ISSN 1936-5330

kc FED Research Working Papers

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November 2022
RWP 22-15
http://doi.org/10.18651/RWP2022-15

Federal Reserve Bank of Kansas City

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October 31, 2022

Abstract

Following the onset of the pandemic, the Federal Reserve employed an unconventional monetary policy that directly intervened in municipal bond markets. We characterize the fiscal and macroeconomic implications of such central bank actions in a New Keynesian model of a monetary union. We assume that state and local governments are subject to a loan-in-advance constraint, reflecting that with lumpy cash flows, they often finance a fraction of expenditures by issuing short-term bonds. The municipal debt is held by financial intermediaries, who also supply credit to the private sector. Direct central bank purchases can transmit to the economy through two main channels: 1) by alleviating cash flow problems of the regional governments and 2) by accelerating lending to the private sector if credit constraints ease more broadly. By quantifying the relative importance of these channels, we highlight that the central bank's actions lead to sizable increases in private investment but have more muted effects on state and local government expenditures. In addition, we also show the transmission of direct federal government aid through intergovernmental transfers is markedly different from unconventional policy.

Keywords: municipal debt; monetary and fiscal policy interactions; quantitative easing; Municipal Liquidity Facility

*For helpful comments, we thank our discussant Kristina Bluwstein, as well as participants at presentations at the Kansas City Federal Reserve, the National Bank of Belgium, University of Amsterdam, and "The Covid-shock and the new macroeconomic landscape" Conference. The views expressed in this paper are those of the authors and do not represent those of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

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1 Introduction

Countries around the world reacted swiftly and decisively to the COVID-19 pandemic with unprecedented monetary and fiscal policy interventions. In the United States, policymakers rushed to provide provisions related to state and local (S&L) government function, as S&L governments account for close to two thirds of government service assistance, such as education and infrastructure expenditures. In March 2020, the U.S. Congress passed the Coronavirus Aid, Relief, and Economic Security (CARES) act, that included backstop funds for the Federal Reserve to intervene in financial markets as buyers of last resort. With the appropriated funds, the Federal Reserve launched the Municipal Liquidity Facility (MLF) in April 2020, a new form of unconventional policy that allowed direct purchase of short-term notes from eligible municipal bond issuers.[1] The same year, other central banks, including the Bank of Canada and Reserve Bank of Australia, commenced programs purchasing sub-national debt as well.[2]

What are the the fiscal and macroeconomic implications of these policy actions targeting sub-national debt markets? While a direct lending facility can have an immediate impact on financial markets, its impact on local budgets and spending may be more limited in scope and slower to materialize, subduing its short-term stimulative effect on local economic conditions. At the same time, if the policy helps ease credit constraints more broadly in the financial sector, it may additionally accelerate lending and help restore private investment. Characterizing the relevance and importance of such channels requires theory, yet to date the macroeconomic literature abstracts from modeling the nature of as well as restrictions on government debt financing at the sub-national level.

This paper takes up the challenge of evaluating policies targeting sub-national government function. Our contribution to the literature is twofold. First, we develop a two-region monetary-union model that accounts for both national and sub-national fiscal policies. Conditioning the model on U.S. data, we document the transmission of the MLF program and quantify its effects. Second,

[1] Kent Hiteshew gave a Congressional Testimony on September 17, 2020 about the purposes of the MLF. It was intended "to help state and local governments better manage the extraordinary cash flow pressures associated with the pandemic ... also intended to encourage private investors to reengage in the municipal securities market, including across longer maturities, thus supporting overall municipal market functioning."

[2] See Finlay, Titkov, and Xiang (2021) for an assessment of Australia's policy. Bank of Canada's website maintains details on its program.

we contrast the MLF program to alternative policy scenarios including (i) direct aid from the federal government through intergovernmental transfers, i.e., the conventional policy for sub-national governments; and (ii) counterfactual policy measures targeting municipal bonds with different maturities, implemented symmetrically or asymmetrically across states. The later set of policy counterfactuals is useful for future potential central bank interventions, as it replicates interventions adopted by other central banks in the pandemic and characterizes how the effectiveness of the municipal lending facility depends on the design of the program.

S&L governments are an important component of U.S. fiscal policy, as their economic activity accounted for roughly 11 percent of GDP in 2019 compared to 7 percent of GDP from the federal government. Recognizing its importance, a growing literature studies the theoretical effects of local public spending and intergovernmental transfers in New Keynesian models of a monetary union, see Nakamura and Steinsson (2014), Brueckner, Pappa, and Valentinyi (2019), Carlino, Drautzburg, Inman, and Zarra (2021) among others. However, this literature abstracts from modeling the municipal bond market, which is central to the analysis of this paper. Although most S&L governments have some form of a balanced-budget rule, investment projects are often exempt and, therefore, the majority of the $3.8 trillion outstanding municipal bonds are long-term bonds funding capital expenditures. Yet, an often overlooked portion of the municipal market is the short-term municipal notes, which serve as a temporary bridge when expenditures and revenues are misaligned.[3]

Seasonality in tax collection makes short-term borrowing a regular component of sub-national government financing. For instance, state governments, funded primarily with sales or income taxes, receive most income tax collection around the April tax filing deadline and most sales taxes during the summer season and winter holiday months. Figure 1 shows that a nontrivial portion of state expenditures can be financed through short-term notes in some states. On aggregate, however, the short-term municipal bond market is small, averaging about $60 billion dollars between 2007 and 2019 and contributing to 2.5 percent of S&L government consumption expenditures. Nevertheless, during an economic downturn, the short-term municipal bond market can suddenly become more pivotal in maintaining S&L government activity, as tax revenues may be delayed or weakened and other funding sources quickly evaporate. The pandemic invoked such a crisis, as municipal bond

[3]The maturities of these municipal short-term securities can vary from 3 months to 3 years, but usually mature within 13 months.

Figure 1: Percent of short-term notes financing state expenditures. Data from individual state annual financial reports of California and Texas.

market yields rose markedly, particularly for bonds with short remaining maturities. For instance, in mid-March 2020 yields on municipal securities with one-year remaining maturity rose 25 times higher than Treasury yields with comparable maturity.[4] In this case, a lending facility that targets this segment of the municipal bond market, such as the MLF introduced by the Federal Reserve, can have a significant impact on municipal bond yields and, potentially, on S&L economic activity.

To study the effects of such a lending facility, we build a two-region New Keynesian model of a monetary union that explicitly accounts for sub-national government financing. Building on Nakamura and Steinsson (2014), each region consists of households, firms, and a local government. The local government uses tax revenue from consumption expenditures and income as well as transfers from federal government to fund public expenditures. To capture a timing misalignment between expenditures and revenues, we assume that the government is also subject to a loan-in-advance constraint, whereby it must finance a fraction of its consumption by issuing short-term bonds. This type of constraint is common in models of private firm borrowing (e.g., Carlstrom, Fuerst, and Paustian, 2017; Sims and Wu, 2021), but novel in its application to the government. Additionally, the government can finance public investment projects separately by issuing long-term

[4]During the Great Recession, short-term municipal debt as a share of total new issuance increased, as governments bridged funding needs in the face of weaker tax revenues (O'Hara, 2012). However, at that time, municipal yields were not impacted as severely as the recent pandemic.

bonds, diverting a portion of tax revenue, and receiving transfers from federal government.

Municipal short- and long-term bonds are purchased by financial intermediaries, who also supply credit to the private sector. As in Gertler and Karadi (2011) and Gertler and Karadi (2013), intermediaries finance themselves with net worth and short-term deposits from households. Because of a costly enforcement problem, intermediaries face an endogenous leverage constraint that results in excess returns of bonds relative to deposits. Our choice to model financial intermediaries holding municipal debt can be interpreted as capturing the role of municipal mutual funds, which played a pivotal role during the COVID-19 pandemic. Li, O'Hara, and Zhou (2022) show that the surge in trading volume of municipal bonds was primarily driven by mutual funds in the pandemic, suggesting holdings by financial institutions drove credit fluctuations.[5]

We interpret the MLF as the central bank directly purchasing short-term sub-national government bonds. The operating surplus from such purchases is returned to households via a lump-sum transfer. As our focus is on the sub-national government, we model the federal government in a simple manner, whereby lump-sum taxes finance lump-sum transfers to the local governments.

We find that direct central bank purchases of short-term municipal bonds (i.e., the MLF) mainly transmit to the economy through easing credit constraints. This policy raises demand for municipal bonds and boosts their prices. Thus, it alleviates the cash flow constraint for the regional government, while at the same time relaxing enforcement constraints for financial intermediaries. Given the small size of the short-term municipal bond market in the United States, however, the cash flow channel associated with the unconventional monetary policy is quite muted. In contrast, loosening financial conditions for banks raises the loan supply to the private sector, alleviating the loan-in-advance constraint for those firms, and, in turn, raising private investment. A counterfactual exercise shows that when private firms cannot borrow from financial intermediaries, there is no positive spillover to financial conditions in the private sector, and the real economic effects of the MLF policy are substantially lower.

Importantly, we highlight that the transmission of the central bank's purchase of sub-national debt differs markedly from conventional intergovernmental transfers. While both policies can stimulate output over time, the two policies have notably opposite effects on the credit constraint of

[5]While households directly hold a large portion of municipal debt, they do so usually for long-term savings and make limited adjustments in their holdings over time. According to Bergstresser and Cohen (2015), the share of household holdings of municipal debt has been declining over time and is likely to be overstated by current metrics.

the financial intermediary; intergovernmental transfers lead to a tightening of this constraint while, by design, the MLF loosens it. We show this distinction has important implications, as private investment increases with the eased credit conditions from the unconventional MLF policy, whereas investment is crowded-out by intergovernmental transfers. Thus, for the same increase in output, the two policies can imply markedly different paths of regional government consumption and private investment — the conventional intergovernmental transfers largely stimulates regional government consumption, while the unconventional monetary policy mainly raises private investment.

