Unconventional Monetary Policy and Local Fiscal policy

Huixin Bi
Federal Reserve Bank of Kansas City

Nora Traum
HEC Montréal

October 2022

Motivation

- The Fed took unprecedented steps in intervening in the municipal bond market during the pandemic.
  - To help state and local (S&L) governments manage cash flow pressures.
  - To support municipal financial market functioning.
  - Its first time as a lender-of-last-resort for S&L governments.
- Other countries launched similar programs:
  - Canada: Provincial Bond Purchase Program
  - Australia: Purchase state/terrioritory government bonds
- This paper:
  - How does the unconventional monetary policy impact S&L government expenditures as well as financial market functioning?
  - We build a two-region model focusing on S&L government fiscal financing as well as municipal market.

Findings

Unconventional monetary policy targeting short-term munis

- Financial market channel dominates cash flow channel
- Stimulative impact from credit condition spillovers (to the private sector)

Findings

Unconventional monetary policy targeting short-term munis

- Financial market channel dominates cash flow channel
- Stimulative impact from credit condition spillovers (to the private sector)

Alternative policy measures

- Conventional fiscal policy: markedly different transmission
  - Cash flow channel dominates $\rightarrow$ higher government consumption, but muted impact on the overall economy
- Unconventional monetary policy targeting long-term munis:
  - Much stronger impact from financial market channel
  - Higher public investment $\rightarrow$ higher productivity

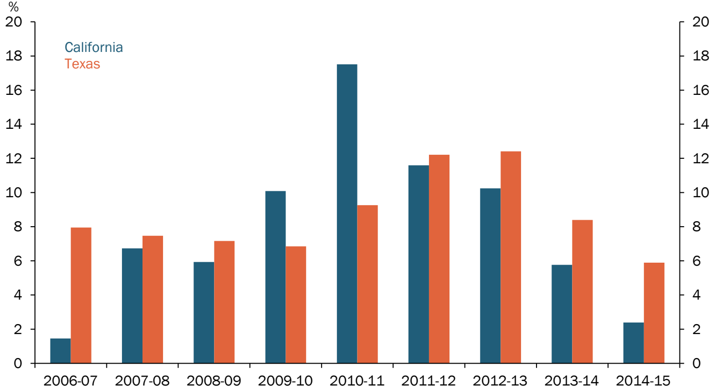
Institutional Background

S&L Governments

- Important player in economic activity:
  - Account for 2/3 of total government consumption and 3/4 of total government investment.
- Most S&L governments subject to a "balanced" budget:
  - Balance revenue with consumption expenditures;
  - Capital spending is usually exempt.
- But S&L revenue receipts are lumpy throughout the year:
  - State governments: sales taxes (summer season and winter holiday) or income taxes (around April tax filing deadline)
  - Local governments: property taxes (received once or twice a year)
- In response, they issue short-term "anticipation notes" to manage cash flow:
  - Tax/Revenue/Grant/Bond anticipation notes
  - Maturity usually less than 13 months

S&L Governments: Short-term Financing

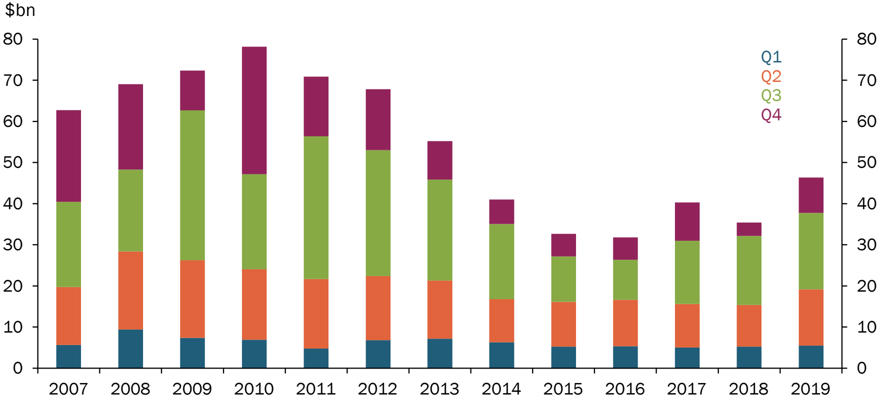
- For some states, a nontrivial portion of expenditures is financed through short-term notes at times.



