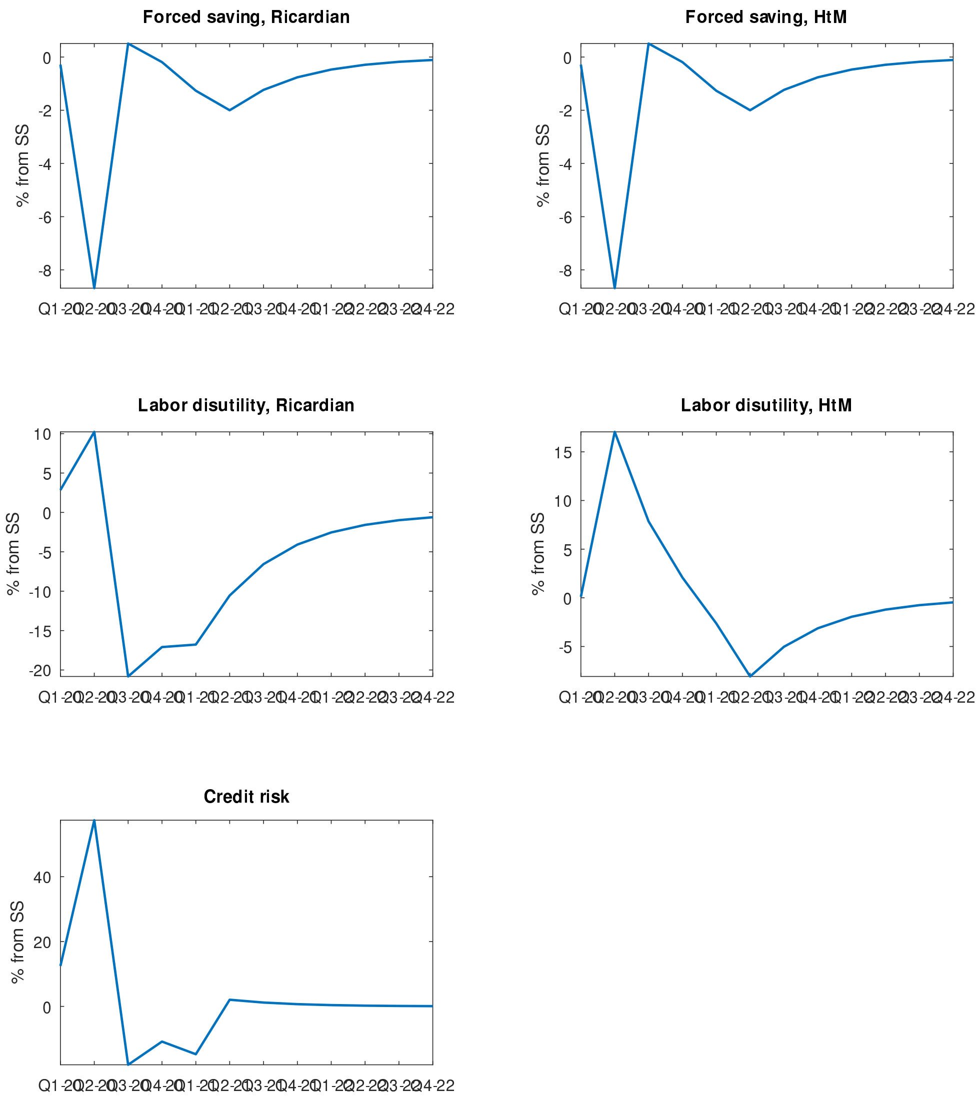


Figure 13: Dynamics of the model economy and the data

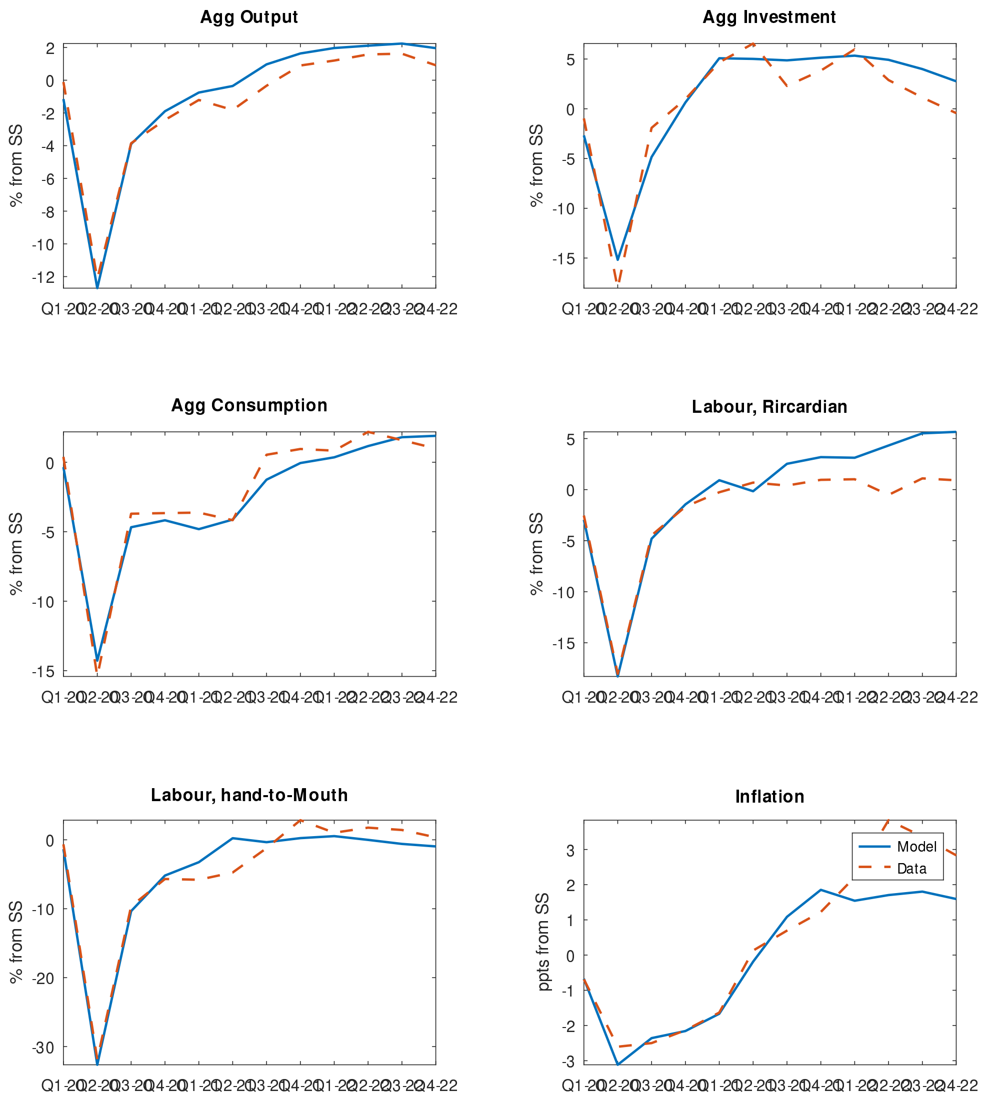


Figure 14: Policy Effects: Levels

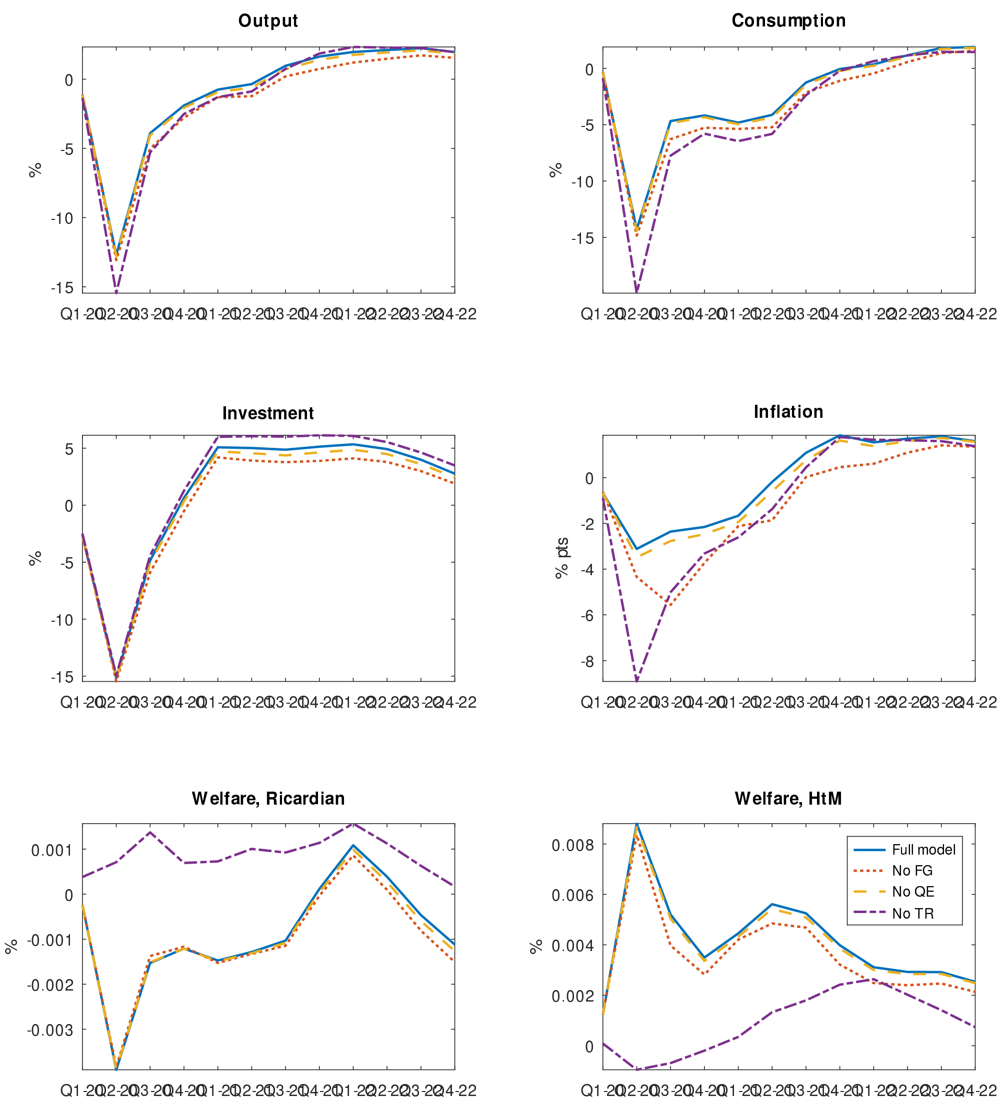