We then examine the effectiveness of the MLF under two counterfactual scenarios: (i) targeting longer-maturity municipal bonds, which fund government investment; and (ii) targeting bonds of all states simultaneously. Both scenarios are more in line with recent policy measures adopted in other countries, such as Canada. For the same size policy actions, both short- and long-term municipal bond purchases have similar credit easing effects and transmission through the financial market, albeit slightly stronger effects with long-term bond purchases. National policies targeting both regions reduce the gains to specific regions, as they are shared across the nation, but preserve the same qualitative outcomes.

Related Literature This paper is related to several strands of the literature. First, it is related to a theoretical literature utilizing New Kenesian models of a monetary union to study fiscal policy. Nakamura and Steinsson (2014), Brueckner, Pappa, and Valentinyi (2019), Carlino, Drautzburg, Inman, and Zarra (2021) examine the effects of local public spending and intergovernmental transfers. Farhi and Werning (2017) and Bianchi, Melosi, and Rogantini Picco (2022) examine the role of introducing a national fiscal authority in a monetary union of several countries.

More closely related, Auray, Eyquem, and Ma (2018) introduce an asset purchase program into a two-country model of the Eurozone to study responses to a sovereign debt crisis.[6] They find the unconventional monetary policy can stimulate the economy and lower bond yields. Our work differs in an important way, as we model a loan-in-advance constraint on sub-national governments that captures S&L government financing in the United States. We emphasize the importance of a policy's effect on the total supply of private and public credit. In addition to considering a

[6] A related literature explores the importance of financial connections and financial participants for the transmission of shocks across countries. See Kollmann, Enders, and Muller (2011), Kollmann (2013), Dedola, Karadi, and Lombardo (2013), Kirchner and Wijnbergen (2016), Auray, Eyquem, and Ma (2018), and Krenz (2022).

range of designs of a local debt purchase program, we also contrast conventional fiscal policy and unconventional monetary policy, highlighting that the two policies have notably opposite effects on the financial markets.

Previous work on U.S. S&L government financing emphasizes the role and stringency of balanced-budget requirements for the extent of tax and expenditure adjustments (e.g., Poterba, 1994; Poterba, 1995; Fatas and Mihov, 2006; and Clemens and Miran, 2012). In practice, there is substantial variation in these balanced-budget requirements. For instance, only 35 states require balance by the end of a single fiscal year (National Association of State Budget Officers, 2021), and Vermont has no such requirement.[7] This variation gives rise to short-term municipal funding, which bridges temporary revenue and expenditure misalignment. Our work compliments this literature by highlighting the importance of this short-term debt market.

A recent empirical literature quantifies the impact of various fiscal and monetary policy interventions in the pandemic on municipal bond market performance and state government activity. Bi and Marsh (2021) show policy interventions eased credit concerns for short-term bonds. Green and Loualiche (2021) find local public employment increased in response to the CARES act, while Haughwout, Hyman, and Shachar (2021) suggest public employment was unresponsive to the MLF. Our results are consistent with these findings, as we find the economic stimulus of the MLF transmits through the credit market more than by directly raising government expenditures. In the end, few local governments utilized the MLF. Guided by our structural model, our analysis offers an alternative take on the policy: if credit to municipal bonds was extended in a large-scale manner, what would have been the fiscal and economic effects? Answering this question is ultimately important for the design of future unconventional monetary policy that could target the municipal bond market once more.

Outline The rest of this paper is organized as follows. Section 2 details the two-region monetary union framework. Section 3 presents our results, while Section 4 concludes.

[7]The National Conference of State Legislatures (NCSL) has traditionally reported that 49 states must balance their budgets, with Vermont being the exception. Other authorities add Wyoming and North Dakota as exceptions, and some authorities in Alaska contend that it does not have an explicit requirement for a balanced budget.

2 Model

Our model extends the two-region monetary-union framework of Nakamura and Steinsson (2014) to incorporate financial intermediaries as in Gertler and Karadi (2011) and Sims and Wu (2021). We refer to each region as Home and Foreign. Home and Foreign sub-national governments set their own taxes and public expenditures. To finance government consumption, regional governments can issue relatively short-term municipal bonds and face a loan-in-advance constraint. This constraint captures a timing friction faced by local governments, where short-term debt is utilized to bridge the gap between the time when spending occurs and when revenues are available. In addition, governments also issue long-term bonds to finance public capital spending. The municipal bond markets are overseen by financial intermediaries that collect deposits from households and lend to local governments and the private sector. Markets are segmented in the sense that households cannot hold government and private bonds directly. In turn, we abstract from complete cross-region risk sharing. At the union level, there is a federal fiscal authority as well as a common monetary authority.

Both regions have the same economic structure and the same size. They produce differentiated tradable goods. Trade is friction-less across the regions, and the goods' markets are completely integrated. Thus, Home and Foreign households pay the same nominal prices for the differentiated goods produced in each region. Below, we describe the economy of the Home region.

2.1 Households

The representative household maximizes the expected intertemporal utility given by

$$E_0 \left\{ \sum_{t=0}^{\infty} \Theta_t u_t^b \left[\frac{(c_t - \psi \tilde{c}_{t-1})^{1-\sigma_c}}{1-\sigma_c} - \chi \frac{l_t^{1+\sigma_l}}{1+\sigma_l} \right] \right\}, \tag{2.1}$$

where c_t is composite consumption, l_t is the number of hours worked, and u_t^b is a preference shock. The household values consumption relative to a habit stock defined in terms of lagged aggregate consumption $\tilde{c}_{t-1}$ with $\psi \in [0, 1)$. Θ_t represents an endogenous discount factor, which in the absence of complete international markets ensures stationarity (Schmitt-Grohe and Uribe, 2003). The endogenous discount factor evolves according to $\Theta_{t+1} = \Theta_t \beta(\tilde{c}_t)$ where,

$$\beta(\tilde{c}_t) = \beta_c (1 + \tilde{c}_t)^{-\omega_\beta} \tag{2.2}$$

and $\Theta_0 = 1$. The composite consumption c_t aggregates Home and Foreign consumption sub-baskets, $c_{H,t}$ and $c_{F,t}$, in Armington form:

$$c_t = \left[\alpha_H^{\frac{1}{\phi}} (c_{H,t})^{\frac{\phi-1}{\phi}} + (1-\alpha_H)^{\frac{1}{\phi}} (c_{F,t})^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}} \tag{2.3}$$

The parameter $\phi > 0$ denotes the elasticity of substitution between Home and Foreign goods, and α_H is the household's relative preference for Home goods.

Let $\rho_{H,t} \equiv P_{H,t}/P_t$ and $\rho_{F,t} \equiv P_{F,t}/P_t$ respectively denote the real prices of the domestic and imported goods expressed in Home consumption units. Optimal demand for domestic and imported goods, resulting from the household's expenditure minimization problem, are respectively

$$c_{H,t} = \alpha_H \rho_{H,t}^{-\phi} c_t, \tag{2.4}$$

$$c_{F,t} = (1-\alpha_H) \rho_{F,t}^{-\phi} c_t. \tag{2.5}$$

The aggregate price index is $P_t = \left[\alpha_H (P_{H,t})^{1-\phi} + (1-\alpha_H) (P_{F,t})^{1-\phi}\right]^{1/(1-\phi)}$. The sub-basket $c_{H,t}$ aggregates Home differentiated consumption varieties $c_{H,t}(j)$, and $c_{F,t}$ aggregates Foreign differentiated consumption varieties $c_{F,t}(j)$, given by

$$c_{H,t} = \left[\int_0^1 c_{H,t}(j)^{(\theta-1)/\theta} dj\right]^{\theta/(\theta-1)} \quad \text{and} \quad c_{F,t} = \left[\int_0^1 c_{F,t}(j)^{(\theta-1)/\theta} dj\right]^{\theta/(\theta-1)}$$

where $\theta > 1$ is the elasticity of substitution across goods.

The household's period budget constraint in real terms is:

$$d_t + b_t^i + c_t (1+\tau^c) = \frac{R_{t-1}^d d_{t-1}}{\pi_t} + \frac{R_{t-1}^d b_{t-1}^i}{\pi_t} + w_t l_t + \Pi_t^f + div_t - x - \tau_t^f, \tag{2.6}$$

where $w_t \equiv W_t/P_t$. Households make one-period savings deposits at financial intermediaries. We denote d_t the amount of savings deposits, and R_{t-1}^d as the nominal interest rate on deposits between $t-1$ and t, known with certainty in $t-1$. Households pay regional consumption taxes τ^c to the regional government and a lump-sum tax τ_t^f to the federal government. In addition, households receive profits from ownership of firms Π_t^f as well as equity from financial intermediaries div_t. Each period, households make a fixed real equity transfusion to newly born financial intermediaries,

which we denote by x.

Across regions, households can only trade nominal one-period bonds b_t^i. As there is a common deposit interest rate across regions, these one-period bonds trade at the same rate, which also equals the interest rate set by the common central bank.[8] For reference below, we define $\Lambda_{t,t+1} \equiv U_{c,t+1}/U_{c,t}$ and note that in equilibrium, $\tilde{c}_t = c_t$.