Source: State annual financial reports

Short-term Municipal Notes: Cyclical and Seasonal

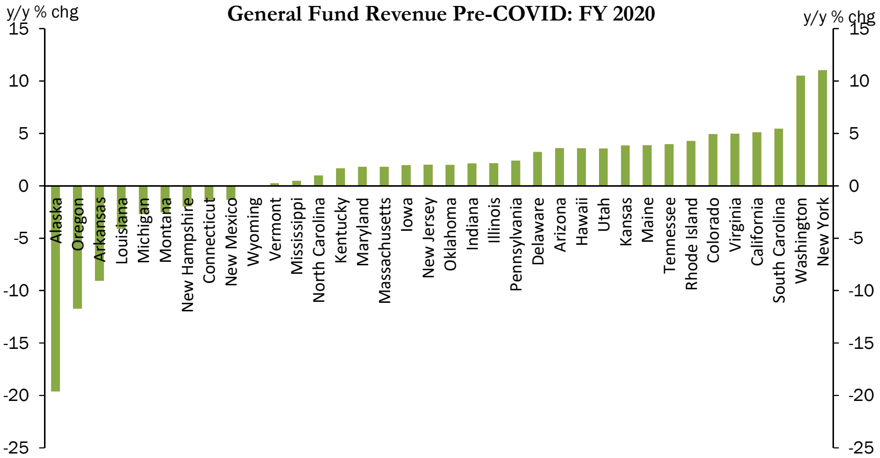
- S&L governments issue more notes following an economic downturn as well as at the beginning of fiscal year.



Source: Bloomberg

Extraordinary Cash Flow Pressures in 2020

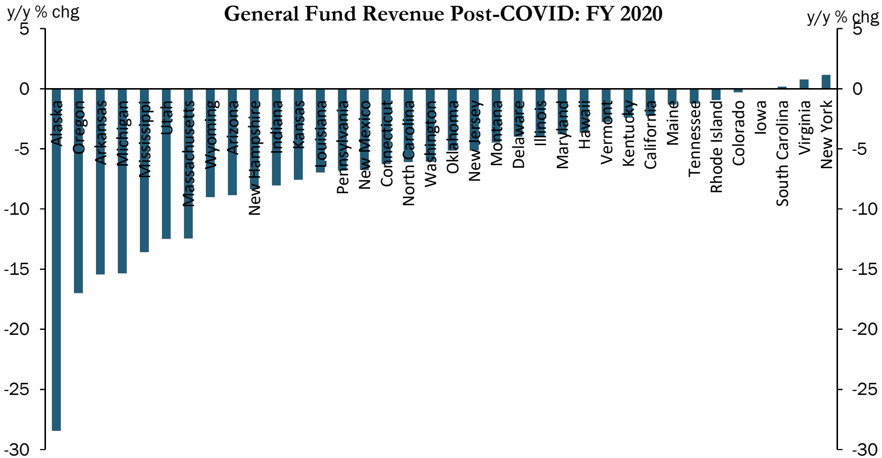
- Pre-COVID: most states expected solid growth in their revenues in FY 2020



Source: NASBO

Extraordinary Cash Flow Pressures in 2020

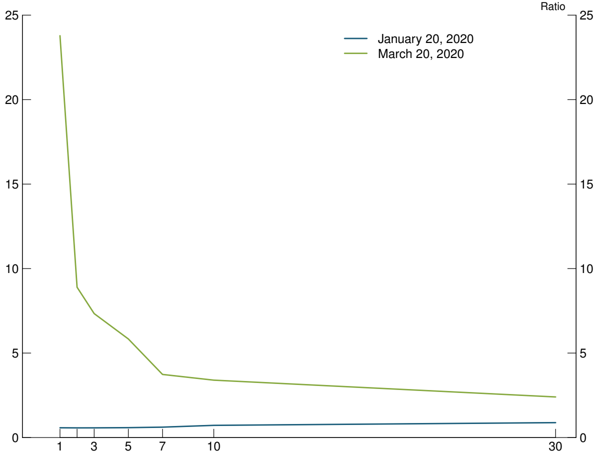
- Early 2020: almost all of them expect declines in revenues



Source: CBPP and NCSL

Financial Stress in Municipal Bond Market in 2020

- Short-term muni yields (w.r.t Treasury yields) surged during the pandemic.



Source: MSRB, Bi and Marsh (2022)

Federal Reserve’s Intervention

- Municipal Liquidity Facility (MLF)
  - Supported by the CARES Act
  - Purchases newly issued, short-term bonds directly from issuers
- Purposes:
  - Cash flow: “to help state and local governments better manage the extraordinary cash flow pressures”
  - Financial conditions: “By ensuring the smooth functioning of the municipal securities market, particularly in times of strain, the Federal Reserve is providing credit that will support families, businesses, and jobs in communities, large and small, across the nation.”

