



**BANK OF GREECE**  
EUROSYSTEM

# A global monetary policy factor in sovereign bond yields

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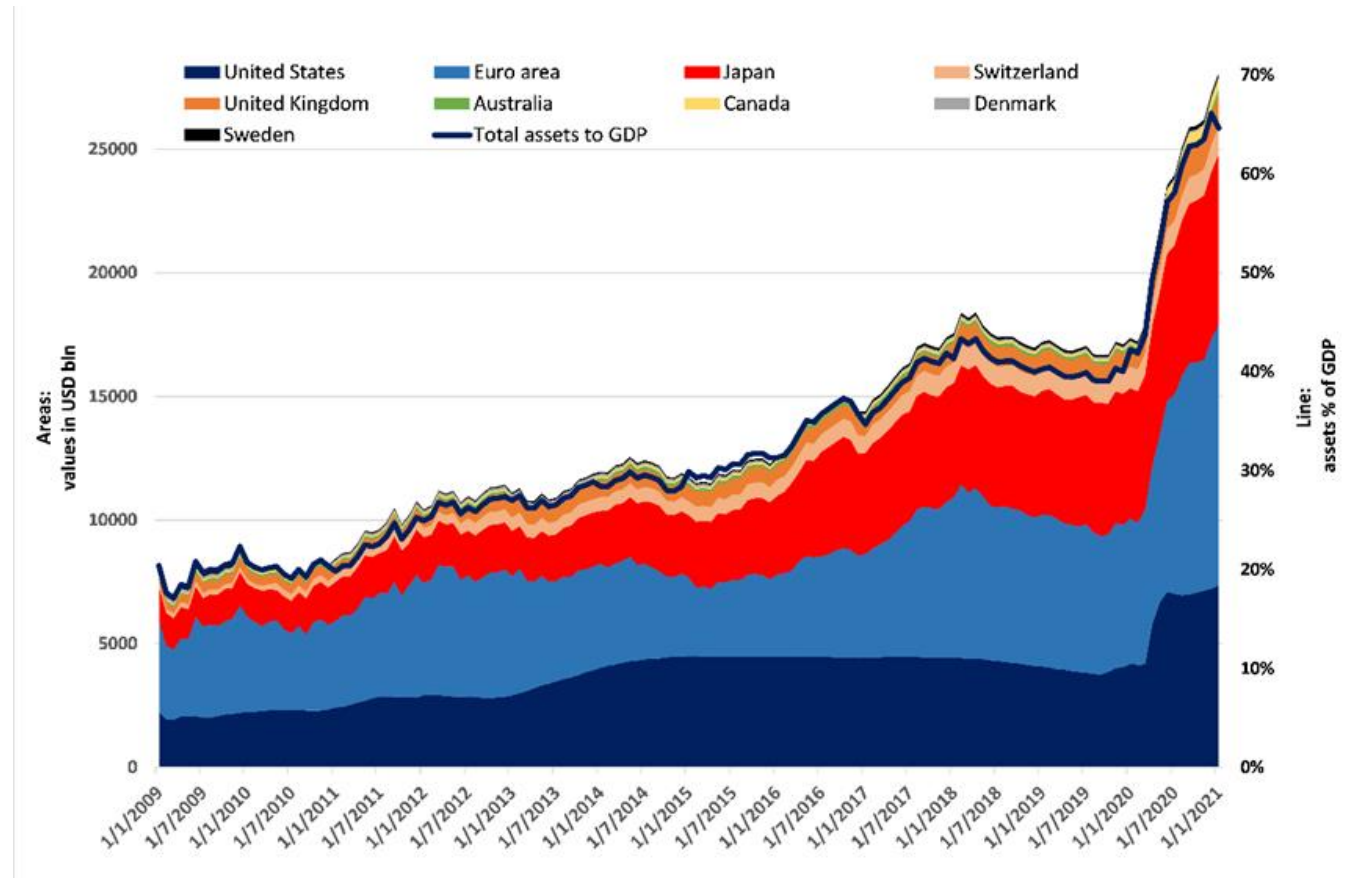
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# Introduction



- ☐ QE policies followed by major central banks have led to a large increase of their balance sheets.
  - Figure 1 shows the aggregate assets of nine major central banks that applied QE policies following the GFC.
  - The sum of their assets almost quadruples from USD 8 trl in 2009:1 to USD 29 trl in 2021:1 (i.e. from around 20% to nearly 70% of aggregate GDP).
- ☐ About 80% of the total assets of the nine central banks are held by central banks other than the Fed;
  - The ECB and the Bank of Japan, jointly, hold about 60% of the aggregate balance sheet by early 2021.