2.2 Regional Government The Home regional government finances its consumption and public investment by collecting regional consumption and revenue taxes, by receiving transfers from the federal government, as well as by floating relatively short-term municipal bonds. Its budget constraint in real term is given by

$$\rho_{H,t} g_t^c + (1 + \kappa^s Q_t^s) \frac{b_{t-1}^s}{\pi_t} = Q_t^s b_t^s + tr_t^{gc} + \psi^{gc} \left[\tau^i p_t^w y_t + \tau^c c_t \right] \tag{2.7}$$

where tr_t^{gc} denotes federal government transfers that are earmarked for consumption, and g_t^c is regional government consumption. Municipal bonds are defined as a perpetuity with coupons that decay exponentially, as in Woodford (2001). A bond issued at date t pays $(\kappa^s)^{k-1}$ at date $t+k$ with the coupon decay factor κ^s capturing the average maturity of the bond portfolio.

Importantly, we assume that the regional government faces a "loan-in-advance constraint". In the United States, although the majority of state and local governments face some form of a balanced-budget rule on their current spending, they can issue relatively shorter-term bonds, usually with maturities of 13 months or less, to bridge the gap between the time when spending occurs and when revenues become available. This institutional feature is captured by the loan-in-advance constraint. We assume that the regional government must finance a fraction, η^{gc}, of its consumption by floating municipal notes,

$$\eta^{gc} \rho_{H,t} g_t^c \leq Q_t^s \left(b_t^s - \kappa^s \frac{b_{t-1}^s}{\pi_t} \right), \tag{2.8}$$

which is in the same spirit as the private-sector financing condition of Sims and Wu (2021). The

[8] We assume households only hold local savings deposits, but as nominal deposit returns are equalized across regions, households are indifferent to holding Home or Foreign savings deposits. To determine allocations of Foreign deposits, Krenz (2022) assumes households utilize one-period cross-region bonds to finance Foreign deposits. Thus, our setup can be thought of as equivalently allowing Home and Foreign savings deposits.

shorter-term segment of the municipal bond market was the target of the Federal Reserve's intervention during the Covid pandemic. We calibrate the coupon factor κ^s accordingly to capture this market.

For low (< 1) values of η^{gc}, the loan-in-advance constraint, equation (2.8), ensures long-term solvency of the government's budget. Intuitively, when the constraint binds, new bond issuance is bounded to be less than a fraction of total spending.[9] Furthermore, for a low η^{gc}, the condition ensures the government quickly returns to a balanced budget following unanticipated changes in the economy. In the Online Appendix, we demonstrate this result by comparing how long it takes the government to finance unanticipated changes in its budget in our model relative to a standard model where the loan-in-advance constraint is replaced by a simple rule allowing government consumption to adjust over time to stabilize debt (e.g., Leeper, Plante, and Traum, 2010; Carlino, Drautzburg, Inman, and Zarra, 2021).

The regional government also provides public capital, such as infrastructure, by issuing long-term municipal bonds, using a share of its tax revenue as well as transfers from the federal government.

$$\rho_{H,t} g_t^i + (1 + \kappa^l Q_t^l) \frac{b_{t-1}^l}{\pi_t} \quad = \quad Q_t^l b_t^l + tr_t^{gi} + (1 - \psi^{gc}) \left[\tau^i p_t^w y_t + \tau^c c_t \right] \tag{2.9}$$

where g_t^i is public investment and tr_t^{gi} denotes federal government transfers that are earmarked for investment.[10] κ^l captures the average maturity of long-term municipal bonds.

Government investment, g_t^i, becomes productive public capital with a one-period delay:

$$K_t^g = (1 - \delta^g) K_{t-1}^g + g_t^i \tag{2.10}$$

In the United States, financing constraints only apply to current spending, such as wage compensation, but not capital expenditure. Thus, the regional government does not face a loan-in-advance constraint in issuing long-term bonds. Instead, to ensure long-term solvency of capital expenditures,

[9] In the Online Appendix, we provide a proof of this solvency condition in a simplified version of our model for a closed economy.

[10] We abstract from the regional government's ability to divert transfers for different purposes. Leduc and Wilson (2022) find dollar-for-dollar pass through of infrastructure grants to government investment.

we assume the following fiscal rule,

$$\frac{tr_t^{gi} - tr^{gi}}{tr^{gi}} = \phi^{gi} \frac{Q_{t-1}^l b_{t-1}^l - Q^l b^l}{Q^l b^l}. \tag{2.11}$$

2.3 PRODUCTION The model includes three different types of production firms, similar to Sims and Wu (2021). A representative wholesale firm produces output using labor as well as its own capital. These firms additionally face a loan-in-advance constraint, thus issuing long-term bonds to finance a portion of their capital purchases. Retail firms repackage wholesale output for resale and are subject to price stickiness. In addition, a representative investment producer generates new capital using Home and Foreign retail goods.

Investment Producers Competitive investment producing firms use Home and Foreign goods (in the same Armington form as consumption) to obtain a composite investment I_t. In turn, composite investment is used to produce new capital I_t^w and is sold to wholesale firms at price p_t^k. The production function is

$$I_t^w = \left(1 - S\left(\frac{I_t}{I_{t-1}}\right)\right) I_t \tag{2.12}$$

where $S(.)$ is an investment adjustment cost. The firm's optimization problem is thus given by

$$\max \quad \sum_{t=0}^{\infty} E_0 \left[\Theta_t \Lambda_{0,t+1} \left(p_t^k \left(1 - S\left(\frac{I_t}{I_{t-1}}\right)\right) I_t - I_t\right)\right].$$

Wholesale Firms A representative wholesale firm produces output according to,

$$y_t^w = A_t l_t^{1-\alpha} K_{t-1}^{\alpha} (K_{t-1}^g)^{\alpha_g} \tag{2.13}$$

where A_t is aggregate productivity. K_{t-1}^g denotes public capital provided by the Home regional government, which is taken as given by firms. $\alpha_g \geq 0$ is the elasticity of output with respect to public capital, which determines the productiveness of public capital. We follow Leeper, Walker, and Yang (2010), Glomm and Ravikumar (1997), and Baxter and King (1993) in modeling increasing returns to scale to public capital. K_{t-1} is private capital that is owned by wholesale firms and evolves

according to a standard law of motion,

$$K_t \quad = \quad I_t^w + (1-\delta)K_{t-1}. \tag{2.14}$$

Similar to Sims and Wu (2021), we assume that the wholesale firm must issue perpetual bonds to finance a fraction η^I of new physical capital, I_t^w. The loan-in-advance constraint is similar to what the regional government faces,

$$Q_t^f \left(f_t - \kappa^f \frac{f_{t-1}}{\pi_t} \right) \quad \geq \quad \eta^I p_t^k I_t^w, \tag{2.15}$$

where f_t denotes the amount of private bonds, and p_t^k is the price at which the wholesale firm purchases new investment. The firm makes decisions on labor, investment, and bond issuance to maximize the present value of their profits,

$$\max \quad \sum_{t=0}^{\infty} E_0 \left[\Theta_t \Lambda_{0,t+1} \left(p_t^w y_t^w (1-\tau^i) - w_t l_t - p_t^k I_t^w - \frac{f_{t-1}}{\pi_t} + Q_t^f \left(f_t - \kappa^f \frac{f_{t-1}}{\pi_t} \right) \right) \right]$$

subject to equations 2.13, 2.14, and 2.15.

Retail Firms We assume producer currency pricing for pricing exports. The law of one price holds and implies

$$\rho_{H,t} = rer_t \rho_{H,t}^* \quad \text{and} \quad \rho_{F,t}^* = \frac{\rho_{F,t}}{rer_t}, \tag{2.16}$$

where $rer_t = P_t^*/P_t$ denotes the real exchange rate, $\rho_{H,t}^* = P_{H,t}^*/P_t^*$ and $\rho_{F,t}^* = P_{F,t}^*/P_t^*$.[11]

The retail firm h repackages wholesale output, $y_t(h) = y_t^w(h)$, and sells it for the price $P_t(h)$. The firm faces a Rotemberg price adjustment cost, where the real cost is denoted by: $\frac{\psi}{2}\left(\frac{P_t(h)}{P_{t-1}(h)}\frac{1}{\pi} - 1\right)^2 y_t$. The firm chooses labor and its price to optimize real profits, given by:

$$\sum_{k=0}^{\infty} E_t \left[\Theta_{t+k} \Lambda_{t,t+k} \left(p_{t+k}(h) y_{t+k}(h) - \frac{p_{t+k}^w}{\rho_{t+k}^H} y_{t+k}(h) - \frac{\psi}{2} \left(\frac{P_{t+k}(h)}{P_{t+k-1}(h)} \frac{1}{\pi^H} - 1 \right)^2 y_{t+k} \right) \right].$$

[11] In general, the law of one price implies that for a nominal exchange rate ϵ_t,

$$P_{F,t} = \epsilon_t P_{F,t}^*, \quad P_{HF,t}^* = \frac{P_{H,t}}{\epsilon_t}.$$

In the above expressions, we have used the fact that the nominal exchange rate in our currency union is one.

where $p_t(h) = P_t(h)/P_t^H$. The firm h sets its price while taking into account demand for its product, which comes from multiple sources: Home and Foreign private consumers and investment firms and the Home regional government. Total demand for good h is given by

$$y_t(h) = \left(\frac{P_t(h)}{P_{H,t}}\right)^{-\theta} \left(c_{H,t} + c^*_{H,t} + i_{H,t} + i^*_{H,t} + g^c_t + g^i_t\right) \tag{2.17}$$

After imposing equilibrium, optimal price setting implies

$$\frac{p^w_t}{\rho^H_t} = \frac{\theta - 1}{\theta} + \frac{\psi}{\theta}\left(\frac{\pi^H_t}{\pi^H} - 1\right)\frac{\pi^H_t}{\pi^H} - \frac{\psi}{\theta}E_t\beta(c_t)\Lambda_{t,t+1}\left(\frac{\pi^H_{t+1}}{\pi^H} - 1\right)\frac{\pi^H_{t+1}}{\pi^H}\frac{y_{t+1}}{y_t}. \tag{2.18}$$

2.4 Financial Intermediaries Financial intermediaries are structured as in Gertler and Karadi (2011) and Sims and Wu (2021). In each region, there is a continuum on the unitary interval of financial intermediaries. Each period, a fraction of financial intermediaries stochastically exit and are replaced by the same number of new intermediaries with startup funds from households. Financial intermediaries accumulate net worth until they exit, whereby they return their net worth to household owners.