Simpler Model: Closed Economy

Model Highlights

- Regional government faces a "loan-in-advance constraint" [Sims and Wu (2021)]
  - Issue short-term anticipation notes to finance a portion of its consumption.
- Financial intermediaries [Gertler and Karadi (2011)]
  - Channel funds from households to regional governments (muni bonds) and firms (corporate bonds).
  - Almost all muni trading activities in 2020 were driven by financial institutions. Details
- Unconventional monetary policy
  - Central bank purchases short-term muni bonds

Government

- Consumption expenditure budget:
  - Finance consumption through short-term notes, taxes as well as federal transfers ◂ Details

$$g_t^c + \frac{b_{t-1}^s}{\pi_t} = Q_t^s \left(b_t^s - \kappa^s \frac{b_{t-1}^s}{\pi_t} \right) + tr_t^{gc} + \psi^{gc} \left[\tau_t^i y_t + \tau_t^c c_t \right]$$

  - Loan-in-advance constraint: a portion of consumption through short-term anticipation notes ◂ Details

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

  - Loan in advance with small η^{gc} captures the S&L budgeting in US.

Government

- Consumption expenditure budget:
  - Finance consumption through short-term notes, taxes as well as federal transfers ◂ Details

$$g_t^c + \frac{b_{t-1}^s}{\pi_t} = Q_t^s \left(b_t^s - \kappa^s \frac{b_{t-1}^s}{\pi_t} \right) + tr_t^{gc} + \psi^{gc} \left[\tau_t^i y_t + \tau_t^c c_t \right]$$

  - Loan-in-advance constraint: a portion of consumption through short-term anticipation notes ◂ Details

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

  - Loan in advance with small η^{gc} captures the S&L budgeting in US.
- Public investment budget:
  - Finance investment through taxes as well as federal transfers

$$g^i = tr_t^{gi} + (1 - \psi^{gc}) \left[\tau_t^i y_t + \tau_t^c c_t \right]$$

Wholesale Firms

- Issue long-term private bonds to finance private investment with loan-in-advance constraint [Sims and Wu (2021)]

$$(\zeta_t^1) \qquad K_t = I_t^w + (1-\delta)K_{t-1}$$

$$(\zeta_t^2) \qquad \eta^I p_t^k I_t^w \le Q_t^f \left(f_t - \kappa^f \frac{f_{t-1}}{\pi_t} \right)$$

- Produce output using labor and private & public capital

$$y_t^w = A_t L_t^{1-\alpha} K_{t-1}^{\alpha} (K^g)^{\alpha_g}$$

- Optimal conditions:

$$\begin{aligned}
\zeta_t^1 &= p_t^k (1 + \eta^I \zeta_t^2) \\
Q_t^f (1 + \zeta_t^2) &= \beta E_t \Lambda_{t+1} \frac{1}{\pi_{t+1}} \left(1 + \kappa^f Q_{t+1}^f (1 + \zeta_{t+1}^2) \right) \\
\zeta_t^1 &= \beta E_t \Lambda_{t+1} \left(\frac{p_{t+1}^w \alpha y_{t+1}}{K_t} (1 - \tau_{t+1}^i) + (1-\delta) \zeta_{t+1}^1 \right)
\end{aligned}$$

Financial Intermediary

- Balance sheet:
  - Collect deposits from households and accumulate net worth
  - Purchase short-term muni bonds as well as corporate bonds

$$Q_t^s b_t^{s,j} + Q_t^f f_t^j = d_t^j + n_t^j$$

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

- Maximize expected net worth with a survival rate of σ

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

- Face agency problem

$$V_t^j \geq \eta^v (Q_t^f f_t^j + \theta^s Q_t^s b_t^{s,j})$$

  - FIs can divert η^v of assets
  - Less severe with government bonds ($\theta^s < 1$)

Financial Intermediary

The first-order conditions are,

$$\frac{\lambda_t^v}{1+\lambda_t^v}\eta^v = \beta E_t \Lambda_{t+1} \frac{\Omega_{t+1}}{\pi_{t+1}} \left(R_{t+1}^f - R_t^d \right)$$
$$\frac{\lambda_t^v}{1+\lambda_t^v}\eta^v \theta^s = \beta E_t \Lambda_{t+1} \frac{\Omega_{t+1}}{\pi_{t+1}} \left(R_{t+1}^s - R_t^d \right)$$
$$\frac{\phi_t}{1+\lambda_t^v}\eta^v = \beta E_t \Lambda_{t+1} \frac{\Omega_{t+1}}{\pi_{t+1}} R_t^d$$

- λ_t^v measures the tightness of the costly enforcement constraint.
- $R_{t+1}^i - R_t^d$: excess returns
- $\phi_t = \frac{Q_t^f f_t^j + \theta^s Q_t^s b_t^{s,j}}{n_t}$: leverage ratio
- $\Omega_t = 1 - \sigma + \sigma \eta_t^v \phi_t$

The Rest of the Model

- Investment producers: assemble investment with adjustment costs
- Retail firms: Rotemberg price adjustment
- Households work, pay taxes, receive lump-sum profits and deposit in FIs.

