Normalizing the Central Bank's Balance Sheet: Implications for Inflation and Debt Dynamics

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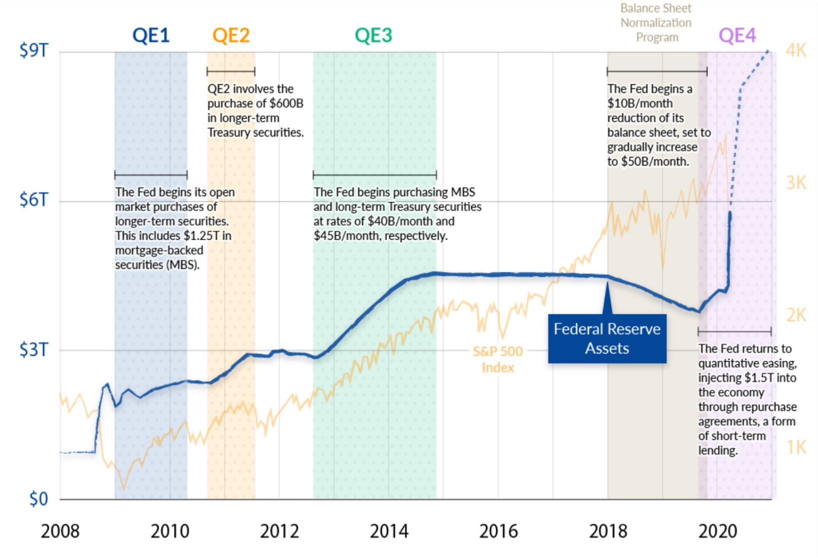
1. Introduction

- Since the GFC, Quantitative Easing (QE) has dramatically changed the Fed's balance sheet. Specifically, it has
  - increased its size;
  - expanded its maturity composition.

- In 2014 the Federal Open Market Committee (FOMC) outlined three key actions in the *monetary policy normalization* process:
  (i) **increase** short-term **interest rates** *("lift-off")*.
  (ii) **reduce** the **size** of the balance sheet *("run-off")*.
  (iii) **restore** the balance sheet's **composition** to that of pre-GFC *("operation un-twist")*.

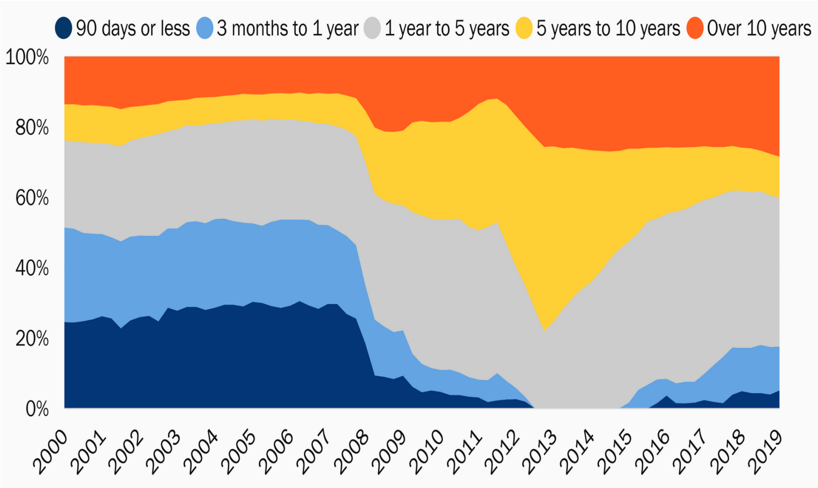
- **This paper ....** what we do and what we find

Federal Reserve Balance Sheet: Assets — Size



Source: Federal Reserve, CNBC.

Federal Reserve Balance Sheet: Assets — Composition



Source: Federal Reserve, The Brookings Institution.