**Figure 1: Central Banks' Total assets**



# Motivation

- There is indeed strong evidence that asset purchases by the central banks have resulted to a significant lowering of bond yields.
  - For the US see, e.g., Gagnon et al. (2011), D’Amico et al. (2012), D’Amico and King (2013), Wright (2012), Krishnamurthy and Vissing-Jorgensen (2011) and Li and Wei (2013)
  - For the U.K., see, e.g., Joyce et al. (2011), Breedon et al (2012), Christensen and Rudebusch (2012), McLaren et al. (2014) and Steeley (2015).
  - For the euro area, see, e.g. Falagiarda and Reitz (2015), De Santis (2020) and Altavilla et al. (2021).
  - For a review of the empirical literature on the effects of QE in the euro area, the UK and Japan see Dell’Ariccia et al. (2018).
  
- However, previous papers in this strand of literature focus on balance sheet policies of a single central bank.  
**Instead, we look at QE as a global phenomenon:**  
*By aggregating monetary policy measures across major central banks, we take the view that QE has acted as a global factor in sovereign bond markets, affecting their valuations.*



# Theoretical framework: Preferred Habitats / Market Segmentation

- ❑ Our paper is closely related to the theoretical literature which emphasizes the role of investors' preferences ("preferred habitats"), frictions in financial intermediation and market segmentation
  - ❑ Vayanos and Vila 2021 ECA, Hamilton and Wu 2012 JMCB, Greenwood and Vayanos 2014 RFS, Greenwood, Hanson, Stein 2015 JF, Greenwood, Hanson, Stein, Sunderam 2020 NBER, Gourinchas, Ray, Vayanos 2022 NBER.
- ❑ In preferred habitat models, central bank purchases of long-term bonds reduce the effective supply of bonds available to private investors and lead, for a given demand, to declines in long-term bond yields.
  - In a two-country version of this model (Greenwood et al. 2020, Gourinchas et al. 2022), asset purchases of the domestic or the foreign central bank lead to a fall in long-term bond yields in both countries.
  - In the *Gourinchas et al. (2022)* model, QE shocks are transmitted almost one-to-one across countries' long bond yields, provided that short-term interest rates are sufficiently positively correlated and foreign currency traders' demand is sufficiently price elastic.
  - In the *Greenwood et al. (2020)* model, bond yields in both countries are driven by the *aggregate* net supply of bonds of both countries if short-term interest rates are perfectly correlated (which is the case, e.g., when short-term rates are at the ZLB).
- ❑ In this case, what matters for the determination of long-term bond yields is the **size of the aggregate balance sheet of the central banks**. The intuition behind this result is that when short-term interest rates are perfectly correlated, investors face the same interest rate risk for both domestic and foreign bonds.



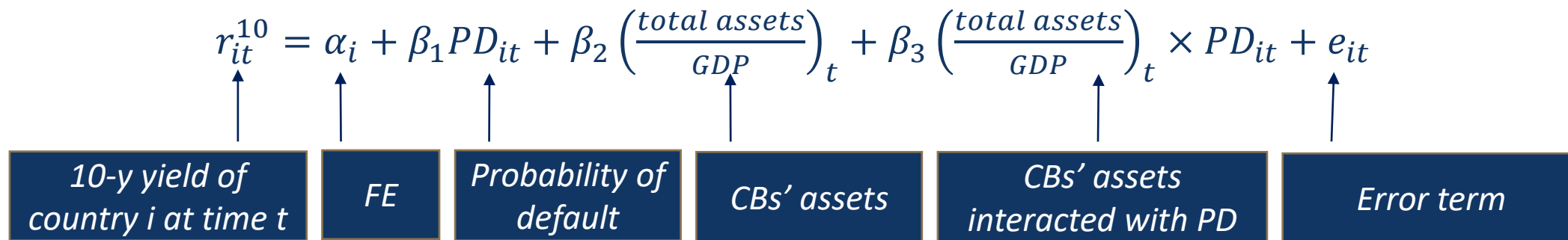
## Theoretical framework: Safe assets & global factors