Figure 15: Policy Effects: Gaps

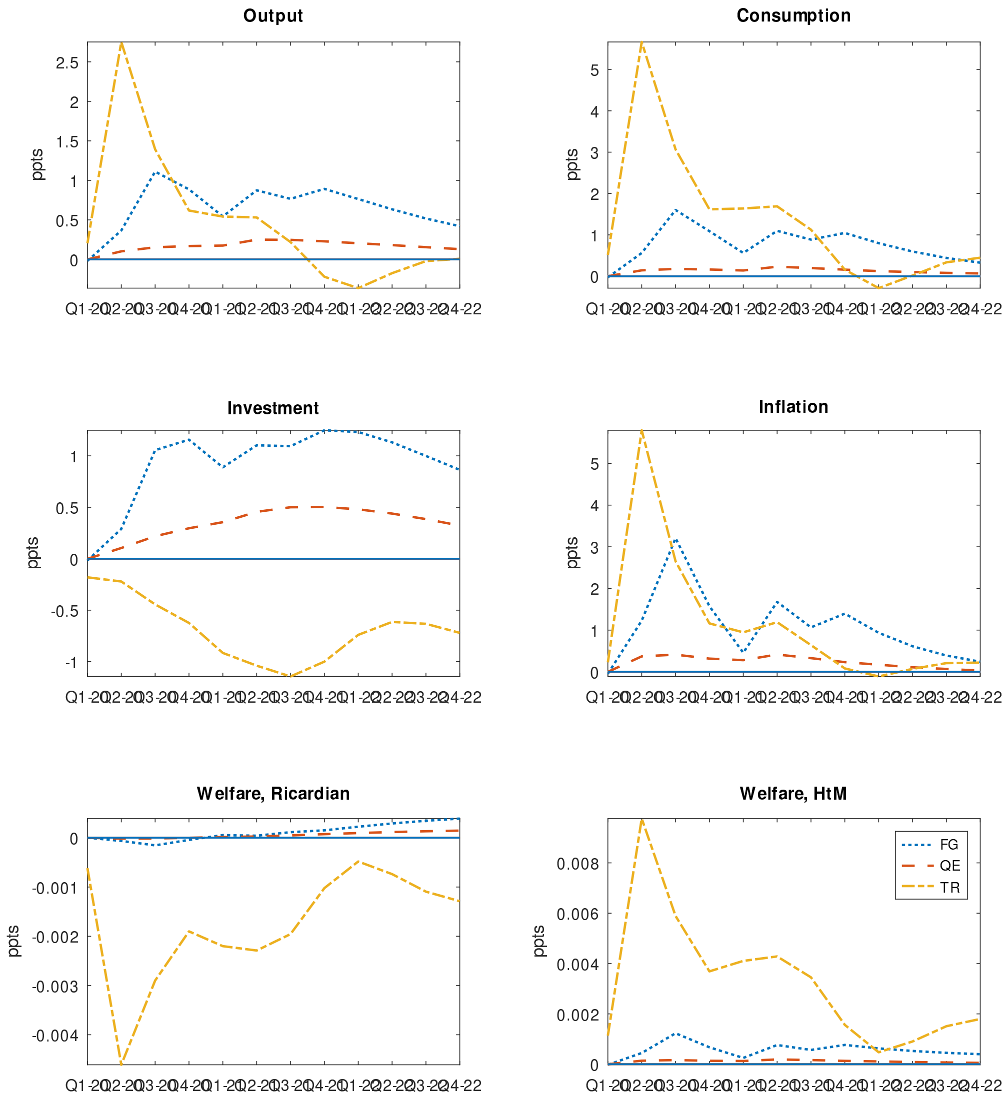


Figure 16: Effects on Households: level

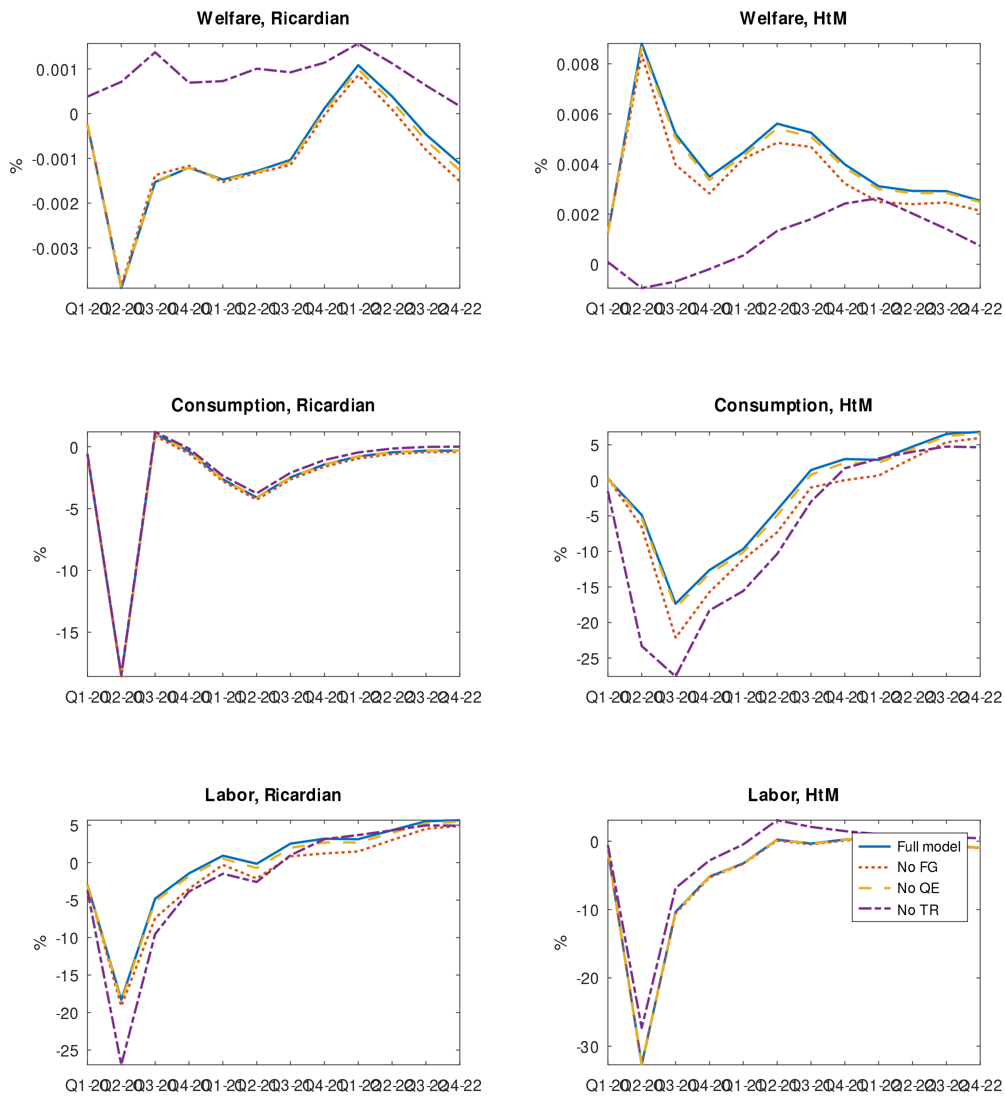


Figure 17: Effects on Households: Gaps

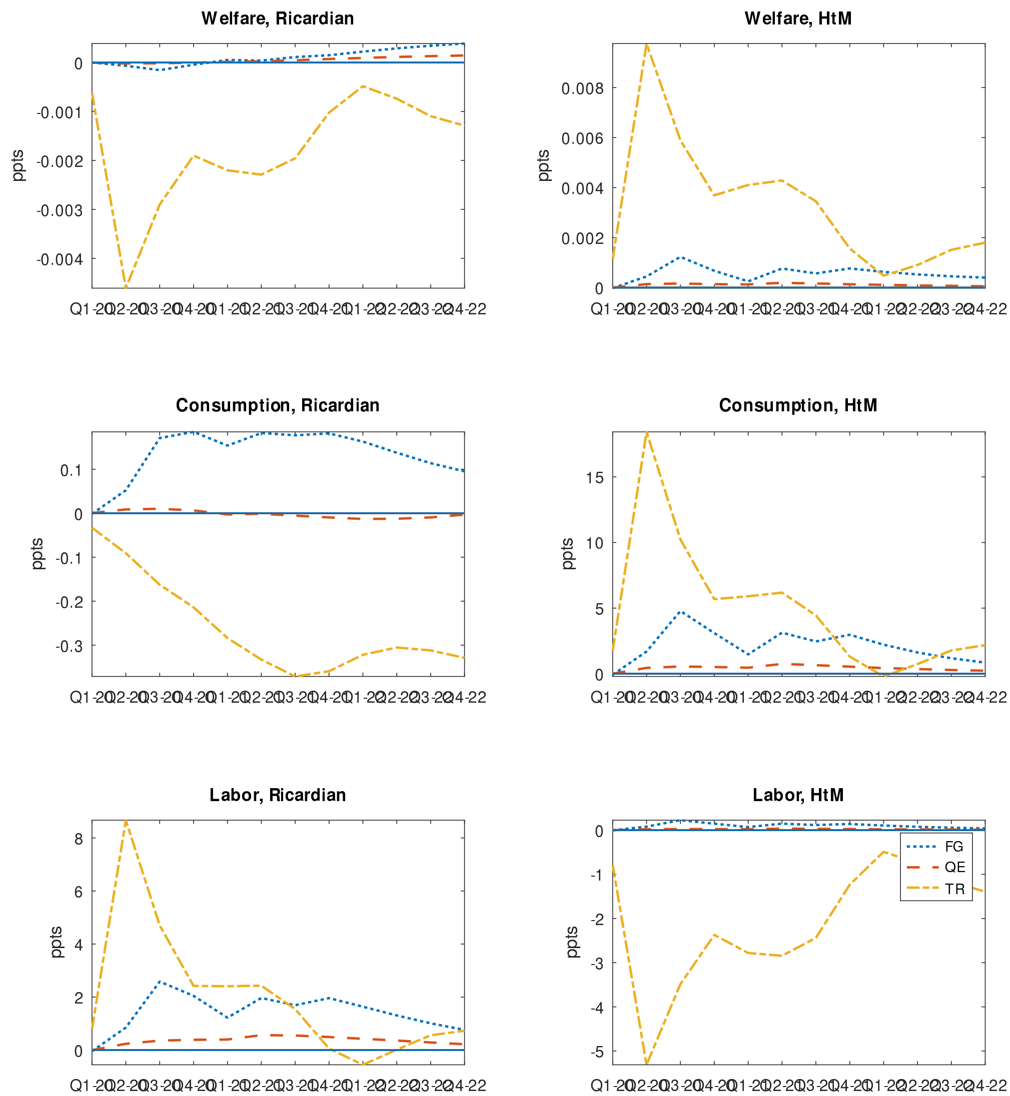