Return

This paper: what we do

- **This paper** builds a macroeconomic model with:
  - Short and long-term bonds with differential liquidity premia.
  - A fiscal authority (with a tax rule).
  - A monetary authority (with an Taylor rule and with **rules on the size and composition of a C.B.'s Balance Sheet**).
- We take as given the increase of the balance sheet.
- We study the monetary normalization process (points (ii) and (iii) of slide 1) for an economy that has already done the lift-off (point (i)).
- Our experiment: we are in 2014, aim to unwind the Central Bank's balance sheet and evaluate:
  - **(1)** implications for inflation and debt dynamics.
  - **(2)** the interaction of fiscal and monetary policies.
  - **(3)** desirable properties for those rules.

This paper: what we find

- **This paper** finds that the characteristic of the equilibria depend on whether there is a liquidity premia.

- Without liquidity premia:
  - **(1)** unique steady state - inflation hits its target.
  - **(2)** fiscal and monetary policies require coordination on changes on the size of the balance sheet.
  - **(3)** standard stability prescriptions prevail as long as balance sheet size it is taken into account for the fiscal stance.

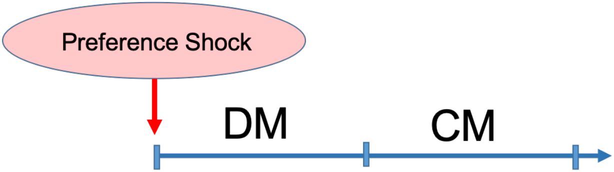
- With liquidity premia:
  - **(1)** there can be multiple steady states - inflation may not hit its target.
  - **(2)** fiscal and monetary policies require coordination on size and composition of the balance sheet.
  - **(3)** low maturity composition, aggressive response to deviations from targets, and slow process are desirable features for the monetary policy normalization.

2. Related Literature

- Dangers of CB's large balance sheet: Bassetto and Messer (2013), Del Negro et al. (2015), Hall and Reis (2015), ...
- Balance sheet management with sticky prices: Andres et al. (2004), Harrison (2011), Reis (2017), Arce et al. (2019), ...
- CB balance sheet management and financial markets: Goodhart and Ashworth (2012), Borio and Zabai (2018), Berentsen et al. (2018), Ennis (2018), Benigno and Benigno (2022), etc.
- Monetary Policy when interest rates are persistently low: Bassetto and Cui (2017), Borio and Hofmann (2017), Hesse et al. (2018), Rocheteau et al (2018), etc.
- Stability properties of fiscal and monetary policy rules with long term bonds: Davig et al. (2011), Bianchi and Illut (2017), Eusepi and Preston (2018), etc.

3. Environment

- Based on Lagos & Wright (2005) and Rocheteau & Wright (2005): cashless environment with short-term and long-term nominal bonds.
- A continuum of infinitely-lived agents of measure one that discount the future at a rate β.



Decentralized Markets (DM)	Centralized Market (CM)
bilateral trading	frictionless
search & bargaining frictions	
limited commitment	
differential pledgeability	

Preferences and Technologies

Household's Preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\underbrace{\chi_{i,t} \frac{q_t^{1-\xi}}{1-\xi} + \frac{\chi_{i,t} - \chi}{\chi} e_t}_{DM} + \underbrace{\ln(x_t) - h_t}_{CM} \right],$$

where $\chi_{i,t} = \{0, \chi\}$ is a preference shock.

Technologies

- In CM and DM, the perishable goods are produced with a constant returns technology.
- Labor is the only input; 1 unit of labor yields 1 unit of output.

Assets and Information & Frictions

- **Nominal Durable Assets**:
  - Short-term bonds B_t^S: one-period govt nominal bond with nominal interest rate R_t.
  - Long-term bonds B_t^L : a more general portfolio of nominal bonds, with a payment structure equal to $\rho^{T-(t+1)}$ units of fiat currency, where $T > t$ and $0 < \rho < 1$, as in Woodford (2001). The price is Q_t.
- **Information & frictions:**
  - In DM, agents face
    - stochastic trading opportunities;
    - limited commitment (unsecured credit not available);
    - differential asset pledgeability (short-term bonds are more pledgeable than long-term bonds).
  - In CM, there are no frictions and all forms of payments are accepted when settling transactions.
- No aggregate shocks (bonds have no extra value for riskless).