- Our paper is also related to the safe asset scarcity literature (Caballero, Farhi, Gourinchas 2016 AER, 2017 JEP, 2021 RES, Caballero and Farhi 2017 RES):
  - Increased purchases of safe assets by the central bank of one country decrease the global supply of safe assets available to private investors, lowering the equilibrium return on safe assets. If the safe assets of the two countries are perfect substitutes, the return of the safe asset declines in both countries independently of which central bank purchases the safe asset.
  
- Finally, our paper is related to the literature on the role of global factors in international bond yields.
  - Numerous papers have shown that a large component of sovereign bond yields' movements is related to global factors (see, e.g., Pan and Singleton 2008; Longstaff et al. 2011; Rey 2013; Malliaropoulos and Migiakis 2018; Miranda-Agrippino and Rey 2020, 2021).



# The empirical model

□ We estimate the following equation:

$$r_{it}^{10} = \alpha_i + \beta_1 PD_{it} + \beta_2 \left( \frac{\text{total assets}}{\text{GDP}} \right)_t + \beta_3 \left( \frac{\text{total assets}}{\text{GDP}} \right)_t \times PD_{it} + e_{it}$$


The diagram illustrates the components of the equation. Below the equation, six dark blue boxes with white text are arranged horizontally. Arrows point from each box to its corresponding term in the equation above: '10-y yield of country i at time t' points to  $r_{it}^{10}$ ; 'FE' points to  $\alpha_i$ ; 'Probability of default' points to  $PD_{it}$ ; 'CBs' assets' points to  $\left( \frac{\text{total assets}}{\text{GDP}} \right)_t$ ; 'CBs' assets interacted with PD' points to  $\left( \frac{\text{total assets}}{\text{GDP}} \right)_t \times PD_{it}$ ; and 'Error term' points to  $e_{it}$ .

→ PD: the probability of default of the sovereign is derived from ratings and, thus, reflects country-specific fundamentals

→  $\left( \frac{\text{total assets}}{\text{GDP}} \right)_t$  is the size of the aggregate balance sheet of the nine central banks as a ratio of aggregate GDP

→  $\left( \frac{\text{total assets}}{\text{GDP}} \right)_t \times PD_{it}$  captures heterogeneity of QE effects across sovereigns with different credit risk

## QE effects in our model

$$r_{it}^{10} = \alpha_i + \beta_1 PD_{it} + \beta_2 \left( \frac{\text{total assets}}{\text{GDP}} \right)_t + \beta_3 \left( \frac{\text{total assets}}{\text{GDP}} \right)_t \times PD_{it} + e_{it}$$