Figure 18: Shortened Monetary Policy: levels

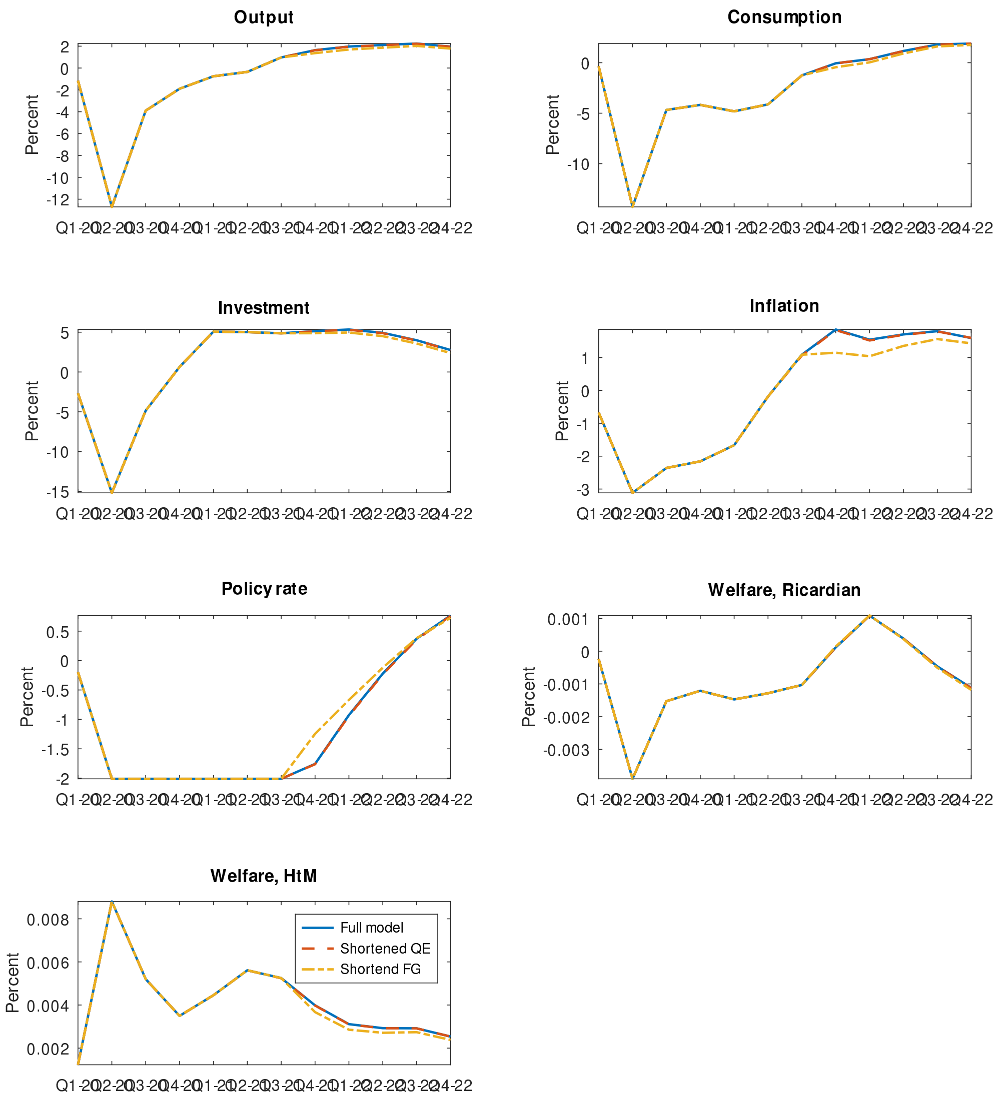
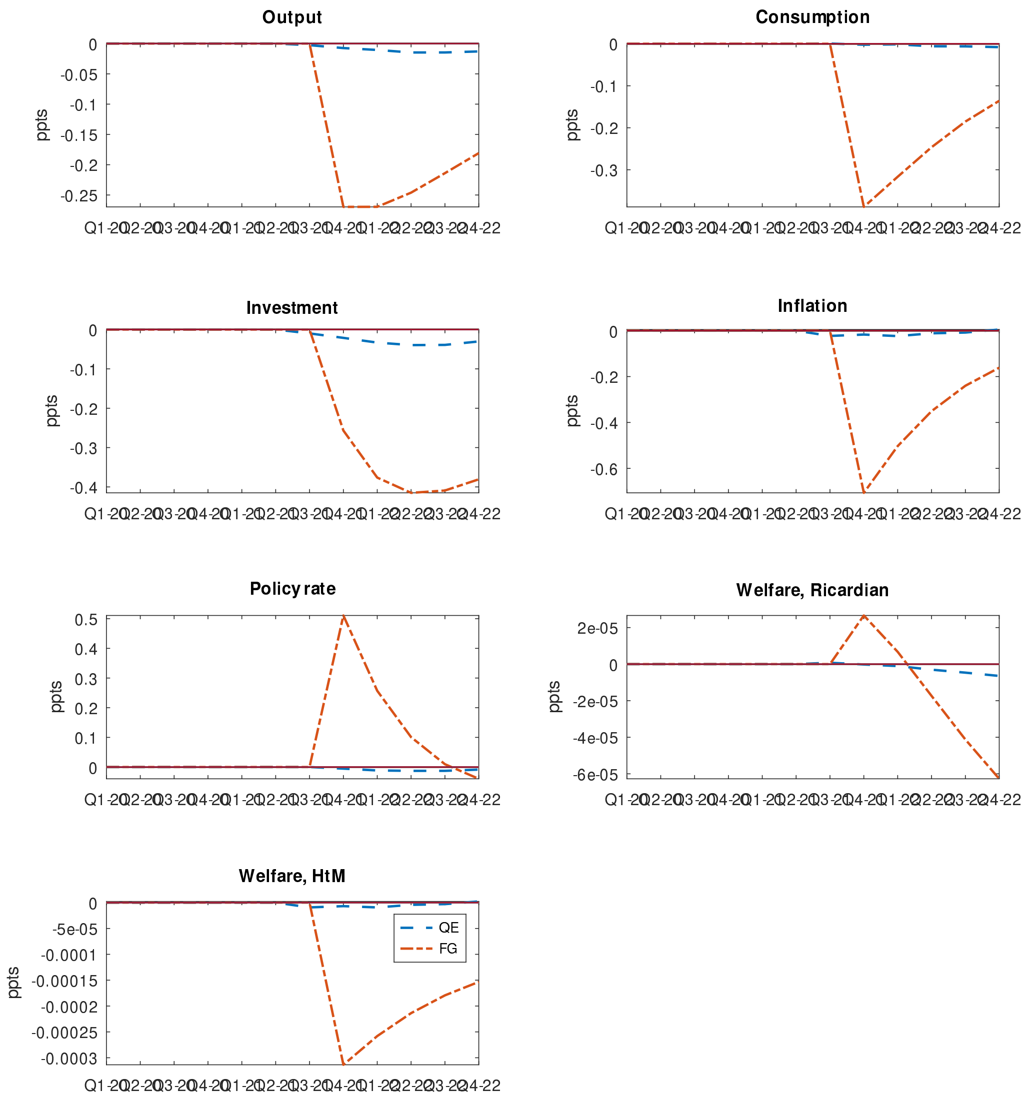


Figure 19: Shortened Monetary Policy: gaps



**Below are not intended for publication**

# B The rest of the model

## B.1 Firms

There are two types of firms: wholesale firms, who produce intermediate good $y_t^m$, and retailers, who would re-package the wholesale goods to produce final goods $y_t$.