Government: Fiscal Authority

- **Budget Constraint:**

  $$\tau_t^{CM} + \phi_t B_t^S + Q_t \phi_t B_t^L + \mathbf{T_t^C} = G + R_{t-1} \phi_t B_{t-1}^S + (1 + \rho Q_t)\, \phi_t B_{t-1}^L,$$

  with $\phi_t \equiv \frac{1}{P_t}$ and T_t^C **= CB transfers**, which can be $+$ or $-$.

- **Size** of real public debt: $b_t = b_t^S + Q_t b_t^L$.
- **Composition** of public debt: $\Omega = \frac{Q_t\ b_t^L}{b_t^S}$.
- **Fiscal policy rule**:

  $$\tau_t^{CM} = \gamma_0 + \gamma^S \left(b_{t-1}^S - b^{S*}\right) + \gamma^L \left(Q_{t-1}\ b_{t-1}^L - b^{L*}\right)$$

  with targets b^{L*}, b^{S*}, $\Omega^* = \frac{Q\ b^{L*}}{b^{S*}}$.

Government: Monetary Authority

- **Budget Constraint:**

$$\mathbf{T_t^C} + \theta_t^S \phi_t B_t^S + \theta_t^L Q_t \phi_t B_t^L = R_{t-1} \theta_{t-1}^S \phi_t B_{t-1}^S + \theta_{t-1}^L \left(1 + \rho Q_t\right) \phi_t B_{t-1}^L.$$

- **Size** of the CB Balance Sheet: $b_t^M = \theta_t^S b_t^S + Q_t \theta_t^L b_t^L$.

- **Composition** of the CB Balance Sheet: $\Omega_{t-1}^M = \frac{\theta_{t-1}^L}{\theta_{t-1}^S} \Omega$.

- **Taylor Rule**: $R_t = \alpha_0 + \alpha_1 \left(\Pi_t - \Pi^*\right)$, away from the ZLB, $\Pi_t = \frac{\phi_{t-1}}{\phi_t}$.

- **Monetary Policy Normalization Rules**:

$$b_t^M = \gamma_0^M + \gamma_1^M \left(b_t - b^*\right),$$

$$\frac{b_t^M}{\left(1 + \Omega_t^M\right)} = \eta_0^M + \eta_1^M \left(\frac{b_t}{\left(1 + \Omega\right)} - \frac{b^*}{\left(1 + \Omega^*\right)}\right),$$

targets: b^{M*}, Ω^{M*}, $\gamma_0^M = b^{M*}$, $\eta_0^M = \frac{b^{M*}}{\left(1 + \Omega^{M*}\right)}$. In a different version, a parameter captures the speed of the normalization process.

4. Solving for the Equilibrium

CM Problem

$$W\left(\tilde{B}^S_{t-1}, \tilde{B}^L_{t-1}, \tilde{L}_{t-1}\right) = \max_{x_t, h_t, \tilde{B}^S_t, \tilde{B}^L_t} \left\{\ln(x_t) - h_t + \beta\, V^{DM}\left(\tilde{B}^S_t, \tilde{B}^L_t\right)\right\} \quad \text{s.t.}$$

$$x_t + \phi_t \tilde{B}^S_t + Q_t \phi_t \tilde{B}^L_t + \phi_t \tilde{L}_{t-1} = h_t - \tau^{CM}_t + \phi_t \left(1 + \rho Q_t\right) \tilde{B}^L_{t-1} + \phi_t R_{t-1} \tilde{B}^S_{t-1},$$

where $\tilde{B}^S_t = \left(1 - \theta^S_t\right) B^S_t$ and $\tilde{B}^L_t = \left(1 - \theta^L_t\right) B^L_t$.