$$d_t + c_t(1+\tau_t^c) = \frac{R_{t-1}^d d_{t-1}}{\pi_t} + w_t l_t + \Pi_t^f + div_t - x - \tau_t^f$$

- Conventional Taylor rule:

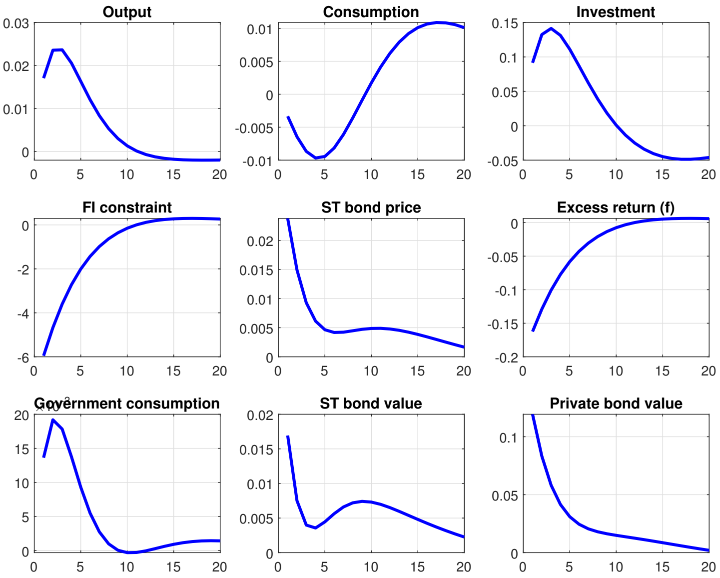
$$\ln \frac{R_t^d}{R^d} = \rho_R \ln \frac{R_{t-1}^d}{R^d} + (1-\rho_R)\left(\phi_\pi \ln \frac{\pi_t}{\pi} + \phi_y \ln \frac{y_t}{y}\right) + \epsilon_t^R$$

- Unconventional monetary policy targeting muni market:

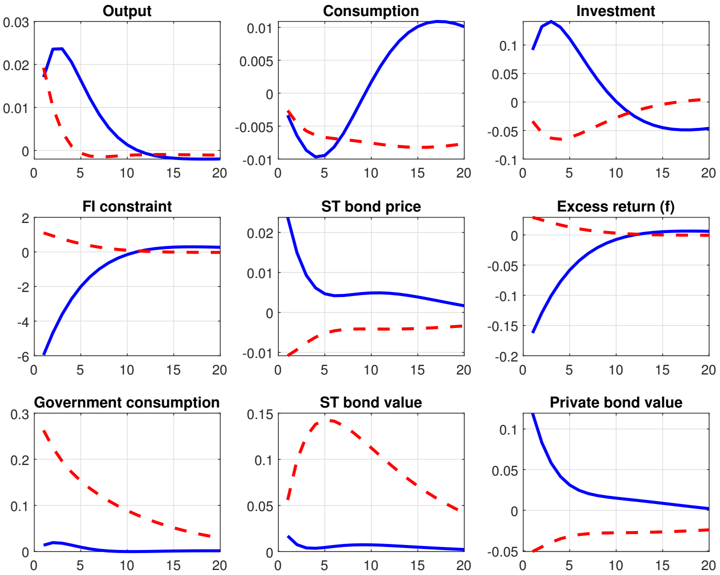
$$T_t^{cb} = \frac{R_t^s}{\pi_t} Q_{t-1}^s b_{t-1}^{s,cb} - Q_t^s b_t^{s,cb}$$

$$b_t^s = b_t^{s,cb} + b_t^{s,f}$$

Baseline: Unconventional MP



Unconventional MP vs. Conventional FP



Two-Region Model

Model Highlights

- Two-region monetary-union framework [Nakamura and Steinsson (2014)]
- Home regional government
  - Issue short-term muni notes to finance a portion of its consumption (loan-in-advance constraint).
  - Issue long-term muni bonds to finance public investment.

$$
\begin{aligned}
\rho_{H,t} g_t^i + (1 + \kappa^l Q_t^l) \frac{b_{t-1}^l}{\pi_t} &= Q_t^l b_t^l + tr_t^{gi} + (1 - \psi^{gc}) \left[\tau_t^i y_t + \tau_t^c c_t \right] \\
K_t^g &= (1 - \delta^g) K_{t-1}^g + g_t^i
\end{aligned}
$$

- Home wholesale firm
  - Issue long-term private bonds to finance private investment (loan-in-advance constraint).