The intermediary j purchases both short- and long-term municipal bonds from the regional government, $b^{H,s,j}_t$ and $b^{H,l,j}_t$, as well as long-term private bonds, $f^{H,j}_t$. In addition, we allow the intermediary to purchase assets from the Foreign region, $b^{F,s,j}_t$ $b^{F,l,j}_t$, and $f^{F,j}_t$.[12] These purchases are financed by deposits from domestic households d^j_t and the firm's net worth n^j_t. The balance sheet condition in real terms is given by

$$Q^s_t b^{H,s,j}_t + Q^l_t b^{H,l,j}_t + Q^f_t f^{H,j}_t + Q^{s,*}_t b^{F,s,j}_t + Q^{l,*}_t b^{H,l,j}_t + Q^{f,*}_t f^{F,j}_t = d^j_t + n^j_t. \tag{2.19}$$

[12] Cross-region exchange of multiple assets could induce multiple unit-roots into the model. Below, we assume home bias in preferences for assets, which ensures there no are unit root dynamics from cross-region financial intermediary asset holdings.

If intermediary j survives, then its net worth evolves as,

$$n_t^j = \left(R_t^s - R_{t-1}^d\right)\frac{Q_{t-1}^s b_{t-1}^{H,s,j}}{\pi_t} + \left(R_t^l - R_{t-1}^d\right)\frac{Q_{t-1}^l b_{t-1}^{H,l,j}}{\pi_t} + \left(R_t^f - R_{t-1}^d\right)\frac{Q_{t-1}^f f_{t-1}^{H,j}}{\pi_t}$$
$$+ \left(R_t^{s,*} - R_{t-1}^d\right)\frac{Q_{t-1}^{s,*} b_{t-1}^{F,s,j}}{\pi_t} + \left(R_t^{l,*} - R_{t-1}^d\right)\frac{Q_{t-1}^{l,*} b_{t-1}^{F,l,j}}{\pi_t} + \left(R_t^{f,*} - R_{t-1}^d\right)\frac{Q_{t-1}^{f,*} f_{t-1}^{F,j}}{\pi_t} + \frac{R_{t-1}^d n_{t-1}}{\pi_t} \tag{2.20}$$

where $R_t^s - R_{t-1}^d$, $R_t^l - R_{t-1}^d$, and $R_t^f - R_{t-1}^d$ are, respectively, the excess returns from holding short-term and long-term municipal bonds, and long-term private bonds related to the cost of funding through deposits. The realized returns on holding domestic municipal bonds and private bonds are

$$R_t^s = \frac{1+\kappa^s Q_t^s}{Q_{t-1}^s}, \quad R_t^l = \frac{1+\kappa^l Q_t^l}{Q_{t-1}^l}, \quad R_t^f = \frac{1+\kappa^f Q_t^f}{Q_{t-1}^f}.$$

Similar expressions hold for the returns on foreign municipal bonds and private bonds.

Each period, a fraction $1-\sigma$ of financial intermediaries exit and return their net worth to domestic household owners. The objective of the intermediary j is to maximize its expected terminal net worth according to,

$$\max V_t^j = (1-\sigma)E_t\beta(c_t)\Lambda_{t,t+1}n_{t+1}^j + \sigma\beta E_t\beta(c_t)\Lambda_{t,t+1}V_{t+1}^j, \tag{2.21}$$

where it discounts future net worth by the stochastic discount factor of households.

If it can make positive excess returns from investing in municipal bonds, an intermediary would want to expand its assets indefinitely by collecting deposits from households. To put a limit on its ability to do so, we assume that financial intermediaries face a costly enforcement problem as in Gertler and Karadi (2011): at the end of a period, an intermediary can divert a fraction of its assets and transfer them to household owners, in which case depositors can recover the remaining assets and force the intermediary into bankruptcy. Thus, an incentive constraint must be satisfied for depositors to be willing to lend in the first place. Following Krenz (2022), we assume that this incentive constraint is in terms of CES composite portfolios of Home anf Foreign assets:

$$V_t^j \geq \eta^\nu(m_t^{f,j} + \theta^s m_t^{s,j} + \theta^l m_t^{l,j}). \tag{2.22}$$

where

$$m_t^{s,j} = \left[\gamma_s^{\frac{1}{\sigma_s}}\left(Q_t^s b_t^{H,s,j}\right)^{\frac{\sigma_s-1}{\sigma_s}} + (1-\gamma_s)^{\frac{1}{\sigma_s}}\left(Q_t^{s,*} b_t^{F,s,j}\right)^{\frac{\sigma_s-1}{\sigma_s}}\right]^{\frac{\sigma_s}{\sigma_s-1}}, \tag{2.23}$$

$$m_t^{l,j} = \left[\gamma_l^{\frac{1}{\sigma_l}}\left(Q_t^l b_t^{H,l,j}\right)^{\frac{\sigma_l-1}{\sigma_l}} + (1-\gamma_l)^{\frac{1}{\sigma_l}}\left(Q_t^{l,*} b_t^{F,l,j}\right)^{\frac{\sigma_l-1}{\sigma_l}}\right]^{\frac{\sigma_l}{\sigma_l-1}}, \tag{2.24}$$

$$m_t^{f,j} = \left[\gamma_f^{\frac{1}{\sigma_f}}\left(Q_t^f f_t^{H,j}\right)^{\frac{\sigma_f-1}{\sigma_f}} + (1-\gamma_f)^{\frac{1}{\sigma_f}}\left(Q_t^{f,*} f_t^{F,j}\right)^{\frac{\sigma_f-1}{\sigma_f}}\right]^{\frac{\sigma_f}{\sigma_f-1}}. \tag{2.25}$$

The parameters $\sigma_s, \sigma_l, \sigma_f < 0$ denote the interest rate elasticity of asset demand, and the parameters $\gamma_s, \gamma_l, \gamma_f$ denote the home bias in asset holdings. The assumption of imperfect substitutability between Home and Foreign assets in the incentive constraint can be motivated by the owners' preference for different asset types, different attitudes towards risks across regional assets, and differential convenience benefits due to institutional differences across regions (see Alpanda and Kabaca, 2020 and Krenz, 2022). For example, according to Schultz (2012), in-state investors are the natural clientele for local municipal bonds for the following reasons. Municipal borrowers tend to disclose less information and disclose it in a less timely fashion than corporate issuers. Thus, in addition to local tax advantages, investors located near an issuer are more likely to feel they have adequate information to invest. Consistent with this view, we assume that local financial intermediaries exhibit home-bias in asset preferences.

Should it choose to enter bankruptcy, the incentive constraint implies the intermediary can keep a fraction of its private bonds, η_t^{ν}. It can also keep a fraction $\eta_t^{\nu}\theta^s$ of short-term municipal bonds and a fraction $\eta_t^{\nu}\theta^l$ of long-term municipal bonds, where $0 \leq \theta^l \leq 1$ and $0 \leq \theta^s \leq 1$, which implies it is easier for the intermediary to divert private bonds than municipal bonds. The above condition implies that the value of continuing as an intermediary V_t^j should be larger or equal to the funds that the intermediary j can divert. The parameter η_t^{ν} captures the tightness of the credit market: the higher η_t^{ν} is, the more funds financial intermediaries can divert, making depositors less willing to lend funds. In the Online Appendix, we detail the solution procedure to the financial intermediary's maximization problem.

Finally, we assume that newly entering intermediaries receive start-up funds from households,

denoted by x in real terms. The aggregate net worth in the FI sector evolves as,

$$\begin{aligned} n_t &= \sigma\left[\left(R_t^s - R_{t-1}^d\right)\frac{Q_{t-1}^s b_{t-1}^{H,s}}{\pi_t} + \left(R_t^l - R_{t-1}^d\right)\frac{Q_{t-1}^l b_{t-1}^{H,l}}{\pi_t} + \left(R_t^f - R_{t-1}^d\right)\frac{Q_{t-1}^f f_{t-1}^H}{\pi_t}\right] \\ &\quad +\sigma\left[\left(R_t^{s,*} - R_{t-1}^d\right)\frac{Q_{t-1}^{s,*} b_{t-1}^{F,s}}{\pi_t} + \left(R_t^{l,*} - R_{t-1}^d\right)\frac{Q_{t-1}^{l,*} b_{t-1}^{F,l}}{\pi_t} + \left(R_t^{f,*} - R_{t-1}^d\right)\frac{Q_{t-1}^{f,*} f_{t-1}^F}{\pi_t}\right] \\ &\quad +\sigma R_{t-1}^d \frac{n_{t-1}}{\pi_t} + (1-\sigma)x \end{aligned} \tag{2.26}$$

Since all financial intermediaries make the same optimal decisions, the balance sheet for the financial intermediary sector is

$$Q_t^s b_t^{H,s} + Q_t^l b_t^{H,l} + Q_t^f f_t^H + Q_t^{s,*} b_t^{F,s} + Q_t^{l,*} b_t^{F,l} + Q_t^{f,*} f_t^F = d_t + n_t. \tag{2.27}$$

2.5 Federal Policy Interventions At the monetary union, the central bank sets a common monetary policy for the two regions by following a Taylor-rule for the economy-wide nominal interest rate:

$$\ln\frac{R_t^d}{R^d} = \rho_R \ln\frac{R_{t-1}^d}{R^d} + (1-\rho_R)\left(\phi_\pi \ln\frac{\pi_t^{ag}}{\pi^{ag}} + \phi_y \ln\frac{y_t^{ag}}{y^{ag}}\right) + \epsilon_t^R \tag{2.28}$$

The money authority responds to variation in the weighted average of consumer price inflation, $\ln\frac{\pi_t^{ag}}{\pi^{ag}} = 0.5\ln\frac{\pi_t}{\pi} + 0.5\ln\frac{\pi_t^*}{\pi^*}$, and the weighted average of output in each state, $\ln\frac{Y_t^{ag}}{Y^{ag}} = 0.5\ln\frac{Y_t}{Y} + 0.5\ln\frac{Y_t^*}{Y^*}$.