DM Problem

- Preference shock: with probability $\frac{1}{2}$ $\left(\frac{1}{2}\right)$ an agent becomes a DM consumer (producer).
- For the buyer: $V^{DM}_b(\tilde{B}^S_{t-1}, \tilde{B}^L_{t-1}) =$

$$\sigma\left(\chi \frac{q_t^{1-\xi}}{1-\xi} + W\left(\tilde{B}^S_{t-1}, \tilde{B}^L_{t-1}, \tilde{L}_{t-1}\right)\right) + (1-\sigma) W\left(\tilde{B}^S_{t-1}, \tilde{B}^L_{t-1}, 0\right)$$

  where $\tilde{L}_{t-1} \leq \zeta^S\, \tilde{B}^S_{t-1} + \zeta^L\, Q_{t-1} \tilde{B}^L_{t-1}$, with ζ^S (ζ^L) the pledgeability of short-term (long-term) bonds.
- Terms of trade are given by *buyer's take it or leave it offer.*

5. Dynamic Equilibria

- $\{\Pi_{t+1}, Q_t, b_t, T_t^C, b_t^M, \Omega_t^M\}_{=0}^{\infty}$ that satisfies

$$\Pi_{t+1} = \beta \left(R_t + s_{t+1}^S \right),$$

$$\Pi_{t+1} Q_t = \beta \left(1 + \rho Q_{t+1} + s_{t+1}^L \right),$$

$$T_t^C + b_t^M = \frac{1}{\beta} b_{t-1}^M - \left(s_t^S + s_t^L \frac{\Omega_{t-1}^M}{Q_{t-1}} \right) \frac{b_{t-1}^M}{\Pi_t \left(1 + \Omega_{t-1}^M \right)},$$

$$\tau_t^{CM} + b_t + T_t^C = G + \frac{1}{\beta} b_{t-1} - \left(s_t^S + s_t^L \frac{\Omega}{Q_{t-1}} \right) \frac{b_{t-1}}{\Pi_t (1 + \Omega)},$$

$$b_t^M = \gamma_0^M + \gamma_1^M (b_t - b^*),$$

$$\frac{b_t^M}{\left(1 + \Omega_t^M\right)} = \frac{b^{M*}}{\left(1 + \Omega^{M*}\right)} + \eta_1^M \left(\frac{b_t}{(1 + \Omega)} - \frac{b^*}{(1 + \Omega^*)} \right).$$

with $R_t = \alpha_0 + \alpha_1 \left(\Pi_t - \Pi^* \right)$, $s_{t+1}^S = \frac{\sigma}{2} \left(\frac{\chi}{q_{t+1}{}^{\xi}} - 1 \right) \zeta^S$, $s_{t+1}^L = \frac{\sigma}{2} \left(\frac{\chi}{q_{t+1}{}^{\xi}} - 1 \right) \zeta^L Q_{t+1}$

$$q_{t+1} = \left(\frac{b_t}{(1+\Omega)} - \frac{b_t^M}{\left(1+\Omega_t^M\right)} \right) \frac{\zeta^S}{\Pi_{t+1}} + \left(\frac{\Omega \ b_t}{(1+\Omega)} - \frac{\Omega_t^M \ b_t^M}{\left(1+\Omega_t^M\right)} \right) \frac{\zeta^L}{\Pi_{t+1}}.$$

- It depends on the liquidity premia: $s^S (s^L)$.

Case 0: No Liquidity Premium ($s^S = s^L = 0$)

- Government bonds are plentiful.
- The dynamic equilibria is described by

$$\Pi_{t+1} = \beta \left[\alpha_0 + \alpha_1 (\Pi_t - \Pi^*) \right],$$

$$(1 - \gamma_1^M) b_t = G - \left[\gamma_0 - \tilde{\gamma}_0^M \right] + \left[\gamma_1 + \tilde{\gamma}_1^M \right] b^* + \left[\frac{1}{\beta}(1 - \gamma_1^M) - \gamma_1 \right] b_{t-1}$$

- Note $\left(\frac{1}{\beta} - 1 \right) \gamma_j^M = \tilde{\gamma}_j^M$.