Financial Intermediary: Domestic and Foreign Assets

- Hold both domestic and foreign assets:
  - Intratemporal portfolio decisions with CES composite [Alpanda and Kabaca (2018), Krenz (2022)]
  - Example: short-term muni

$$\max \quad E_t\left(R^s_{t+1}Q^s_t b^{H,s,j}_t + R^{s,*}_{t+1}Q^{s,*}_t b^{F,s,j}_t\right)$$

$$s.t. \quad m^{s,j}_t = \left[\gamma_s^{\frac{1}{\sigma_S}}\left(Q^s_t b^{H,s,j}_t\right)^{\frac{\sigma_S-1}{\sigma_S}} + (1-\gamma_s)^{\frac{1}{\sigma_S}}\left(Q^{s,*}_t b^{F,s,j}_t\right)^{\frac{\sigma_S-1}{\sigma_S}}\right]^{\frac{\sigma_S}{\sigma_S-1}}$$

Financial Intermediary: Domestic and Foreign Assets

- Hold both domestic and foreign assets:
  - Intratemporal portfolio decisions with CES composite [Alpanda and Kabaca (2018), Krenz (2022)]
  - Example: short-term muni

$$\max \quad E_t\left(R^s_{t+1} Q^s_t b^{H,s,j}_t + R^{s,*}_{t+1} Q^{s,*}_t b^{F,s,j}_t\right)$$

$$s.t. \quad m^{s,j}_t = \left[\gamma_s^{\frac{1}{\sigma_s}}\left(Q^s_t b^{H,s,j}_t\right)^{\frac{\sigma_s-1}{\sigma_s}} + (1-\gamma_s)^{\frac{1}{\sigma_s}}\left(Q^{s,*}_t b^{F,s,j}_t\right)^{\frac{\sigma_s-1}{\sigma_s}}\right]^{\frac{\sigma_s}{\sigma_s-1}}$$

- Balance sheet:

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

- Maximize expected net worth with an agency problem

$$\max \quad V^j_t = (1-\sigma)\beta E_t \Lambda_{t+1} n^j_{t+1} + \sigma\beta E_t \Lambda_{t+1} V^j_{t+1}$$

$$s.t. \quad V^j_t \geq \eta^\nu (m^{f,j}_t + \theta^s m^{s,j}_t + \theta^l m^{l,j}_t)$$

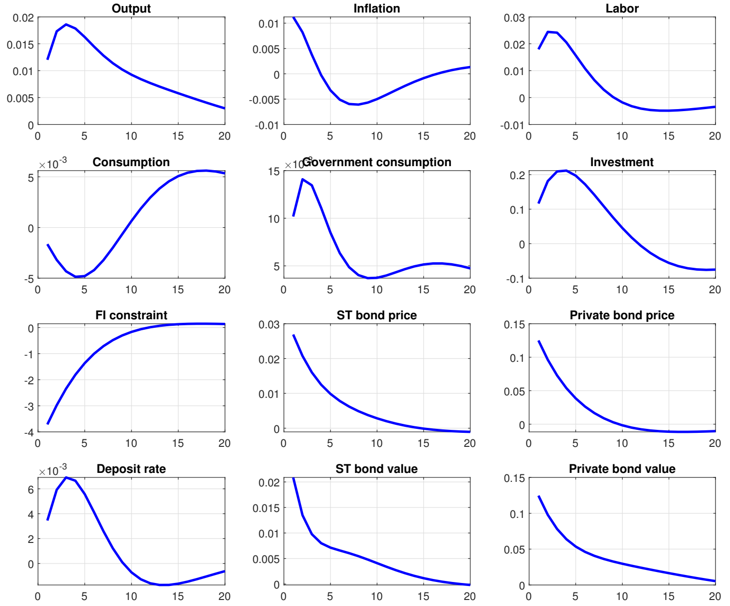
Details

The Rest of the Model

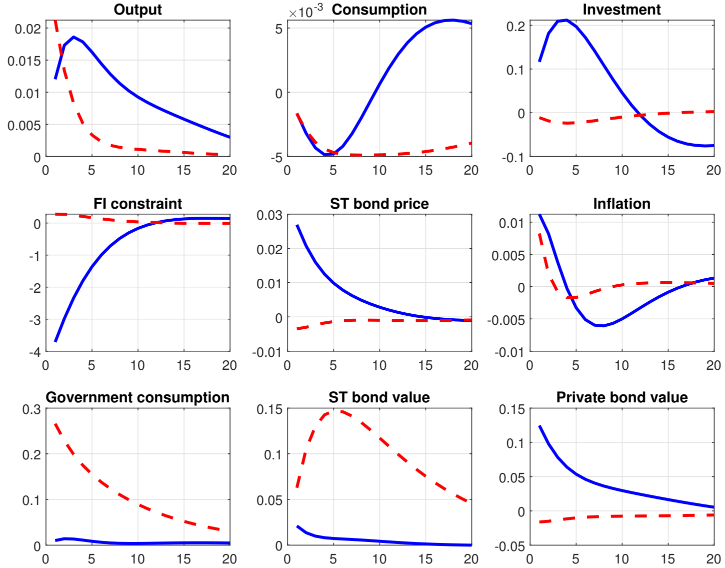
- Households:
  - Deposits at home FI as well as hold one-period cross-region bond
  - Consume a bundle of home and foreign goods
  - Endogenous discount factor to "close" the model
- Monetary Policy:
  - Union-wide Taylor rule
  - Unconventional monetary policy
- Asset markets clearing conditions:

$$b_t^s = b_t^{s,cb} + b_t^{H,s} + b_t^{H,s,*} rer_t; \qquad b_t^l = b_t^{H,l} + b_t^{H,l,*} rer_t; \qquad f_t = f_t^H + f_t^{H,*} rer_t$$