We model the unconventional policy of a municipal lending facility as liquidity injections directly on the issuance of new short-term municipal bonds. This is consistent with the Federal Reserve's policy during the COVID pandemic, as the Municipal Lending Facility specifically targeted the primary market. In this case, the outstanding short-term municipal bonds are held by the domestic and foreign financial intermediaries, as well as by the central bank ($b_t^{s,cb}$). In equilibrium, the total short-term municipal bonds satisfy

$$b_t^s = b_t^{s,cb} + b_t^{H,s} + b_t^{H,s,*} rer_t. \tag{2.29}$$

The central bank's holding of municipal bonds is denoted as $Q_t^s b_t^{s,cb} = re_t$. The operating surplus

is returned to households via a lump-sum transfer:

$$T_t^{cb} = R_t^s Q_{t-1}^s \frac{b_{t-1}^{s,cb}}{\pi_t} - Q_t^s b_t^{s,cb}.$$

In normal times, the central bank doesn't hold any municipal bonds with $re_t = 0$. During a crisis, it raises re_t to inject liquidity to the financial market given by,

$$re_t = (1-\rho^{re})re + \rho^{re} re_{t-1} + \epsilon_t^{re}. \tag{2.30}$$

For comparison, we also consider the conventional policy measure of direct aid to the state government from the federal government. We consider a shock to intergovernmental transfers and assume the government aid tr_t follows the process

$$tr_t^{gc} = (1-\rho^{tr})tr^{gc} + \rho^{tr} tr_{t-1}^{gc} + \epsilon_t^{tr}. \tag{2.31}$$

Lump-sum transfers from the federal government to regional governments are financed through lump-sum taxes collected by the federal government and central bank transfers from reserves. As our focus is on the transmission of sub-national fiscal policy, we abstract from other features of the federal government.

$$tr_t^{gc} + tr_t^{gi} + tr_t^{gc,*} + tr_t^{gi,*} = \tau_t^f + \tau_t^{f,*} + T_t^{cb} \tag{2.32}$$

2.6 Market Clearing and Further Equilibrium Conditions Private bond market clearing implies

$$f_t = f_t^H + rer_t f_t^{H,*}, \quad f_t^* = \frac{f_t^F}{rer_t} + f_t^{F,*} \tag{2.33}$$

Long-term municipal bond market clearing implies

$$b_t^l = b_t^{H,l} + rer_t b_t^{H,l,*}, \quad b_t^{l,*} = \frac{b_t^{F,l}}{rer_t} + b_t^{F,l,*} \tag{2.34}$$

Short-term municipal bond market clearing is given by equation (2.29).

Home goods market clearing implies $y_t = c_{H,t} + c_{H,t}^* + i_{H,t} + i_{H,t}^* + g_t^c + g_t^i$. Adjustment of

international relative prices is summarized by the condition linking the real exchange rate to relative inflation (since the nominal exchange rate is fixed): $rer_t/rer_{t-1} = \pi_t^*/\pi_t$. As shown in the Appendix, the equation for net foreign asset accumulation can be written as:

$$\begin{aligned} & b_t^i + Q_t^{s,*} b_t^{F,s} + Q_t^{l,*} b_t^{F,l} + Q_t^{f,*} f_t^F - Q_t^s b_t^{H,s,*} rer_t - Q_t^l b_t^{H,l,*} rer_t - Q_t^f f_t^{H,*} rer_t \\ = & \frac{R_{t-1}^d b_{t-1}^i}{\pi_t} + \frac{R_t^{s,*} Q_{t-1}^{s,*} b_{t-1}^{F,s}}{\pi_t} + \frac{R_t^{l,*} Q_{t-1}^{l,*} b_{t-1}^{F,l}}{\pi_t} + \frac{R_t^{f,*} Q_{t-1}^{f,*} f_{t-1}^F}{\pi_t} - \frac{R_t^f Q_{t-1}^f f_{t-1}^{H,*} rer_{t-1}}{\pi_t} \\ & - R_t^s Q_{t-1}^s \frac{b_{t-1}^{H,s,*} rer_{t-1}}{\pi_t} - R_t^l Q_{t-1}^l \frac{b_{t-1}^{H,l,*} rer_{t-1}}{\pi_t} + \rho_t^H (c_{H,t}^* + i_{H,t}^*) - \rho_t^{F,*} rer_t (c_{F,t} + i_{F,t}) \end{aligned} \tag{2.35}$$

3 Policy Analysis

The COVID-19 pandemic delivered a sudden blow to the U.S. economy in early 2020, and its impact on the state and local government sector was propagated through two channels. First, S&L governments faced extraordinary cash flow pressures in the early pandemic. Shelter-in-place and quarantine orders limited permissible economic activity, posing a significant blow to state and local revenues at a time when higher expenditures were necessary to fight the pandemic. In particular, the IRS federal tax deadline was extended from April 15 to July 15 2020, exacerbating cash flow challenges for state and local governments at the time. Secondly, municipal bond yields surged as liquidity conditions deteriorated rapidly in the overall financial markets, raising financing costs for state and local governments.

In response, the fiscal and monetary authorities took unprecedented policy actions. In March 2020, Congress swiftly passed the Coronavirus Aid, Relief, and Economic Security (CARES) act that provided relief measures of $2.2 trillion to the broad economy. In terms of supporting state and local governments, the CARES act included conventional measures that provided direct aid to state and local governments through the Coronavirus Relief Fund. It also included new unconventional policies, such as appropriating backstop funds such that the Federal Reserve could establish a direct lending facility in support of municipal bond issuers.

In this section, we study the impact of both conventional and unconventional policy measures that target the state and local government. Conventional policy measures, such as federal aid or transfers, directly alleviate pressure on state and local finances by improving their budgets. Nev-

Table 1: Calibration

Parameter	Value	Description
κ^f	$1-40^{-1}$	Coupon decay parameter for private bonds
κ^l	$1-40^{-1}$	Coupon decay parameter for long-term municipal bonds
κ^s	$1-4^{-1}$	Coupon decay parameter for short-term municipal bonds
η^I	0.86	Fraction of investment from debt
η^{gc}	0.025	Fraction of government consumption from debt
ϕ	4	Leverage ratio
η^v	0.60	Recoverability parameter
θ^s	0.37	Short-term municipal bond recoverability
θ^l	0.43	Long-term municipal bond recoverability
$\frac{Q^f f}{4y}$	1.68	Private bonds as share of GDP
$\frac{Q^s b^s}{4y}$	0.003	Short-term municipal bonds as share of GDP
$\frac{Q^l b^l}{4y}$	0.165	Long-term bonds as share of GDP
σ_i	-2	Elasticities of substitution between domestic & foreign assets
γ_i	0.7	Home bias in domestic assets
τ^c	0.045	Consumption tax rate
τ^i	0.049	Regional income tax rate
$\frac{g^c}{y}$	0.105	Regional government consumption as share of GDP
$\frac{g^i}{y}$	0.021	Public investment as share of GDP

ertheless, these policies usually do not directly impact the financial market and lending conditions. In contrast, unconventional policy tools, such as the direct lending facility, can have an immediate impact through financial markets, which may take more time to materialize on state and local budgets and spending. In this section, we incorporate these different aspects of conventional versus unconventional policy tools in our model to explore their effectiveness.

3.1 Calibration We impose a symmetric calibration across regions, and our parametrization uses standard values from the literature, see Sims and Wu (2021). We calibrate ω_β to 0.01, as in Devereux and Sutherland (2009). The small value ensures the influence of the endogenous discount factor is muted in the dynamics. We assume the steady-state real interest rate is 2 percent annualized, which implies $\beta(c) = 0.995$. Given our calibration of ω_β, we set β_c to ensure the calibration for $\beta(c)$. To have a steady-state price markup of 10 percent, we let $\theta = 11$. We calibrate the price adjustment cost parameter, ψ, to a value that would replicate firms adjusting prices 25%

of the time in a Calvo-type Phillips curve in the absence of strategic price complementary.[13] The Frisch elasticity is set to 1. We assume logarithmic preferences ($\sigma_c = 1$), and household consumption habit, ψ, is set to 0.8. Following Nakamura and Steinsson (2014), we set the elasticity of substitution between goods to $\phi = 2$ and the degree of home bias α_H to 0.7.

The relatively non-standard parameters in our model are related to financial intermediaries, private and municipal bonds, and the loan-in-advance constraints for wholesale firms and regional governments. Table 1 summarizes our calibration for these parameters. We assume a symmetric structure across regional governments and calibrate this sector based on the average state and local government revenues and expenditures between 1977 and 2017.[14] The consumption tax rate, τ^c, matches the average sales tax revenue as a share of personal consumption expenditures during this period, which is 0.045. The regional income tax rate, τ^i, is set to 0.049, matching the average share of total state and local tax revenue, net sales taxes, out of GDP. Regional government consumption, g^c, is set to the average current operation expenditures of state and local governments as a share of GDP, which is 10.5%.[15] Public investment, g^i, matches the average state and local capital expenditures as a share of GDP of 2%.