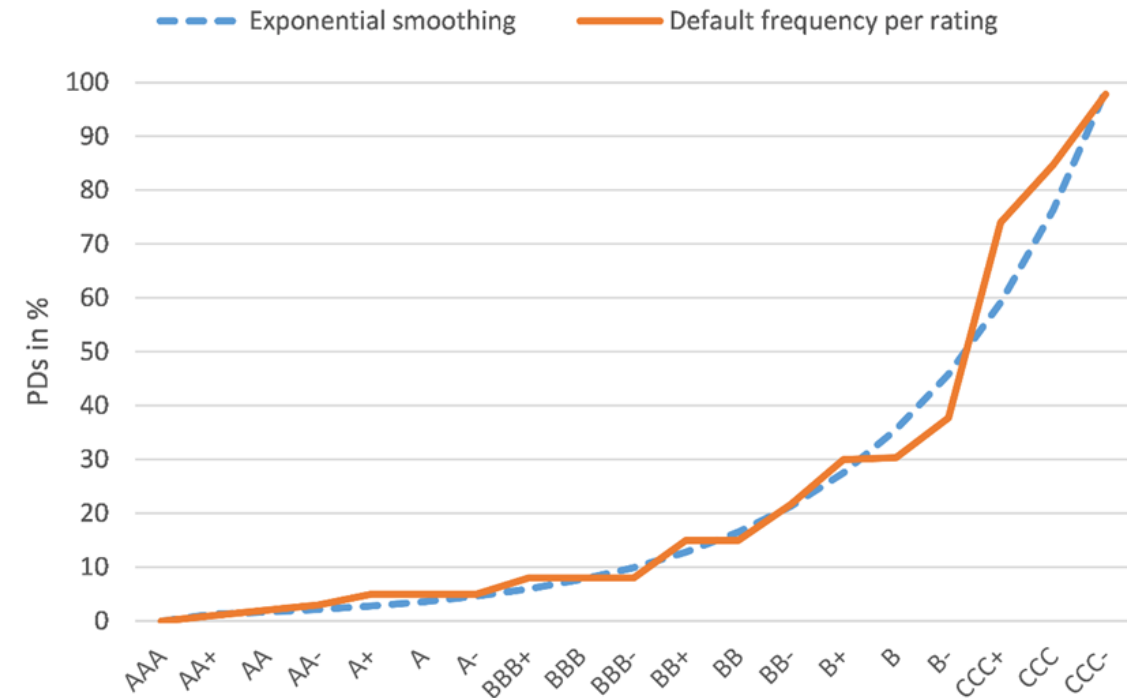
An increase in  $\left( \frac{\text{total assets}}{\text{GDP}} \right)_t$  by one percentage point reduces yields by  $\beta_2 + \beta_3 \times PD_{it}$ .

- $\beta_2$ : Across-the-board (or system-wide) effect
  - $\beta_3 \times PD_{it}$ : Rating-specific effect
  - We expect  $\beta_2 < 0$ ,  $\beta_3 < 0$
- 
- Net supply effect:**  $\beta_2$  captures the effect of central banks' purchases of high-rated government bonds (safe assets) on their own yields;
  - The coefficient of the interaction term,  $\beta_3$ , captures two effects:
    - **Portfolio rebalancing effect:** when central banks expand their balance sheet, lowering safe asset yields, investors rebalance their portfolios towards risky assets, bidding their yields down;
    - **Direct effects on risky assets:** CBs purchased either lower-rated government bonds (e.g. ECB's purchases of peripheral countries' government bonds) or risky private debt (e.g. Fed's purchases of GSEs and MBSs during Q1 or ECB's purchases of private bonds).
      - CB purchases of risky bonds reduce the free float, thus the incentives of the sovereign to default or restructure its debt (Costain, Nuno and Thomas 2021) → fall in credit/default risk premium.

# Data

- ❑ Cross-section: 45 countries (developed and emerging)
- ❑ Time: 2009:1 to 2021:1 (+sub-sample analysis extending to 2001).
- ❑ Frequency: monthly
- ❑ Dependent variable ( $r_{it}$ ): yields of 10-year bonds
- ❑ Explanatory variables:
  - Ratings-implied probability of default (Figure 2)
  - 9 CBs' total assets: aggregate of assets of Fed, ECB, BoE, BoJ, SNB, Riksbank, RBA, BoC, DNB
    - We take the ratio of total assets to the aggregate GDP of the 9 economies
    - Other versions of this variable: 1<sup>st</sup> PC of assets-to-GDP of the nine CBs, Fed vs others, decomposition to gvt bonds vs. private debt
- ❑ Other controls: Short-term yields, shadow rates, global economic conditions, global inflation, futures for short-term rates, fiscal balances, exchange rates.
- ❑ Estimation method: Cointegration for heterogeneous panels.

**Figure 2: Probability of default of sovereigns**



**Note:** The figure plots the observed 10-year default frequencies, per rating category (orange line) and an exponential smoothing interpolation (blue dotted line) of the observations. The default frequencies are those provided by rating agencies, according to the history of default in each rating category from 1975 to 2020.