Case 0: No Liquidity Premium ($s^S = s^L = 0$) (cont.)

- It is easy to show the steady state is unique.
- Inflation hits target: $\Pi = \Pi^* = \beta\alpha_0$.
- Local dynamics can be determined from the Jacobian:

$$J = \begin{pmatrix} \beta\alpha_1 & 0 \\ 0 & \frac{1}{\beta} - \frac{\gamma_1}{(1-\gamma_1^M)} \end{pmatrix}.$$

- The responses of the size of the CB balance sheet matters - but composition is irrelevant.
- Equilibria is locally stable under Leeper (1991)'s Active/Passive (adjusted by the responses of the size of the balance sheet) M/F policies.

Case 1: Liquidity Premium

- Government bonds are scarce.
- The dynamic equilibria is described by

$$\Pi_{t+1} = \Pi^* + \beta\alpha_1(\Pi_t - \Pi^*) + \beta s^S_{t+1},$$

$$(1-\gamma_1^M)b_t = G - \left[\gamma_0 - \tilde{\gamma}_0^M\right] + \left[\gamma_1 + \tilde{\gamma}_1^M\right] b^* + \left[\frac{1}{\beta}(1-\gamma_1^M) - \gamma_1\right] b_{t-1}$$

$$-\frac{s_t^S}{\Pi_t}\left[(1-\eta_1^M)\frac{b_{t-1}}{1+\Omega} - \eta_0^M + \eta_1^M\frac{b^*}{1+\Omega^*}\right]$$

$$-\frac{s_t^L}{Q_{t-1}\Pi_t}\left[b_{t-1}\left(\frac{\Omega+\eta_1^M}{1+\Omega} - \gamma_1^M\right) + \eta_0^M - \gamma_0^M + b^*\left(\gamma_1^M - \frac{\eta_1^M}{1+\Omega^*}\right)\right],$$

Case 1: Liquidity Premium (cont.)

- Multiple steady states cannot be ruled out.
- Active (Passive) MP, i.e. $\beta\alpha_1 > 1$ ($\beta\alpha_1 < 1$), induce inflation rates below (above) target Π^*: $\Pi = \Pi^* + \frac{\beta s^S}{(1-\beta\alpha_1)}$.
- Local dynamics are given by the Jacobian:

$$J = \begin{pmatrix} \frac{\beta\alpha_1}{\omega_1} - \beta\omega_2\omega_4 & \beta\omega_4\left[\frac{1}{\beta} - \frac{\gamma_1}{\left(1-\gamma_1^M\right)} - \omega_3\right] \\ \omega_2 & \frac{1}{\beta} - \frac{\gamma_1}{\left(1-\gamma_1^M\right)} - \omega_3 \end{pmatrix}.$$

- Number of SS and stability properties depend on the monetary and fiscal policy rules and on the size and composition of CB balance sheet (b^{M*}, Ω^{M*}, η_1^M, γ_1^M).

6. Quantitative Analysis

- Set $\sigma = 1$ to eliminate search frictions.
- To discipline the choice of parameters, we use data annual on interest rates, inflation, GDP and short-term bonds holdings from U.S.A. data from 1985 to 2014.
- Premia s_{t+1} : the Δ 10-Year & the 3-Month Treasury - relative to the 20-Year.
- Bond pledeagibility: set $\zeta^S = 1$ and calibrate ζ^L to match the premia differential $\zeta^L = \frac{s^L}{s^S} \frac{1}{Q\zeta^S}$.
- Given η and σ, we use data to construct an implied time series for q_t. For each ξ, we recover χ by assuming that the highest value of implied q_t coincides with the efficient one. Then, we choose the pair (χ, ξ) that minimizes the MSE between the implied premia and the historical US data.