Additionally, the municipal bond markets are calibrated to be consistent with the data. The average duration for long- and short-term bonds are 10 years and 1 year respectively.[16] The long-run municipal bond market value is around \$3.8 trillion dollars, or 16.5% of GDP. According to Bloomberg, the short-term municipal bond market value is about \$60 billion dollars on average between 2007 and 2019. The tax-adjusted spreads between municipal bonds and Treasuries averaged around 130 basis points between 1998 and 2015, according to Schwert (2017). We also calibrate the spread between long- and short-term municipal bonds to 20 basis points. These values imply that the fraction of government consumption that the regional government must finance by short-term bonds, η^{gc}, is 0.025.

The private bond market and financial intermediaries are calibrated in line with the existing literature, see Sims and Wu (2021) and Gertler and Karadi (2011). We target an excess return over

[13] The mapping implies $\psi = \theta/[(1-\xi_p)/\xi_p(1-\beta\xi_p)]$, where $\xi_p = 0.75$ is the Calvo adjustment parameter.

[14] Fiscal data for state and local governments are from the U.S. Census Bureau and the National Association of State Budget Officers.

[15] We exclude public welfare expenditures from the current operation expenditures.

[16] The maturities of U.S. municipal short-term securities can vary from 3 months to 3 years, but usually mature within 13 months.

the deposit rate, $R^f - R^d$, of 3 percent annualized and an average duration, $1 - 1/\kappa^f$, of 10 years. Following Sims and Wu (2021), the outstanding private debt to annualized GDP is set to 1.68. Thus, private investment accounts for 20% of GDP, and the fraction of investment the wholesale firms must finance by issuing debt, η^I, is 0.86. For financial intermediaries, we assume that they have a survival probability, σ, of 0.95. The value of startup funds to new financial intermediaries, x, is chosen to be consistent with a leverage ratio of 4.

The elasticities of substitution between assets with respect to interest rates, σ_i for $i = s, l, f$, are set to -2, inline with evidence from Poutineau and Vermandel (2015). Home bias in asset holdings, γ_i for $i = s, l, f$, is set to 0.7, which is lower than estimates for the Eurozone (around 0.9), reflecting the stronger integration across U.S. states.

Finally, we assume that the central bank does not hold bonds at the steady state. The Taylor rule parameters are set to standard values: $\rho_r = 0.8$, $\phi_\pi = 1.5$, and $\phi_y = 0.15$.

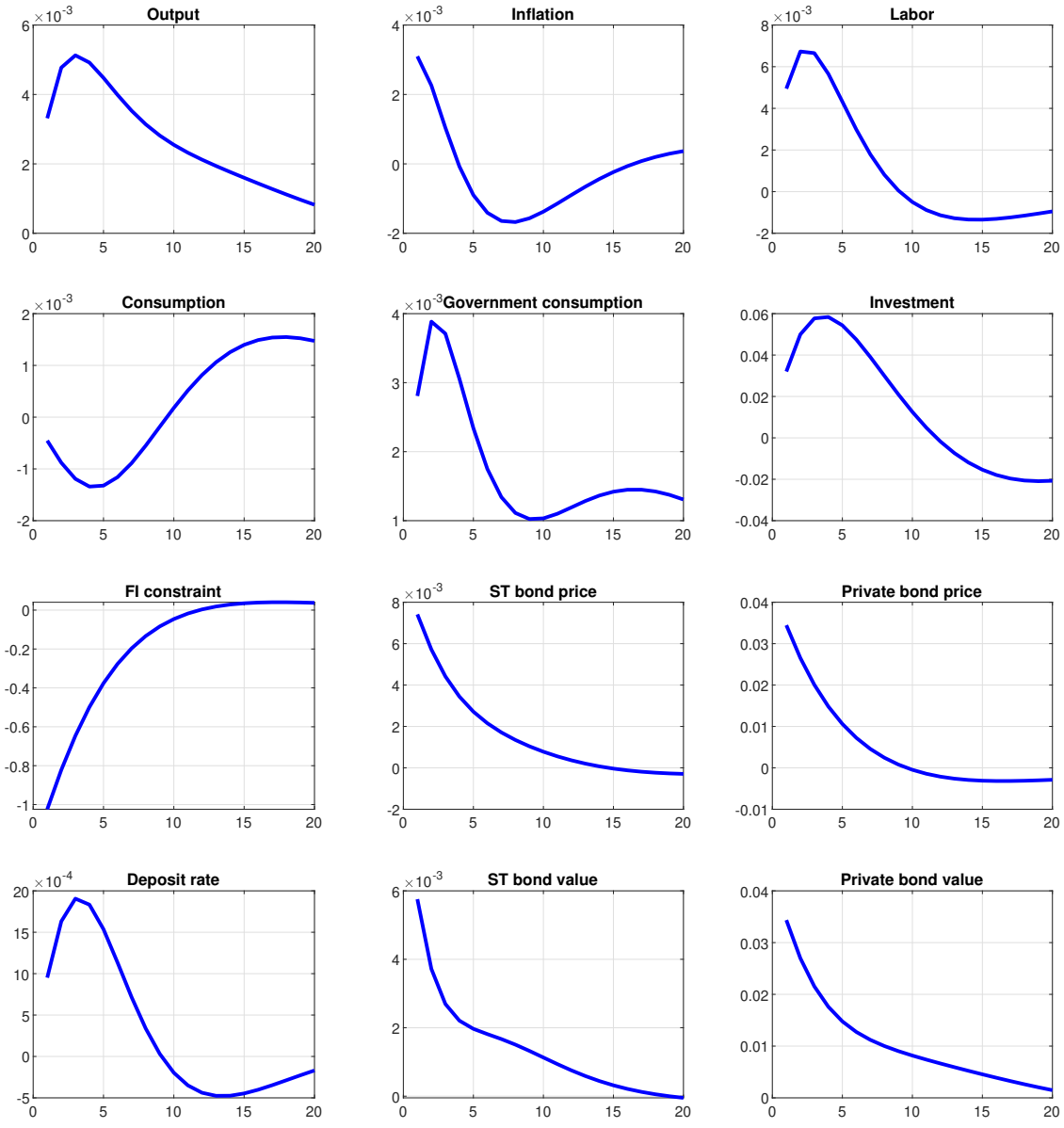
3.2 Unconventional Monetary Policy We start with an unconventional monetary policy intervention of a targeted liquidity injection where the central bank purchases short-term municipal bonds directly from issuers. In the baseline case, the liquidity injection is asymmetric and directed to the Home region, reflecting the fact that the Federal Reserve's MLF was not designed to affect all municipal bonds equally.

Figure 2 shows the impulse responses in this baseline case, highlighting the importance of the credit market.[17] The central bank's purchase of municipal bonds relaxes the enforcement constraint associated with financial intermediaries, which raises municipal bond prices. Higher demand for municipal bonds alleviates the loan-in-advance constraint for the regional government, raising government consumption on impact. Importantly, loosening financial conditions for banks raises private bond prices. Higher private bond prices alleviate the loan-in-advance constraint for investment, and, in turn, raise investment. Following the higher demand by investment firms and the government, output increases, despite the crowding-out effect on private consumption in the near and medium term.

From the inflation perspective, higher initial demand raises inflation on impact. However, over the medium term, loosening financial conditions that boost private investment acts as a supply

[17] Unless otherwise indicated, all variables belong to the Home region.

Figure 2: Impulse responses under an unconventional monetary policy shock applying to the Home region.



shock and lowers inflation. This, in turn, raises private and public consumption, where the latter is fostered by higher tax revenues.

The gains of the unconventional policy mainly stem from its transmission through the credit market. It is worthwhile to note that the increase in private investment accounts for the majority of the increase in aggregate demand, even though the policy targets the state and local government sector. By easing the private sector's loan-in-advance constraint, the policy raises private investment.

To highlight this transmission channel, we consider an alternative, hypothetical case where private firms cannot borrow from financial intermediaries. In figure 3, the red dashed lines show this alternative case in which the credit condition spillover to the private bond market is shut down, while the blue solid lines illustrate the baseline model. While the shock sizes are the same in the two cases, the impact on the economy is strikingly different. In the alternative case, the central bank's asset purchase raises municipal bond prices more significantly, which boosts government consumption. However, without the positive spillover to financial conditions in the private sector, the real economic effects of the unconventional policy are substantially lower. This, in part, depends on the calibration: the short-term municipal bond market is relatively small, and without spillovers, the economic impact is muted. At the same time, if private firms do engage in credit markets as in the baseline, the unconventional policy can have sizeable effects on output, even though the policy does not have a significant impact on state and local government spending.

3.3 Unconventional Monetary vs. Conventional Fiscal Policy

We now turn to a comparison of the economic impact of the unconventional MLF versus a conventional intergovernmental transfer. As shown in figure 4, the solid blue lines show the impulse responses under an unconventional policy shock to the central bank's bond purchase, while the dashed red lines illustrate those under an increase in intergovernmental transfers.

Although both policies have roughly similar impact on output initially, the dynamics diverge substantially over time as the underlying transmission channels are quite different. A persistent increase in direct federal aid alleviates the regional government's budget constraint. As a result, the regional government consumes more, which tightens the loan-in-advance constraint. The government's demand for more Home goods pushes up labor demand, inflation, and output and, at

Figure 3: Impulse response comparison of the baseline model (blue solid lines) versus a model without private bonds (red dashed lines). Both cases feature an unconventional monetary policy shock.