# Long-run effects of QE on sovereign bond yields

	PD	Total assets-to-GDP	Total assets-to-GDP x PD
	$\beta_1$	$\beta_2$	$\beta_3$
	0.002** (1.90x10 <sup>-4</sup> )	-6.85x10 <sup>-4</sup> ** (1.69x10 <sup>-5</sup> )	-3.92x10 <sup>-5</sup> ** (4.67x10 <sup>-6</sup> )
Adj. R-squared	Jarque-Berra	ADF z-stat	LLC t-stat
79.98%	515,820.3 [0.000]	-11.227** [0.000]	-12.779** [0.000]

Our model provides strong significant effects:

- Higher credit risk adds to sovereign yields
- Expansion of CBs' aggregate balance sheet by 10% of GDP leads to a decline of AAA yields by 68bps. Effect on non-IG yields is stronger, e.g. yields of BB-rated bonds decline by 127bps.

Global QE over 2009-2021 has contributed to a permanent decline in sovereign bond yields.

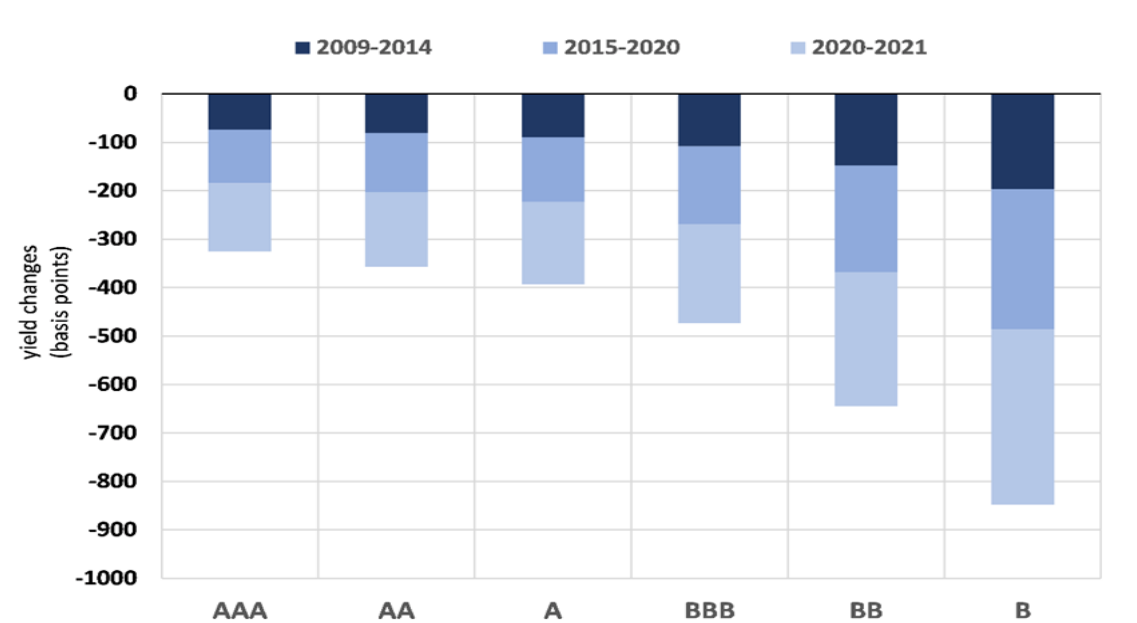
- From 330 bps for AAA rated bonds to 850 bps for B rated bonds.

Nearly half of the decline in bond yields took place during the Covid-19 period.

- Central banks expanded their balance sheet by about 25% of aggregate GDP in less than one year, roughly equal to the expansion of their balance sheet over the previous decade.

We obtain similar results when we substitute the aggregate assets-to-GDP with the common component of CBs' assets-to-GDP.

**Figure 3: Estimated effect of balance sheet expansion on bond yields**



## Short-run dynamics

$$\begin{aligned}\Delta r_{i,t}^{10} = & -0.043 \cdot ECT_{it-1} - 4.78 \times 10^{-4} \cdot Liq_t - 0.007 \cdot Gvt_t \cdot PD_{it} \\ & + 2.02 \times 10^{-4} \cdot \Delta(PD_{it}) + 1.39 \times 10^{-4} \cdot VIX_t \cdot PD_{it} \\ & + 0.002 \cdot \Delta(\overline{10y} - \overline{2y})_t + 0.001 \cdot \Delta(\overline{10y} - \overline{2y})_t \cdot PD_{it} \\ & + 1.79 \times 10^{-4} \cdot \Delta Ft(FFR) \cdot PD_{it} + 0.002 \cdot \Delta Ft(EONIA) + 1.42 \times 10^{-4} \cdot \Delta Ft(EONIA) \cdot PD_{it}\end{aligned}$$

$$\widetilde{R}^2 = 23.09\%$$

$\overline{10y} - \overline{2y}$ : difference between common components of 10y and 2y yields across 45 countries (global term spread)

$Ft(FFR)$  and  $Ft(EONIA)$ : futures contracts of FFR and EONIA (€STR since 2021) rates

□  $\Delta$ (Gvt bonds) and  $\Delta$ (liquidity) lower yields in the short-run.