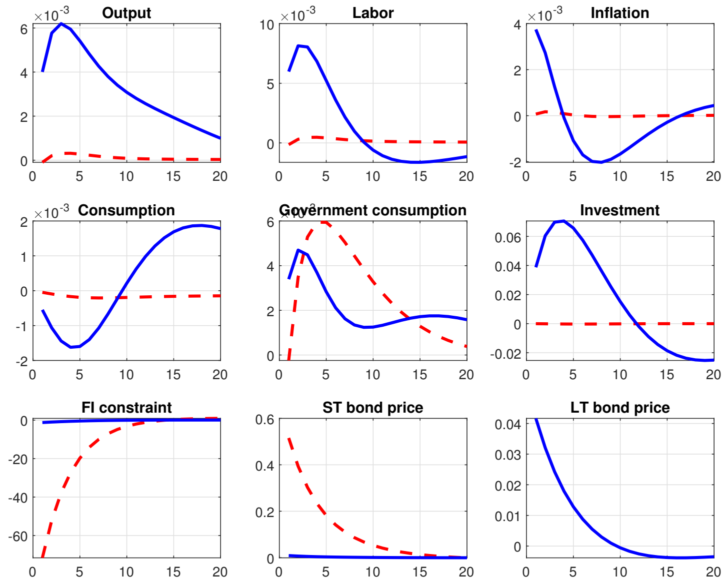
Baseline: Unconventional MP



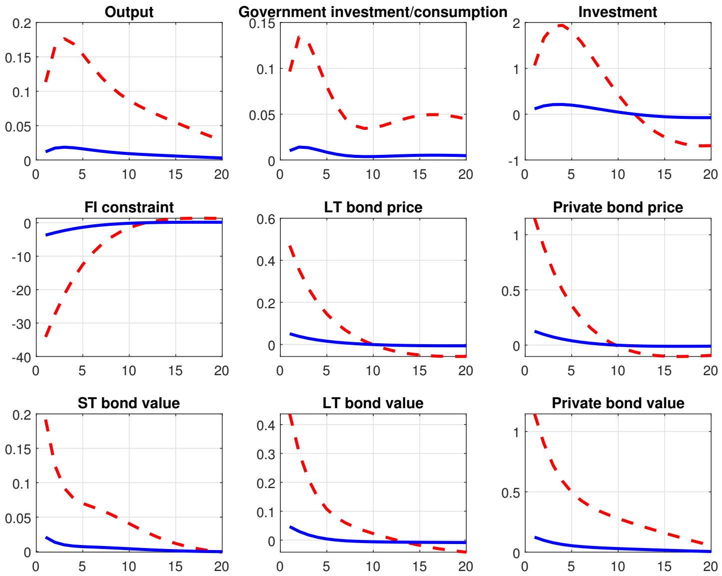
Unconventional MP vs. Conventional FP



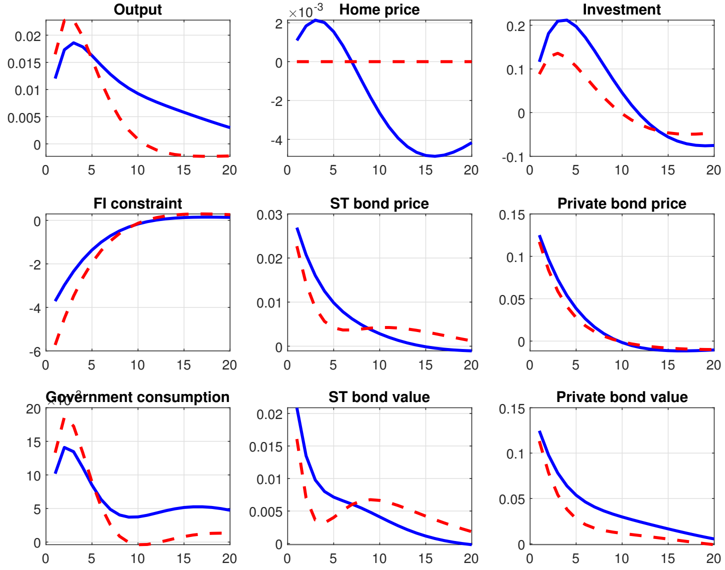
Cases with vs. without Private Bonds



Short- vs. Long-term Muni Bond Purchases



Asymmetric vs. Symmetric Unconventional MP

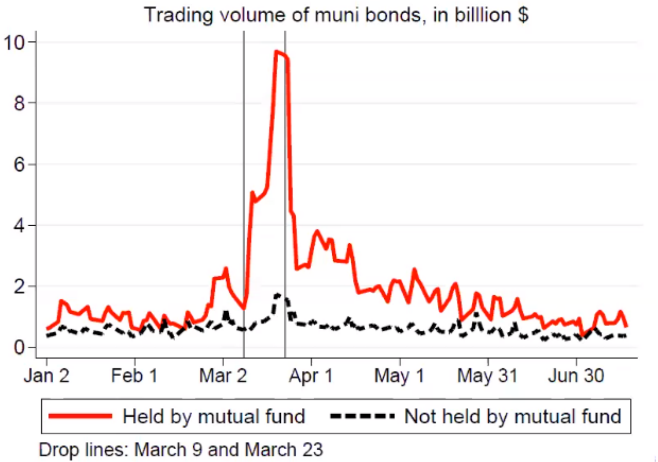


Conclusion

- Unconventional monetary policy targeting munis:
  - Financial market channel dominates cash flow channel
  - Targeting long-term munis is more expansionary than targeting short-term munis.
- Conventional fiscal policy works through cash flow channel

Appendix

Municipal Bond Market: Mutual Funds



Source: Li, O'Hara and Zhou (2021) Back

Bond Maturity

- New bond issuance of $\hat{b}_t$ at each period with payoff of κ^j at period $t+j+1$
- Define existing bonds as $b_t = \sum_{j=1}^{\infty} \kappa^{j-1} \hat{b}_{t-j}$
- Government budget constraint:

$$Q_t \hat{b}_t + T_t = \underbrace{\sum_{j=1}^{\infty} \kappa^{j-1} \hat{b}_{t-j}}_{b_{t-1}} + g_t$$

$$\rightarrow Q_t (b_t - \kappa b_{t-1}) + T_t = b_{t-1} + g_t$$

Back

Loan-in-advance Constraint

Government budget constraint (linearized):

$$\hat{b}_{t-1} = \frac{1}{R}\left(\hat{b}_t + X_{tr}\hat{tr}_t + X_T\hat{T}_t - X_g\hat{g}_t + X_Q\hat{Q}_t\right) + \hat{\pi}_t$$

Roll forward k periods:

$$\sum_{j=0}^{k}\left(\prod_{i=0}^{j}\frac{1}{R_{t+i-1}}\right)X_{tr}\hat{tr}_{t+j} = \underbrace{\hat{b}_{t-1} - \left(\prod_{i=0}^{k}\frac{1}{R_{t+i}}\right)\hat{b}_{t+k} + \sum_{j=0}^{k}\left(\prod_{i=0}^{j}\frac{1}{R_{t+i-1}}\right)X_Q\hat{Q}_{t+j}}_{\text{debt financing}}$$

$$+\underbrace{\sum_{j=0}^{k}\left(\prod_{i=0}^{j-1}\frac{1}{R_{t+i-1}}\right)\hat{\pi}_{t+j} + \sum_{j=0}^{k}\left(\prod_{i=0}^{j}\frac{1}{R_{t+i-1}}\right)\left(X_g\hat{g}_{t+j} - X_T\hat{T}_{t+j}\right)}$$

Back

Loan-in-advance Constraint

No persistence to shock, $\rho_{tr} = 0$				
	$k = 1$	$k = 4$	$k = 10$	$k = 25$
% of transfers distributed	100	100	100	100
LIA (baseline)	103	101	100	100
LIA with a higher η^{gc}	126	108	100	100
Standard fiscal rule	0.68	157	71	95
Persistent shock, $\rho_{tr} = 0.9$				
	$k = 1$	$k = 4$	$k = 10$	$k = 25$
% of transfers distributed	11	36	68	94
LIA (baseline)	11	37	68	94
LIA with a higher η^{gc}	13	41	71	94
Standard fiscal rule	0.20	32	62	93

Back

Unconventional MP vs. Conventional FP Shocks

- Government budget:

$$g_t^c + \frac{b_{t-1}^s}{\pi_t} = Q_t^s \left(b_t^s - \kappa^s \frac{b_{t-1}^s}{\pi_t} \right) + tr_t^{gc} + \psi^{gc} \left[\tau_t^i y_t + \tau_t^c c_t \right]$$

- Loan-in-advance constraint:

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

- Unconventional MP shock vs. conventional FP shock (on transfer):

$$\frac{\epsilon^b}{\epsilon^{tr}} = \frac{Q^s}{\eta^{gc}} \left(1 - \frac{\kappa^s}{\pi} \right)$$