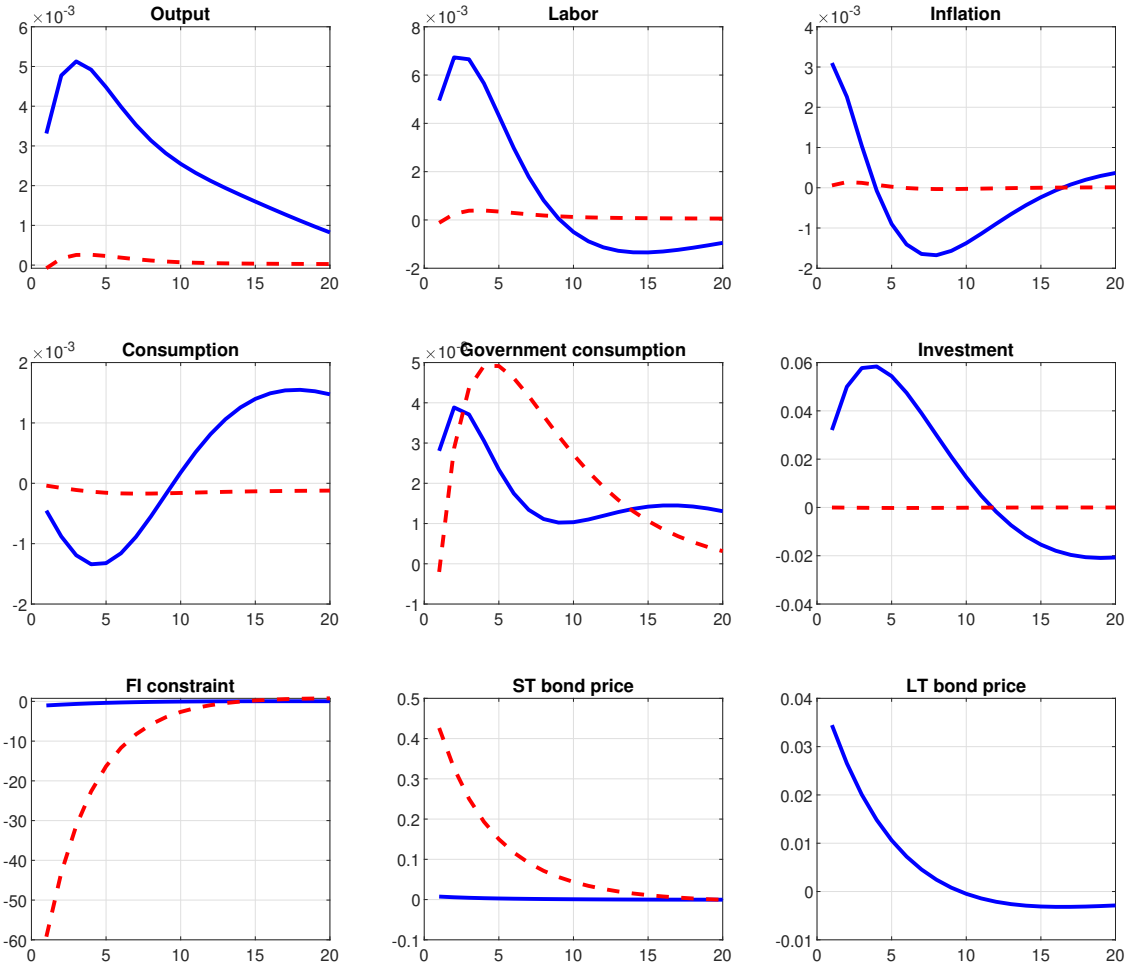
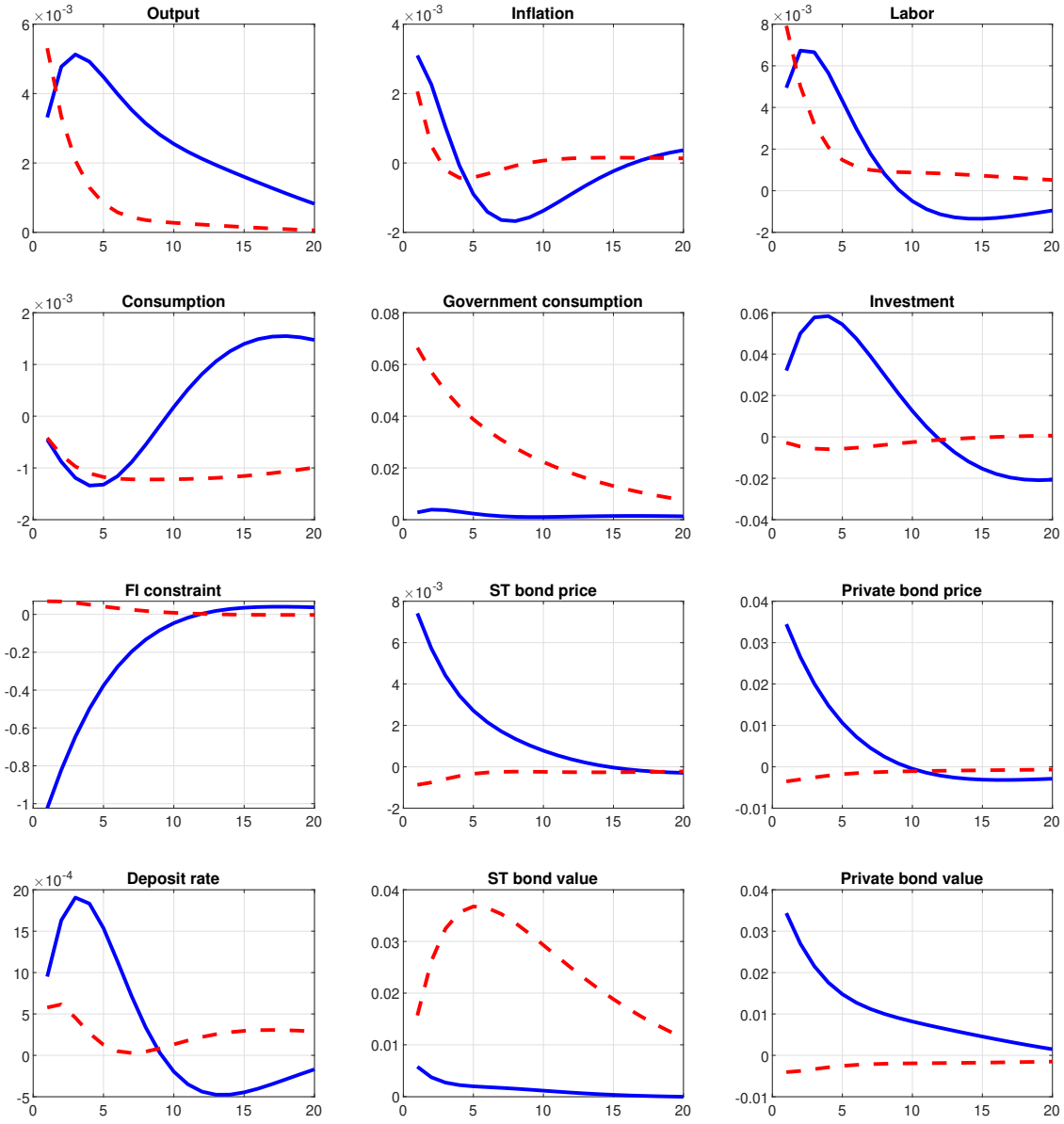


Figure 4: Impulse response comparison of an unconventional monetary policy shock (blue solid lines) versus a conventional policy shock to transfers (red dashed lines). Both policies to the Home region.



the same time, crowds out private consumption and investment. In addition, the higher supply of municipal bonds also tightens the credit conditions for financial intermediaries, lowering municipal as well as private bond prices.

Taken together, conventional policy measure through higher intergovernmental transfers stimulates the economy through higher government expenditure, crowding out private economic activity and raising inflation. The unconventional policy measure, despite targeting the municipal bond market, has a much more muted impact on state and local government expenditures. Instead, it stimulates the economy through a credit channel, improving borrowing conditions and strengthening private investment.