- Purchases of gvt bonds are related to larger reduction for lower-rated sovereigns
- Provision of liquidity has across-the-board effects, thus predominantly works in favor of higher-rated sovereigns.

□ Increases in implied volatility, global term premia and short term interest rates, all affect positively bond yields.

- These effects are more pronounced for lower-rated sovereigns.



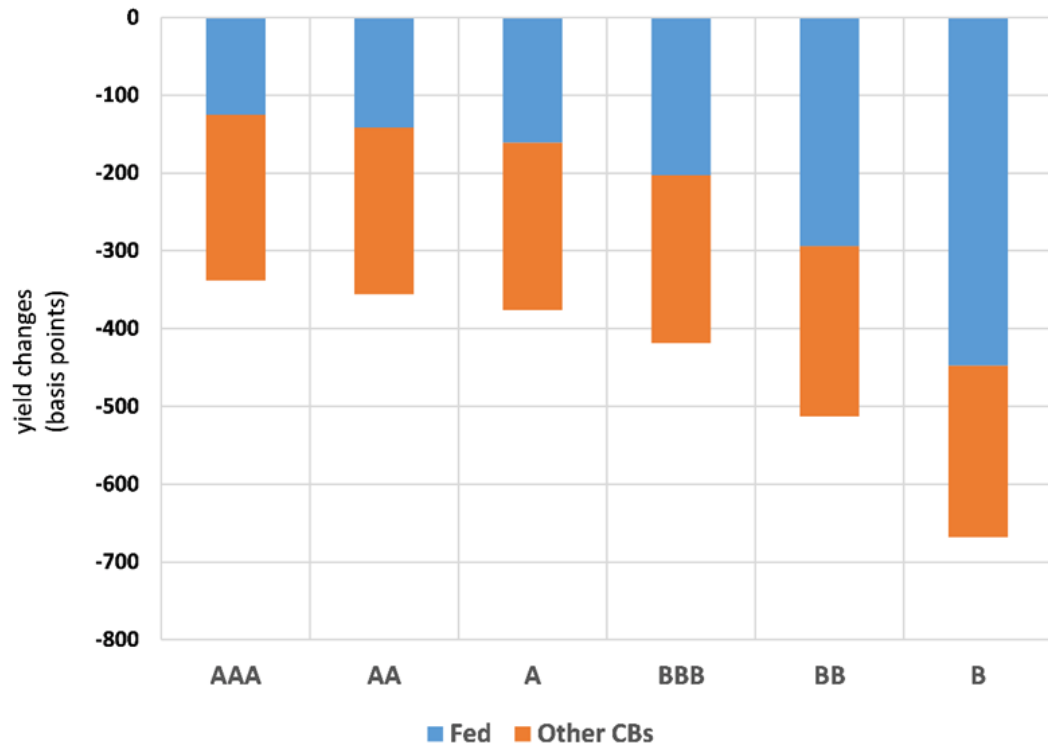
# **Refinements and robustness tests**

- 1. Does the Fed dominate global monetary policy effects?**
- 2. Do effects differ across types of balance sheet policies?**
- 3. Controlling for fiscal policy effects**
- 4. Controlling for forward guidance**
- 5. Controlling for foreign currency risk premia**
- 6. Controlling for conventional monetary policy effects**
- 7. Controlling for global economic conditions and global inflation**
- 8. Disentangling direct effects from spillover effects**