### B.1.1 Intermediate good firms

To produce the intermediate goods $y_t^m$, firms use labour and capital as inputs. The production function is as follows.

$$y_t^m = A_t(k_t)^{1-\alpha-\theta}(L_t^R)^\alpha(L_t^H)^\theta. \tag{35}$$

where $L_t^R = (1-\omega)l_t^R$, and $L_t^H = \omega l_t^H$. Let wholesale goods' price be $P_t^w$, and the price for capital goods be $P_t^k$. Define $p_t^w = P_t^w/P_t$, $q_t^k = P_t^k/P_t$ as relative prices. $A_t$ is the productivity shock, following an AR(1) process as follows:

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_t^A, \qquad \varepsilon_t^A \sim i.i.d.N(0, \sigma^2_{\varepsilon^A}),$$

The labour demand for both types of households is static, and they are

$$\alpha p_t^w \frac{y_t^m}{L_t^R} = (1-s_t)w_t^R,$$

and

$$\theta p_t^w \frac{y_t^m}{L_t^H} = (1-s_t)w_t^H.$$

where $s_t$ is the wage subsidy rate.

It is assumed that the wholesale goods producers acquire capital from capital producers at the end of $t-1$ for use in production in period $t$. After production, they sell the underappreciated capital in the open market. To finance the purchase, firms need to obtain funds from banks. We follow GK (2013) to assume that for each unit of new capital acquired, firms issue a capital claim. To be precise, at the end of each period $t$, to finance capital acquisition $k_{t+1}$ to use for the next period production, firms issue a state contingent claim $s_t^k$, with $q_t^k s_t^k = q_t^k k_{t+1}$.

The firms are competitive and earn zero profits. At the end of period $t$, the return of capital from is

$$R_{k,t} = \frac{mpk_t + (1-\delta)q_t^k}{q_{t-1}^k}. \tag{36}$$

where $\delta$ is the capital depreciation rate, and $mpk_t$ is the marginal product of capital with

$$mpk_t = (1-\alpha-\theta)p_t^w \frac{y_t^m}{k_t}.$$

### B.1.2 Capital goods producers

Capital goods producers operate in a competitive market. They purchase the final goods $i_t$ at price $P_t$ from retailers, and transform them into investment goods subject to capital adjustment costs. They then sell capital to firms at the price of $P_t^k$. Following Christiano, Eichenbaum and Evans (2005), we assume that capital producers face investment adjustment costs $S(i_t, i_{t-1})$, such that in steady state $S = S' = 0$ and $S'' = \chi^k > 0$, and $\chi^k > 0$ is an investment adjustment cost parameter. We assume that households own capital producers and the capital producer solves for $i_t$ to maximize

$$\max E_t \sum_{\tau=0}^{\infty} \beta^\tau \Lambda_{t,t+\tau} \left( P_{t+\tau}^k \left[ 1 - S_k(\frac{i_{t+\tau}}{i_{t+\tau-1}}) \right] i_{t+\tau} - P_{t+\tau} i_{t+\tau} \right)$$

where $\Lambda_{t,t+\tau} \equiv \lambda_{t+\tau}^R / \lambda_t^R$. Let functional form for $S(i_t, i_{t-1})$ be

$$S(i_t, i_{t-1}) = 0.5\chi^k (\frac{i_t}{i_{t-1}} - 1)^2.$$

Define that

$$q_t^k = \frac{P_t^k}{P_t}.$$

We can show that the first-order condition for $i_t$ is

$$q_t^k = 1 + 0.5 q_t^k \chi^k (\frac{i_t}{i_{t-1}} - 1)^2 + q_t^k \chi^k (\frac{i_t}{i_{t-1}} - 1)(\frac{i_t}{i_{t-1}}) - E_t \beta \Lambda_{t,t+1} q_{t+1} \chi^k (\frac{i_{t+1}}{i_t} - 1)(\frac{i_{t+1}}{i_t})^2. \quad (37)$$

The aggregate stock of capital evolves as follows:

$$k_{t+1} = (1 - \delta^k) k_t + i_t, \quad (38)$$

where $\delta^k$ is the capital depreciation rate.

### B.1.3 Retailers

There are continuum of retailers of mass 1, indexed by $j$. They buy intermediate goods from wholesale goods producers at $P_t^w$ in a competitive market and differentiate the goods at no costs into final goods $y_t(j)$ at the price $P_t(j)$.

The final goods $y_t$ is the composite of individual variety,

$$y_t = \left[ \int_0^1 y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

The price index that minimizes the final producers' cost function is

$$P_t = \left[ \int_0^1 P_t(j)^{1-\varepsilon} dj \right]^{\frac{1}{1-\varepsilon}}.$$

The demand function faced by each retailer is given by

$$y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon} y_t. \tag{39}$$

Following Calvo (1983), in each period, only a fraction $1-\nu$ of retailers reset their prices, while the remaining retailers keep their prices unchanged. The retailer chooses price $P_t(j)$ to maximize its expected real total profit over the periods during which its prices remain fixed:

$$E_t \Sigma_{i=0}^{\infty} \nu^i \beta^i \Lambda_{t,t+i} \left[\frac{P_t(j)}{P_{t+i}} y_{t+i}(j) - mc_{t+i} y_{t+i}(j)\right]$$

where $mc_t = p_t^w$, is the real marginal cost, namely, the price of wholesale goods relative to the price of sectoral final goods. Note here we use $\lambda_t^R$ for the subjective discount factor since firms are owned by the Ricardian households. Let $P_t^*$ be the optimal price chosen by all firms $j$ adjusting at time $t$.