Back

Financial Intermediary: Domestic and Foreign Assets

- CES asset portfolios

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

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

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

- FOCs for short-term muni:

$$\frac{Q_t^s b_t^{H,s,j}}{m_t^{s,j}} = \gamma_s \left(\frac{E_t R_{t+1}^s}{E_t R_{t+1}^{m,s}}\right)^{-\sigma_s}$$

$$\frac{Q_t^{s,*} b_t^{F,s,j}}{m_t^{s,j}} = (1-\gamma_s) \left(\frac{E_t R_{t+1}^{s,*}}{E_t R_{t+1}^{m,s}}\right)^{-\sigma_s}$$

$$R_{t+1}^{m,s} = \left[\gamma_s \left(R_{t+1}^s\right)^{1-\sigma_s} + (1-\gamma_s)\left(R_{t+1}^{s,*}\right)^{1-\sigma_s}\right]^{\frac{1}{1-\sigma_s}}$$

$$R_t^s \equiv \frac{1+\kappa^s Q_t^s}{Q_{t-1}^s}, \quad R_t^{s,*} \equiv \frac{1+\kappa^{s,*} Q_t^{s,*}}{Q_{t-1}^{s,*}}.$$

Financial Intermediary

- Balance sheet:
  - Collect deposits from households and accumulate net worth
  - Purchase short- and long-term muni bonds as well as corporate bonds

$$Q_t^s b_t^{H,s,j} + Q_t^{s,*} b_t^{F,s,j} + Q_t^l b_t^{H,l,j} + Q_t^{l,*} b_t^{F,l,j} + Q_t^f f_t^{H,j} + Q_t^{f,*} f_t^{F,j} = d_t^j + n_t^j$$

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

- Maximize expected net worth with a survival rate of σ

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

- Face agency problem

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

  - FIs can divert η^V of assets
  - Less severe with government bonds ($\theta < 1, \theta_l < 1$)

Financial Intermediary

The first-order conditions are,

$$\frac{\lambda_t^v}{1+\lambda_t^v}\eta^v = \beta E_t \Lambda_{t+1} \frac{\Omega_{t+1}}{\pi_{t+1}} \left(R_{t+1}^{m,f} - R_t^d\right)$$

$$\frac{\lambda_t^v}{1+\lambda_t^v}\eta^v \theta^s = \beta E_t \Lambda_{t+1} \frac{\Omega_{t+1}}{\pi_{t+1}} \left(R_{t+1}^{m,s} - R_t^d\right)$$

$$\frac{\lambda_t^v}{1+\lambda_t^v}\eta^v \theta^l = \beta E_t \Lambda_{t+1} \frac{\Omega_{t+1}}{\pi_{t+1}} \left(R_{t+1}^{m,l} - R_t^d\right)$$

$$\frac{\phi_t}{1+\lambda_t^v}\eta^v = \beta E_t \Lambda_{t+1} \frac{\Omega_{t+1}}{\pi_{t+1}} R_t^d$$

- λ_t^v measures the tightness of the costly enforcement constraint.
- $R_{t+1}^{m,i} - R_t^d$: excess returns
- $\phi_t = \frac{m_t^f + \theta^s m_t^s + \theta^l m_t^l}{n_t}$: leverage ratio
- $\Omega_t = 1 - \sigma + \sigma \eta_t^v \phi_t$

Back

Households

- Endogenous discount factor to "close" the model

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

with $\Theta_{t+1} = \beta_c (1 + \tilde{c}_t)^{-\omega_\beta}$

- Deposits at home FI as well as hold one-period cross-region bond

$$d_t + b_t^i + c_t (1 + \tau^c) = \frac{R_{t-1}^d d_{t-1}}{\pi_t} + \frac{R_{t-1}^d b_{t-1}^i}{\pi_t} + w_t l_t + \Pi_t^f + div_t - x - \tau_t^f, \tag{2}$$

- Consume a bundle of home and foreign goods

$$c_t = \left[\alpha_H^{\frac{1}{\phi}} (c_{H,t})^{\frac{\phi-1}{\phi}} + (1 - \alpha_H)^{\frac{1}{\phi}} (c_{F,t})^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}} \tag{3}$$

Other Firms

- Investment producers:
  - Bundle domestic and foreign goods

$$I_t = \left[\alpha_H^{\frac{1}{\phi}} \left(I_{H,t}\right)^{\frac{\phi-1}{\phi}} + (1-\alpha_H)^{\frac{1}{\phi}} \left(I_{F,t}\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}$$

  - Investment adjustment costs
- Retail firms:
  - Rotemberg price adjustment
  - Law of one price $P_{H,t} = P^*_{H,t}$

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
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