**Important note: All estimated effects are LONG-RUN effects**

# Does the Fed dominate global monetary policy effects?

PD	Fed's assets-to-GDP		Other CBs' (aggregate) assets-to-GDP		
$\beta_1$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	
0.002** (1.82x10 <sup>-4</sup> )	-0.001** (1.27x10 <sup>-4</sup> )	-8.49x10 <sup>-5</sup> * (3.51x10 <sup>-5</sup> )	-5.58x10 <sup>-4</sup> ** (3.68x10 <sup>-5</sup> )	9.26x10 <sup>-6</sup> (1.06x10 <sup>-6</sup> )	
Adj. R-squared	Jarque-Berra	ADF z-stat	LLC t-stat		
80.83%	84,461.9 [0.000]	-11.793** [0.000]	-12.344** [0.000]		



□ We decompose assets to those of the Fed and all others:

$$\left( \frac{\text{Other central banks' assets}}{GDP} \right)_t = a + b \left( \frac{\text{Fed's assets}}{GDP} \right)_t + u_t$$

$u_t$  is orthogonal to the Fed's balance sheet.

We estimate:

$$r_{it}^{10} = \alpha_i + \beta_1 PD_{it} + \beta_2 \left( \frac{\text{Fed's assets}}{GDP} \right)_t + \beta_3 \left( \frac{\text{Fed's assets}}{GDP} \right)_t \times PD_{it} + \beta_4 u_t + \beta_5 u_t \times PD_{it} + e_{it}$$

$\beta_4$  and  $\beta_5$  capture effects of other CBs' balance sheet expansion, independently of the Fed.

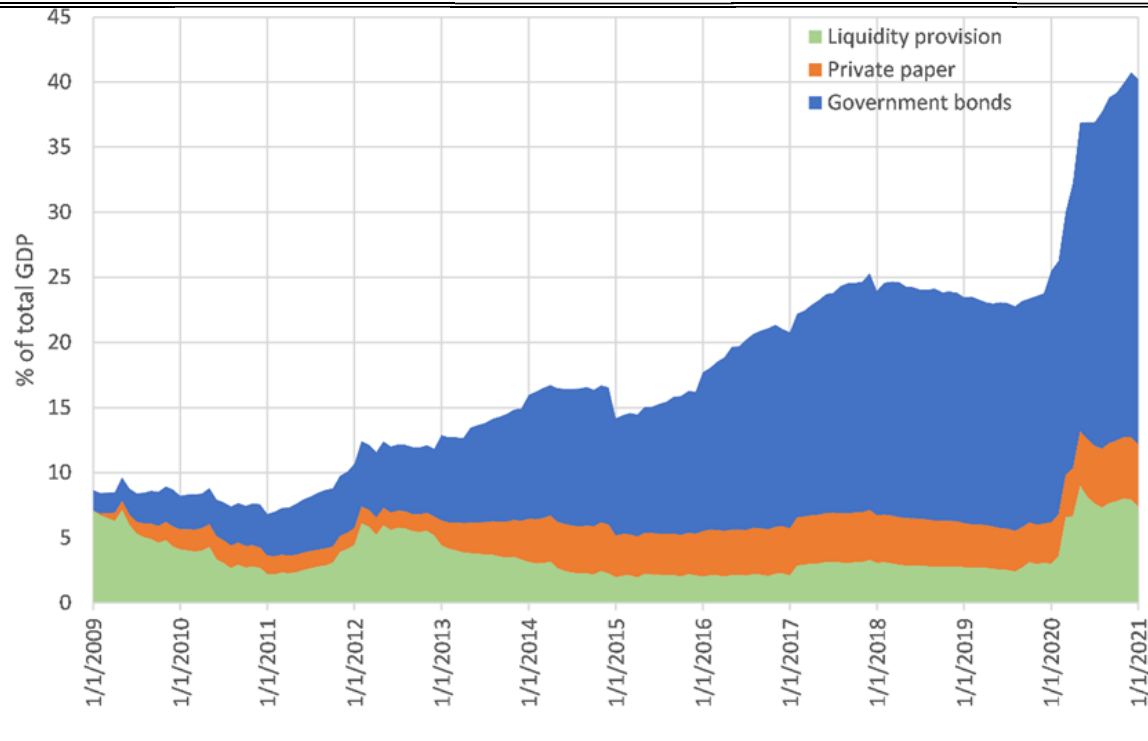
□ Findings:

- An increase in Fed's BS by 10 percent of aggregate GDP is related to a 100 bps decline of global bond yields in the investment-grade (IG) category.
- A similar increase of all other central banks' BS is related to a 56 bps decline of IG bond yields.
- Overall, the Fed on its own accounts on average for about half of the decline of bond yields across all rating classes.
- However, most of decline in IG yields is due to other CBs balance sheet policies (size effect), whereas most of the decline in non-IG yields is due to Fed's balance sheet policies.
- → Only Fed's QE has significant spillover effects on EMEs' bond yields.