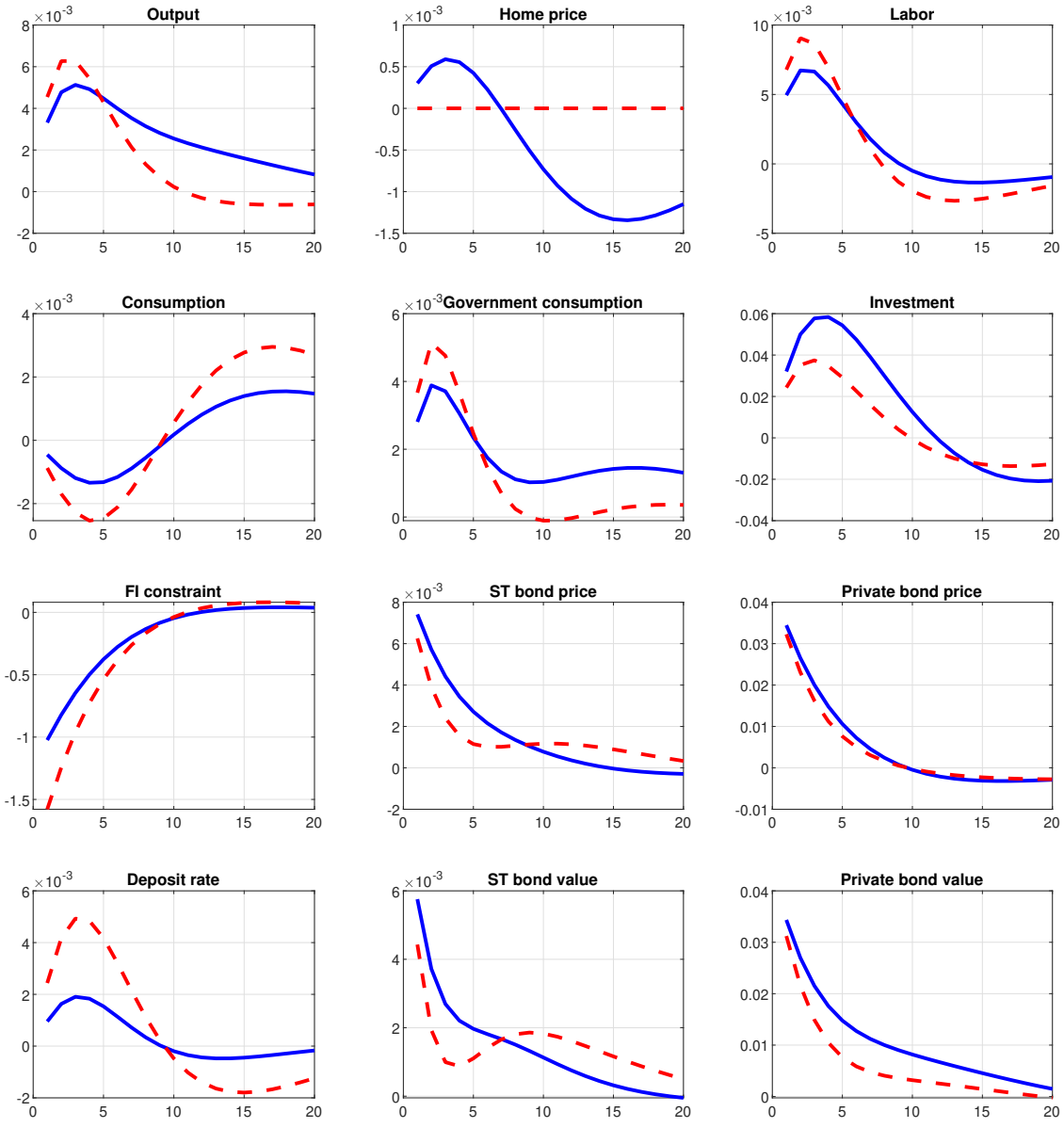
While the unconventional policy can stimulate economic activity, we also note that a central bank policy purchasing private bonds is always more stimulative. Since $\theta^s < 1$ and both public and private loan-in-advance constraints bind, central bank purchases of private bonds have a stronger effect on excess returns compared to municipal bond purchases. In turn, private bond purchases are always more stimulative. Sims and Wu (2021) demonstrate a similar result when comparing central bank purchases of Treasury and private bonds.

3.4 Alternative Unconventional Monetary Policy In this section, we examine two alternative unconventional monetary policy measures: (i) targeting bonds of both regions simultaneously; (ii) targeting longer-maturity municipal bonds which account for the majority of the municipal bond market.

We first consider the counterfactual scenario with unconventional monetary policy targeting both regions (red dashed lines). That is, the central bank purchases equal shares of Home and Foreign municipal bonds, and the federal government gives an equal transfer to each region. Figure 5 compares the impulse responses in this alternative case to those in the baseline case with policy targeting only the Home region (blue solid lines). The outcomes are qualitatively similar. However, in the baseline case, asymmetric bond purchases prompt strong demand for investment in the Home region, but not in the Foreign region; thus the Home region imports more consumption as well as investment goods from the Foreign region, leading to a more persistent boom in output, accompanied by lower relative Home prices in the medium term.

In the second scenario, the central bank can commit to purchase longer-term municipal bonds

Figure 5: Impulse response comparison of an unconventional monetary policy targeting only the Home region (baseline, blue solid lines) versus one targeting both regions (red dashed lines).



instead of targeting short-term debt. For instance, the Bank of Canada implemented this type of policy with its Provincial Bond Purchase Program in 2020-2021 that purchased sub-national debt with maturities up to 10 years. To investigate the role of long-term debt purchases, we augment the model with a loan-in-advance constraint for government investment:

$$\eta^{gi}\rho_{H,t}g_t^i \quad \leq \quad Q_t^l\left(b_t^l - \kappa^l\frac{b_{t-1}^l}{\pi_t}\right), \tag{3.1}$$

Our baseline calibration implies a value for $\eta^{gi} = 0.77$, substantially higher than the value for η^{gc} and consistent with the notion that most state and local government investment expenditures are financed with debt.

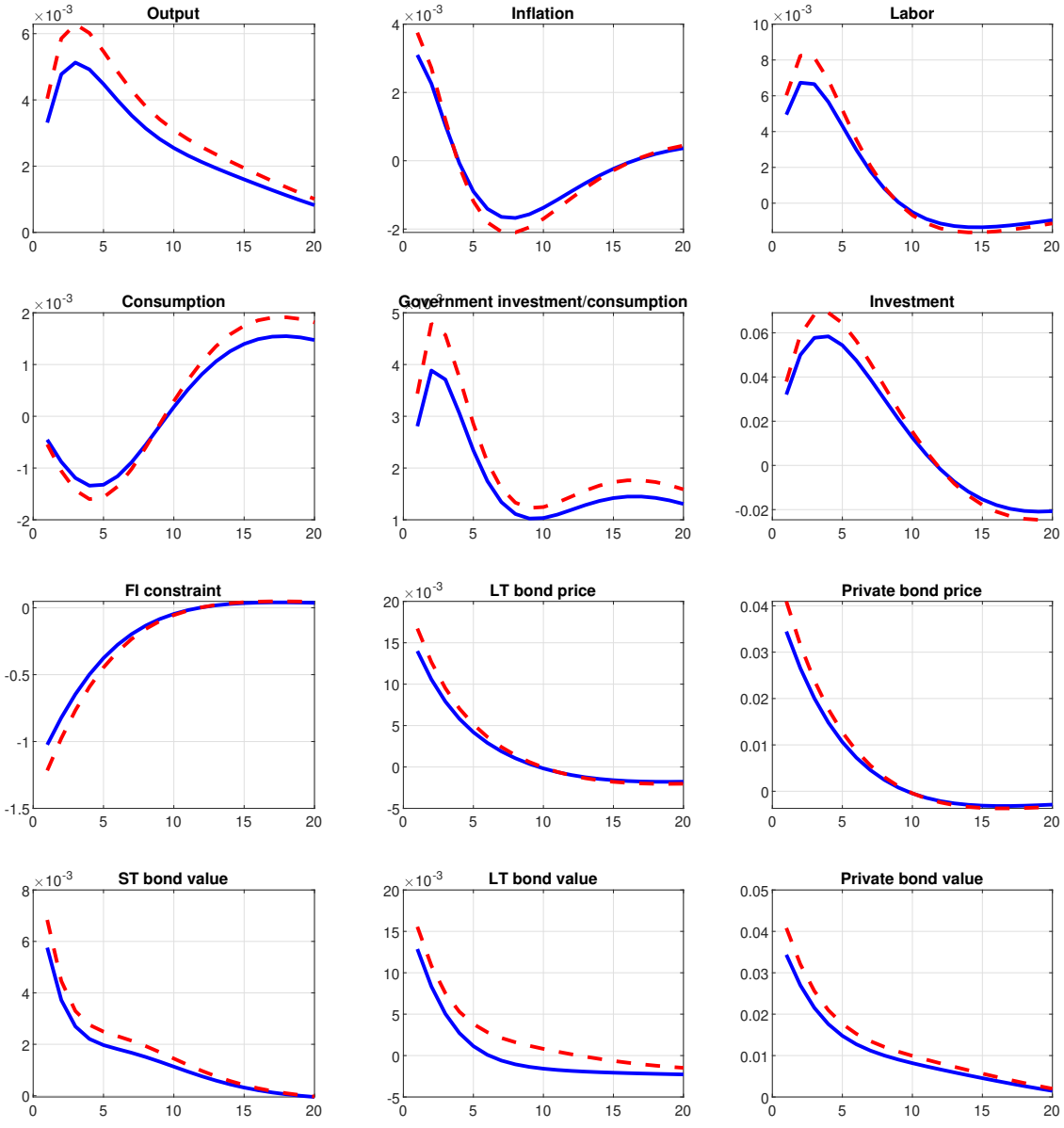
Figure 6 compares the impulse responses of the central bank's purchase of long-term municipal bonds (dashed red lines) and those of purchases of short-term municipal bonds in the baseline case (solid blue lines). For comparison, we assume the amount of bond purchases is the same in both cases. The responses are similar qualitatively while the long-term bond purchases having slightly larger effects. For the same size shock, both short- and long- term municipal bond purchases have similar credit easing effects and transmission through the financial market. The stronger effects from the long-term purchases stem from the differential impact on the regional government. Similarly to the baseline case, the long-term municipal bond purchases ease the loan-in-advance constraint of public investment, but in this case, government investment is more tightly connected to the level of new bond issuance (through a higher value of η^{gi}). Higher public investment further boosts firms' productivity, raising output and private investment more over time.

4 Conclusion

Following the pandemic, central banks expanded their options for unconventional policy measures. One new action allowed for the direct purchase of sub-national government debt. In this paper, we quantify the economic and fiscal effects of this unconventional policy in a two-region New Keynesian model of a monetary union that explicitly accounts for sub-national government financing.

We find the transmission of the central bank's unconventional purchase of local debt (MLF) can differ markedly from conventional intergovernmental transfers. While both policies can stimulate

Figure 6: Impulse response comparison of an unconventional monetary policy targeting short-term municipal bonds (baseline, blue solid lines) versus one targeting long-term municipal bonds (red dashed lines). Both policies apply to the Home region.



local output over time, the two policies have notably opposite effects on the credit constraint of the financial intermediary; intergovernmental transfers lead to a tightening of this constraint while, by design, the unconventional monetary policy loosens it. We show this distinction has important implications, as private investment increases with the eased credit conditions from the unconventional policy, whereas investment is crowded-out by intergovernmental transfers. In addition, the unconventional policy has significantly smaller effects on government consumption. Thus, for the same increase in output, the two policies can imply markedly different paths of GDP's expenditure components, which in turn could affect relative welfare rankings of the policies.

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