Calibration Targets

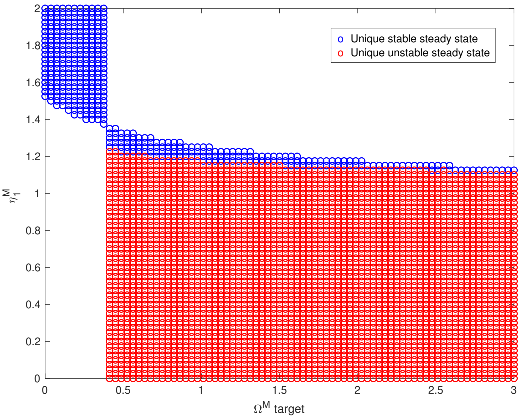
Parameter	Target
$\beta = 0.9735$	Model Implied with data on Π, R and s in 1985-2014
$\chi = 0.6760$ $\xi = 0.2084$ $\zeta^S = 1$ $\zeta^L = 0.2045$	Short-term bond premia defined by the difference between the 20-Year and the 3-Month Treasury in 1985-2014 fixed 20-Year and the 10-Year in 1985-2014
$G = 0.2317$	Federal government expenditure of 21.97 % of GDP as of 2014 Q4
$b^* = 0.7576$	Public debt (domestically held) of 71.84 % of GDP as of 2014 Q4
$\Omega^* = 2.3527$	Long-term to short-term public debt (domestically held) as of 2014 Q4
γ_0	A public debt (dom. held) of 71.84 % of GDP as of 2014 Q4
γ_1	Passive fiscal policy (without a premium)
$\alpha_0 = 1.0478$	Inflation target of 2 %
$\alpha_1 = 1.5000$	Active monetary policy (without a premium)

Note: γ_0 (γ_1) & adjusts with γ_0^M (γ_1^M).

Experiments

- We set ourselves in 2014.
- In 2014 the Fed had a BS equal to 45% GDP $\Rightarrow b^M = 0.47$.
- According to FOMC statements, the explicit target size of the BS is $\approx$ 3 trillion $\Rightarrow b^{M*} = 0.32$.
- Given the size target b^{M*}, we evaluate some counterfactuals and consider different Ω^{M*}, and η_1^M, and compute the resulting equilibria.
- For reference: the Fed's long-term to short-term bond holdings in 2007 $\Rightarrow \Omega^{M*} = 2.125$.

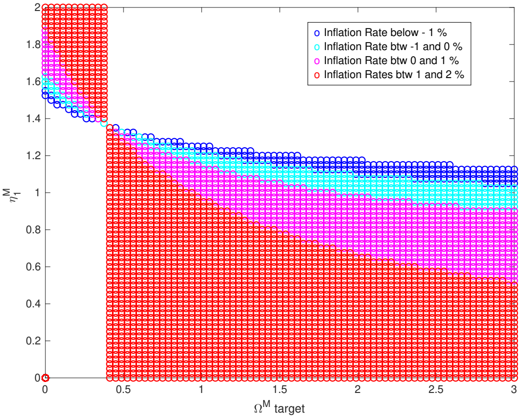
Numerical Findings – Fixing the Size of Total Debt



- For stability, the monetary policy normalization process ...
  - a low Ω^{M*}: low maturity composition of the BS.
  - a high η^M: an aggressive response to deviations from target.
- Additional results (not in the graph above): With a different rule, the process of normalization should be slow.

Numerical Findings – Fixing the Size of Total Debt

Steady State Inflation Rates



- For $\Omega^{M*} \leq 0.5$, Ω^{M*} close to 0.5 delivers inflation closest to target.
- As Ω^{M*} decreases, those inflation rates can be achieved increasing a higher responsiveness η_1^M.