Let $\Delta_{t,t+i} = \beta^i \Lambda_{t,t+i}$, the first-order condition for the optimal price $P_t^*$ gives us

$$P_t^* = \left(\frac{\varepsilon}{\varepsilon - 1}\right) \frac{E_t \sum_{i=0}^{\infty} \nu^i \Delta_{t,t+i} mc_{t+i} y_{t+i} P_{t+i}^{\varepsilon}}{E_t \sum_{i=0}^{\infty} \nu^i \Delta_{t,t+i} y_{t+i} P_{t+i}^{\varepsilon-1}}. \tag{40}$$

The aggregate price evolves according to:

$$P_t = [\nu P_{t-1}^{1-\varepsilon} + (1-\nu)(P_t^*)^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}. \tag{41}$$

Dividing by $P_t^{1-\varepsilon}$, and define $p_t^* = \frac{P_t^*}{P_t}$,we have the following equation in terms of inflation,

$$1 = \nu \pi_t^{\varepsilon-1} + (1-\nu)(p_t^*)^{1-\varepsilon}. \tag{42}$$

Note that due to sticky prices, firms are subject to price setting frictions. As a result, there is a price dispersion and this is a distortion in the economy. Define $\upsilon_t^p$ the measure of price dispersion

$$\upsilon_t^p = \int_0^1 \left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon} dj$$

$\upsilon_t^p$ would be one if there is no price dispersion, and it is bound from blow by unity. Using the fact that a fraction of $1-\nu$ of the firms can choose the optimal price $P_t^*$, and a fraction of $\nu$ of the firms have to keep the last period's price $P_{t-1}(j)$, $\upsilon_t^p$ can be expressed as

$$\upsilon_t^p = (1-\nu)(p_t^*)^{-\varepsilon} + \pi_t^{\varepsilon} \int_{1-\nu}^1 \left(\frac{P_{t-1}(j)}{P_{t-1}}\right)^{-\varepsilon} dj. \tag{43}$$

Using the fact that price adjustment is purely random, taking the sum of a subset of previous prices is just proportional to summing over all previous prices. That is

$$\int_{1-\nu}^{1} \left(\frac{P_{t-1}(j)}{P_{t-1}}\right)^{-\varepsilon_t} dj = \nu \int_{0}^{1} \left(\frac{P_{t-1}(j)}{P_{t-1}}\right)^{-\varepsilon_t} dj = \nu \upsilon_{t-1}^{p} \tag{44}$$

Substitute equation (44) to (43), now we have

$$\upsilon_t^p = (1-\nu)(p_t^*)^{-\varepsilon} + \pi_t^{\varepsilon} \nu \upsilon_{t-1}^p.$$

# C Additional derivations for the banking sector

To solve the problem, following Gertler and Kiyotaki (2010), we use the undetermined coefficients method – we guess that the bank's value function is a linear function of net worth

$$V_{jt} = \mu_{n,t} n_{jt}, \tag{45}$$

where $\mu_{n,t}$ can be thought of as the expected discounted marginal gain of having one more unit of net worth. The Lagrangian is

$$L = E_t\{\Delta_{t,t+1}[(1-\sigma)n_{jt+1} + \sigma V_{jt+1}(n_{jt+1})] - \lambda_{bank}(\kappa^k q_t^k s_{jt}^b + \kappa^b q_t^b b_{jt}^b + \kappa^{re} re_{jt} - V_{jt})\}, \tag{46}$$

where $\lambda_{bank}$ is the multiplier on the incentive constraint.

The first order condition with respect to $s_{jt}^{k,b}$ is

$$\frac{dL}{ds_{jt}^{k,b}} = E_t\{\Delta_{t,t+1}[(1-\sigma)\frac{dn_{jt+1}}{ds_{jt}^{k,b}} + \sigma \frac{dV_{jt+1}}{dn_{jt+1}} \frac{dn_{jt+1}}{ds_{jt}^{k,b}} - \lambda_{bank}\kappa^K q_t^k]\} = 0, \tag{47}$$

Equation (21) gives

$$\frac{dV_{jt+1}}{dn_{jt+1}} = \mu_{n,t+1}$$

and equation (17) gives

$$\frac{dn_{jt+1}}{ds_{jt}^{k,b}} = (R_{k,t+1} - R_t^d)\frac{q_t^k}{\pi_{t+1}}$$

Thus, we have

$$E_t\Delta_{t,t+1}[((1-\sigma) + \sigma\mu_{n,t+1})\frac{(R_{k,t+1} - R_t^d)}{\pi_{t+1}}] = \lambda_{bank}\kappa^K. \tag{48}$$

Note that although both $R_{k,t+1}$ and $R_{t+1}^d$ have subscript $t+1$, $R_{t+1}^d$ is known at time $t$, while $R_{k,t+1}$ is not known since $R_{k,t+1} = \frac{mpk_{t+1} + (1-\delta)q_{t+1}^k}{q_t^k}$.

Similarly, the first order condition with respect to $B_t^b$ is

$$\frac{dL}{dB_{jt}^b} = E_t\{\Delta_{t,t+1}[(1-\sigma)\frac{dn_{jt+1}}{db_{jt}^b} + \sigma \frac{dV_{jt+1}}{dn_{t+1}} \frac{dn_{jt+1}}{db_{jt}^b} - \lambda_{bank}\kappa_t^B q_t^b]\} = 0, \tag{49}$$

which is

$$E_t\Delta_{t,t+1}[((1-\sigma)+\sigma\mu_{n,t+1})\frac{R_{b,t+1}-R_t^d}{\pi_{t+1}}]=\lambda_{bank}\kappa_t^b. \tag{50}$$

Similarly, the first order condition with respect to $re_{jt}$ is

$$\frac{dL}{dRE_{jt}}=E_t\{\Delta_{t,t+1}[(1-\sigma)\frac{dn_{t+1}}{dre_t}+\sigma\frac{dV_{jt+1}}{dn_{jt+1}}\frac{dn_{jt+1}}{dre_{jt}}-\lambda_{bank}\kappa_t^{re}]\}=0, \tag{51}$$

that is

$$E_t\Delta_{t,t+1}[((1-\sigma)+\sigma\mu_{n,t+1})\frac{R_{t+1}^{RE}-R_t^d}{\pi_{t+1}}]=\lambda_{bank}\kappa_t^{re}. \tag{52}$$

Denote $\Delta^B=\frac{\kappa_t^B}{\kappa_t^K}$ and $\Delta^{RE}=\frac{\kappa_t^{RE}}{\kappa_t^K}$ and define bank's modified leverage as

$$\phi_t=\frac{q_t^k s_{jt}^{k,b}+\Delta^b q_t^b b_{jt}^b+\Delta^{re}re_{jt}}{n_{jt}}=\frac{a_{tj}^{adj}}{n_{jt}},$$

where $a_{tj}^{adj}=q_t^k s_{jt}^{k,b}+\Delta^b q_t^b b_{jt}^b+\Delta^{re}re_{jt}$ is the assets adjusted by diversion rate. Later on, we assume that $\Delta^{RE}=0$, and $\phi_t=\frac{q_t^k s_{jt}^{k,b}+\Delta^b q_t^b b_{jt}^b}{n_{jt}}$.

Note that equations (50) and (**??**) give us

$$\begin{aligned}&\Delta^b E_t\Delta_{t,t+1}[((1-\sigma)+\sigma\mu_{n,t+1})\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}] && (53)\\ = \; & E_t\Delta_{t,t+1}[((1-\sigma)+\sigma\mu_{n,t+1})\frac{R_{b,t+1}-R_t^d}{\pi_{t+1}}], && (54)\end{aligned}$$

and equations (48) and (50) imply

$$\begin{aligned}&\Delta^{re} E_t\Delta_{t,t+1}[((1-\sigma)+\sigma\mu_{n,t+1})\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}] && (55)\\ = \; & E_t\Delta_{t,t+1}[((1-\sigma)+\sigma\mu_{n,t+1})\frac{R_{re,t+1}-R_t^d}{\pi_{t+1}}], && (56)\end{aligned}$$

Given the above equations and the definition of $\phi_t$, we can rewrite equation (17) as

$$
\begin{aligned}
n_{jt+1} &= \frac{R_{b,t+1}-R_t^d}{\pi_{t+1}}q_t^b b_{jt}^b + \frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}q_t^k s_{jt}^{k,b} + \frac{R_t^{re}-R_t^d}{\pi_{t+1}}re_{jt} + R_t^d\frac{n_{jt}}{\pi_{t+1}} && (57)\\
&= \Delta^b\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}q_t^b b_{jt}^b + \frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}q_t^k s_{jt}^{k,b} + \Delta^{re}\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}re_{jt} + R_t^d\frac{n_{jt}}{\pi_{t+1}} && (58)\\
&= (q_t^k s_{jt}^{k,b} + \Delta^b q_t^b b_{jt}^b + \Delta^{re} re_{jt})\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}} + R_t^d\frac{n_{jt}}{\pi_{t+1}} && (59)\\
&= \{\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}\phi_t + \frac{R_t^d}{\pi_{t+1}}\}n_{jt} && (60)
\end{aligned}
$$

Define

$$z_t = \frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}\phi_t + \frac{R_t^d}{\pi_{t+1}},$$

we have

$$n_{jt+1} = z_t n_{jt}.$$

Below, we verify whether our guess is correct and that the bank's value is indeed linear in net worth with

$$\mu_{n,t} = E_t\{\Delta_{t,t+1}((1-\sigma)+\sigma\mu_{n,t+1})\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}\phi_t + R_t^d/\pi_{t+1}\},$$

To verify, we substitute $V_{jt} = \mu_{n,t}n_{jt}$ and equation (17) into the value function equation (19), and we have

$$
\begin{aligned}
V &= E_t\{\Delta_{t,t+1}((1-\sigma)n_{jt+1} + \sigma V_{jt+1})\}\\
&= E_t\{\Delta_{t,t+1}((1-\sigma)+\sigma\mu_{n,t+1})\{(\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}\phi_t + \frac{R_t^d}{\pi_{t+1}})n_{jt}\}.
\end{aligned}
$$

This confirms our conjecture of $\mu_{n,t}$:

$$\mu_{n,t} = E_t\{\Delta_{t,t+1}[(1-\sigma)+\sigma\mu_{n,t+1}][\frac{R_{k,t+1}-R_t^d}{\pi_{t+1}}\phi_t + \frac{R_t^d}{\pi_{t+1}}]\},$$

and thus we have verified our conjecture that

$$V_{jt} = \mu_{n,t}n_{jt}.$$

With this, the bank's incentive constraint can be rewritten as

$$\mu_{n,t}n_{jt} \geq \kappa^k q_t^k s_{jt}^{k,b} + \kappa^k\Delta^b q_t^b b_{jt}^b + \kappa^k\Delta^v v_{jt}. \tag{61}$$

When the incentive constraint binds, we have

$$\mu_{n,t}n_{jt} = \kappa^k q_t^k s_{jt}^{k,b} + \kappa^k\Delta^B q_t^b b_{jt}^b + \kappa^k\Delta^{RE} v_{jt}. \tag{62}$$

We can then have

$$\mu_{n,t} = \frac{\kappa^k q_t^k s_{jt}^{k,b} + \kappa^k \Delta^B q_t^b b_{jt}^b + \kappa^k \Delta^{RE} v_{jt}}{n_{jt}} = \phi_t \kappa_t^k. \tag{63}$$

Thus

$$\phi_t = \frac{\mu_{n,t}}{\kappa_t^k}. \tag{64}$$

$$\phi_t \kappa_t^k = \mu_{n,t} = E_t\{\beta \Lambda_{t,t+1}[(1-\sigma) + \sigma \mu_{n,t+1}][\frac{R_{k,t+1} - R_t^d}{\pi_{t+1}} \phi_t + \frac{R_t^d}{\pi_{t+1}}]\}$$

Thus the adjusted leverage $\phi_t$ is

$$\phi_t = \frac{E_t\{\beta \Lambda_{t,t+1}[(1-\sigma) + \sigma \phi_{t+1} \kappa_{t+1}^k] R_t^d\}}{\kappa_t^k - E_t\{\beta \Lambda_{t,t+1}[(1-\sigma) + \sigma \phi_{t+1} \kappa_{t+1}^k][\frac{(R_{k,t+1} - R_t^d)}{\pi_{t+1}})\}}. \tag{65}$$

# D List of equations

$$1. \left((c_t^R - \varepsilon_t^{fs}) - h(c_{t-1}^R - \varepsilon_{t-1}^{fs})\right)^{-\sigma^c} - \beta h E_t \left((c_{t+1}^R - \varepsilon_{t+1}^{fs}) - h(c_t^R - \varepsilon_t^{fs})\right)^{-\sigma^c} = \lambda_t^R.$$

$$2. \lambda_t^R = \beta E_t \lambda_{t+1}^R \frac{R_t^d}{\pi_{t+1}}$$

$$3. \chi^R \varepsilon_t^{l^R} (l_t^R)^{\varphi} = \lambda_t^R (1 - \tau^{l^R}) w_t^R.$$

$$4. (c_t^H - \varepsilon_t^{fs})^{-\sigma^c} = \lambda_t^H.$$

$$4a. c_t^H = (1 - \tau^{l^H}) w_t^H l_t^H + tr_t^H.$$

$$5. \chi^H \varepsilon_t^{l^H} (l_t^H)^{\varphi} = \lambda_t^H (1 - \tau^{l^H}) w_t^H.$$

$$6. \Lambda_{t,t+1} = \lambda_{t+1}^R / \lambda_t^R$$

$$7. y_t^m = A_t (k_t)^{1-\alpha-\theta} (L_t^R)^{\alpha} (L_t^H)^{\theta}.$$

$$8. \alpha p_t^w \frac{y_t^m}{L_t^R} = (1 - s_t) w_t^R,$$

$$9. \theta p_t^w \frac{y_t^m}{L_t^H} = (1 - s_t) w_t^H.$$

$$10. mpk_t = (1 - \alpha - \theta) p_t^w \frac{y_t^m}{k_t}.$$

$$11. R_{k,t} = \frac{mpk_t + (1-\delta) q_t^k}{q_{t-1}^k}.$$

$$12. q_t^k = 1 + 0.5 q_t^k \chi^k (\frac{i_t}{i_{t-1}} - 1)^2 + q_t^k \chi^k (\frac{i_t}{i_{t-1}} - 1)(\frac{i_t}{i_{t-1}}) - E_t \beta \Lambda_{t,t+1} q_{t+1}^k \chi^k (\frac{i_{t+1}}{i_t} - 1)(\frac{i_{t+1}}{i_t})^2.$$

$$13. k_{t+1} = (1 - \delta^k) k_t + i_t,$$

$$14. x1_t = mc_t y_t + \nu \Delta_{t,t+1} x1_{t+1} \pi_{t+1}^{\epsilon}$$

$$15. x2_t = y_t + \nu \Delta_{t,t+1} x2_{t+1} \pi_{t+1}^{\varepsilon - 1}$$

$$16. p_t^* = \left( \frac{\varepsilon}{\varepsilon - 1} \right) \frac{x1_t}{x2_t}$$