Numerical Findings – Fiscal Authority

- When the target level of debt issuance by the fiscal authority increases to $b^* = 0.78$ (75% of GDP) and/or their issuance of long-term bonds decreases to $\Omega^* = 2.00$:

Figure 4a: Stability & Uniqueness, $b^* = 0.78$

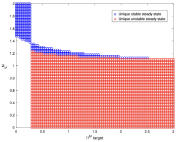


Figure 4b: Inflation Rates, $b^* = 0.78$

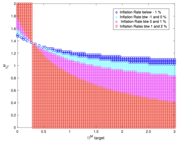


Figure 4c: Stability & Uniqueness, $\Omega^* = 2.00$

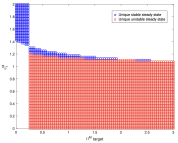
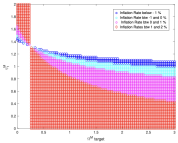


Figure 4d: Inflation Rates, $\Omega^* = 2.00$

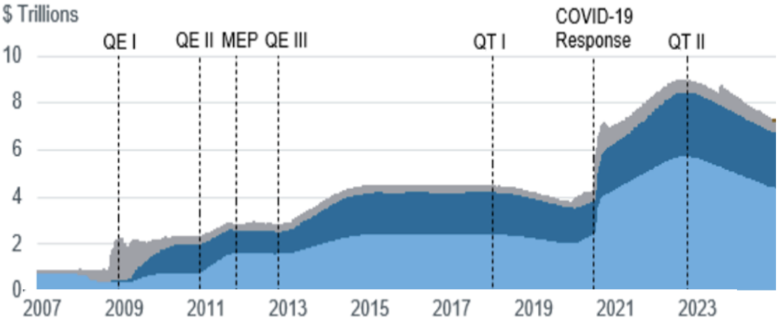


  - an even lower Ω^{M*}: lower maturity composition of the BS.
  - a high (slightly lower) η^M: aggressive response to deviations.
  - **coordination between monetary and fiscal authorities is key to achieve desirable equilibria.**

7. Conclusions

- This paper has explored the effects of the monetary policy normalization process.
- In order to ensure a unique and stable steady state and inflation close to target, the normalization process should
  - have a BS with a maturity composition that is low enough.
  - respond aggressively to changes on current economic conditions.
  - be slow enough.
- Our findings highlight that communication and coordination between fiscal and monetary authorities is key.

Federal Reserve's Balance Sheet: Today's context



Source: U.S. Federal Reserve.

- U.S. Fed's balance sheets further expanded during the Covid-19 pandemic.
- In 2022, *Principles for Reducing the Size of the Federal Reserve's Balance Sheet* were issued.

Federal Reserve's Balance Sheet: Principles

January 26, 2022

Principles for Reducing the Size of the Federal Reserve's Balance Sheet

For release at 2:00 p.m. EST

Share

The Federal Open Market Committee agreed that it is appropriate at this time to provide information regarding its planned approach for significantly reducing the size of the Federal Reserve's balance sheet. All participants agreed on the following elements:

- The Committee views changes in the target range for the federal funds rate as its primary means of adjusting the stance of monetary policy.
- The Committee will determine the timing and pace of reducing the size of the Federal Reserve's balance sheet so as to promote its maximum employment and price stability goals. The Committee expects that reducing the size of the Federal Reserve's balance sheet will commence after the process of increasing the target range for the federal funds rate has begun.
- The Committee intends to reduce the Federal Reserve's securities holdings over time in a predictable manner primarily by adjusting the amounts reinvested of principal payments received from securities held in the System Open Market Account (SOMA).
- Over time, the Committee intends to maintain securities holdings in amounts needed to implement monetary policy efficiently and effectively in its ample reserves regime.
- In the longer run, the Committee intends to hold primarily Treasury securities in the SOMA, thereby minimizing the effect of Federal Reserve holdings on the allocation of credit across sectors of the economy.
- The Committee is prepared to adjust any of the details of its approach to reducing the size of the balance sheet in light of economic and financial developments.