$$17. 1 = \nu \pi_t^{\varepsilon - 1} + (1 - \nu)(p_t^*)^{1-\varepsilon}.$$

$$18. A_t k_t^{1-\alpha-\theta} L_{Rt}^{\alpha} L_{Ht}^{\theta} = y_t^m = \upsilon_t^p y_t.$$

$$19. \upsilon_t^p = (1 - \nu) p_t^{*-\varepsilon} + \nu \pi_t^{\varepsilon} \upsilon_{t-1}^p.$$

$$20. R_{b,t} = \frac{1 + \kappa q_t^b}{q_{t-1}^b},$$

$$21. a_t^{adj} = q_t^k s_t^{k,b} + \Delta^b q_t^b b_t^b.$$

$$22. \phi_t = \frac{a_t^{adj}}{n_t}.$$

$$23. q_t^k s_t^{k,cb} + q_t^b b_t^{cb} = re_t.$$

$$24. \mu_{n,t} = E_t \{ \Delta_{t,t+1} ((1 - \sigma) + \sigma \mu_{n,t+1}) \frac{R_{k,t+1} - R_t^d}{\pi_{t+1}} \phi_t + R_t^d / \pi_{t+1} \},$$

$$25. E_t \Delta_{t,t+1} [((1 - \sigma) + \sigma \mu_{n,t+1}) \frac{(R_{k,t+1} - R_t^d)}{\pi_{t+1}}] = \lambda_{bank} \kappa_t^K.$$

$$26. E_t \Delta_{t,t+1} [((1 - \sigma) + \sigma \mu_{n,t+1}) \frac{R_{b,t+1} - R_t^d}{\pi_{t+1}}] = \lambda_{bank} \kappa_t^b.$$

$$27. E_t \Delta_{t,t+1} [((1 - \sigma) + \sigma \mu_{n,t+1}) \frac{R_{t+1}^{RE} - R_t^d}{\pi_{t+1}}] = \lambda_{bank} \kappa_t^{re}.$$

$$28. \phi_t = \frac{\mu_{n,t}}{\kappa_t^k}.$$

$$29. n_{t+1} = n_{t+1}^e + n_{t+1}^n$$

$$30. z_t = (R_{k,t+1} - R_t^d) \phi_t + R_t^d$$

$$31. n_{t+1}^e = \sigma z_t n_t$$

$$32. n_{t+1}^n = \omega^b a_t^{adj}$$

$$33.\frac{R_n}{R_{ss}} = (\frac{R_{n-1}}{R_{ss}})^{\rho^r}((\frac{\pi_t}{\pi_{ss}})^{\rho^\pi}(\frac{y_t}{y_{ss}})^{\rho^y})^{1-\rho^r}.$$

$$34.R_n = \max\{0, R_n\}$$

$$35.s_t^{k,cb} = \varphi_t^k s_t$$

$$36.b_t^{cb} = \varphi_t^b b_t,$$

$$37.tr_t^{cb} = re_t + R_{kt}q_{t-1}^k s_{t-1}^{k,cb}/\pi_t + R_{bt}q_{t-1}^b b_{t-1}^{cb}/\pi_t - q_t^k s_t^{k,cb} - q_t^b b_t^{cb} - R_{t-1}^{re} re_{t-1}/\pi_t.$$

$$38.(1+\kappa q_t^b)\frac{b_{t-1}}{\pi_t} + g_t + s_t w_t^H L_t^H + s_t w_t^R L_t^R + tr_{Ht}^{agg} = \tau_t^{agg} + tr_t^{cb} + \tau^{l^R} w_t L_{Rt} + \tau^{l^H} w_t L_{Ht} + q_t^b b_t.$$

$$39.\tau_t^{agg} = (\frac{q_{t-1}^b b_{t-1}}{q_{ss}^b b_{ss}})^{\phi^{tax}} \tau_{ss}^{agg}$$

$$40.\frac{tr_{Ht}^{agg}}{tr_{Hss}^{agg}} = (\frac{tr_{Ht-1}^{agg}}{tr_{Hss}^{agg}})^{\rho^{tr}}((\frac{y_t}{y_{ss}})^{\rho^y})^{1-\rho^{tr}} \zeta_t^{tr}$$

$$\zeta_t^{tr} \sim i.i.d.\, N(0, \sigma_{\zeta^{tr}}^2).$$

$$41.s_t^k = s_t^{k,b} + s_t^{k,cb}.$$

$$42.b_t = b_t^b + b_t^{cb}.$$

$$43.C_t^R + C_t^H + g_t + i_t + 0.5\chi^k(\frac{i_t}{i_{t-1}} - 1)^2 = y_t$$

$$44.L_t^R = (1-\omega)l_t^R$$

$$45.L_t^H = \omega l_t^H$$

$$46.C_t^R = (1-\omega)c_{Rt}$$

$$47.C_t^H = \omega c_{Ht}$$

$$48.\tau_t^{agg} = (1-\omega)\tau_t$$

$$49.tr_{Ht}^{agg} = \omega tr_{Ht}$$

# E Data sources

In the following all tables refer to those downloaded from Statistics Canada website.

**National Income Accounts and fiscal policy.** Table 36100104 “Gross domestic product, expenditure-based, Canada, quarterly”. Table 36100477 “Revenue, expenditure and budgetary balance - General governments”.

Real GDP, Table 36100104, series “Gross domestic product at Market prices”, seasonally adjusted at annual rates.

Household consumption spending, Table 36100104, series “Household final consumption expenditure”, seasonally adjusted at annual rates.

Investment spending, Table 36100104, series "Business gross fixed capital formation", seasonally adjusted at annual rates.

Government spending, Table 36100104, series "General governments final consumption expenditure", seasonally adjusted at annual rates.

Transfer payments, Table 36100477, series "Current transfer to households" by Federal Government.

Federal government bonds, Table 36100580 "National Balance Sheet Accounts", series "Government of Canada bonds".

Total factor productivity, Table 36100208, series "Multifactor productivity", business sector.

CPI inflation, Table 18100006 "Consumer Price Index, monthly, seasonally adjusted", series "All-items".

**Labor inputs.** Labor inputs are measured as hours worked by household types, calculated from the "Labour Force Survey: Public Use Microdata File".[12] Hand-to-mouth workers are those in sectors (2-digit NAICS): Retail trade (44-45), Transportation and warehousing (48-49), Information, culture and recreation (51, 71), and Accommodation and food services (72). Ricardian workers are those working in all other sectors.

**Central bank.** Table 10100108 "Bank of Canada, assets and liabilities, at month-end". Table 10100139 "Bank of Canada, money market and other interest rates".

Long-term government bond is the sum of the following series, all from Table 10100108: "Government Of Canada, Bonds, Over 3 Years To 5 Years", "Government Of Canada, Bonds, 5 Years To 10 Years", "Government Of Canada, Bonds, Over 10 Years".

Reserves, Table 10100108, series "Canadian Dollar Deposits, Members Of Payments Canada".

Policy interest rate, Table 10100139, series "Target rate".

[12] Data files can be downloaded from https://www150.statcan.gc.ca/n1/en/catalogue/71M0001X.