# Do effects differ across different types of balance sheet policies?

PD	GovtBonds	GovtBonds x PD	Private	Private x PD
$\beta_1$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$
0.002** (1.02x10 <sup>-4</sup> )	-0.001** (5.59x10 <sup>-5</sup> )	-1.11x10 <sup>-4</sup> ** (8.01x10 <sup>-6</sup> )	-9.94x10 <sup>-4</sup> ** (3.23x10 <sup>-4</sup> )	-5.12x10 <sup>-4</sup> ** (8.25x10 <sup>-6</sup> )
Adj. R-squared	Jarque-Berra	ADF z-stat	LLC t-stat	
84.43%	38,022.8 [0.000]	-13.698** [0.000]	-15.044** [0.000]	

- ❑ Three main types of BS policies: Purchases of government bonds, purchases of private debt, liquidity provision.
- ❑ Liquidity provision is I(0) with structural breaks.
- ❑ We decompose the BS to the asset type purchased: gvt bonds & private paper.
  - Both types of asset purchases lead to a decline in AAA bond yields by 10 bps for every 1% of GDP increase in central banks' asset purchases.
  - Private debt has stronger spillover effects on yields of lower-rated bonds than government debt.
  - Probably because private debt is a closer substitute of risky sovereign debt; implying that central bank purchases of private debt induce stronger portfolio rebalancing effects towards risky government bonds.



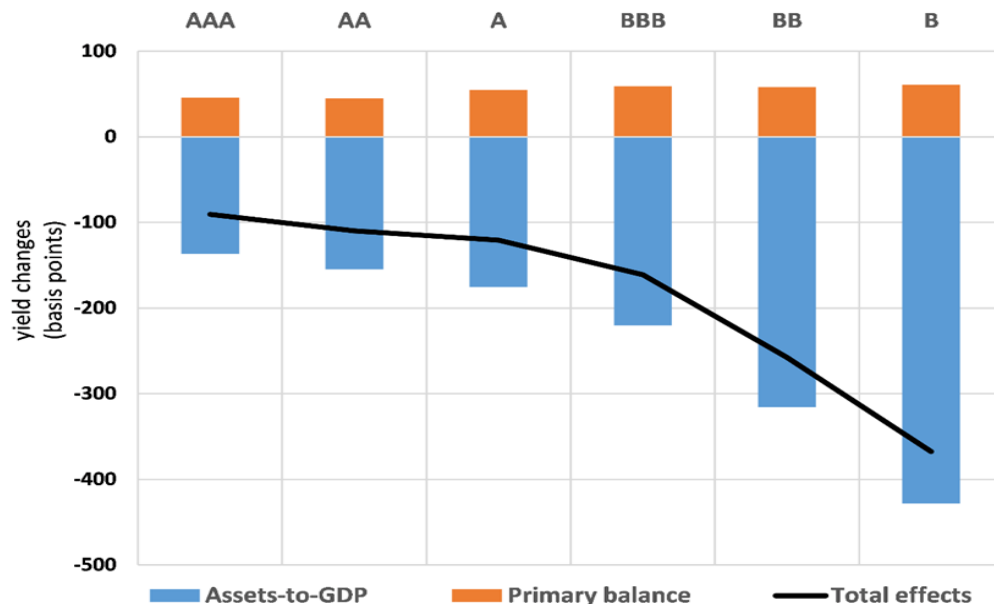


# Controlling for fiscal policy

PD	Total assets-to-GDP	Total assets-to-GDP x PD	Primary balance-to-GDP
$\beta_1$	$\beta_2$	$\beta_3$	$\beta_4$
0.003** (3.05x10 <sup>-4</sup> )	-7.90x10 <sup>-4</sup> ** (2.47x10 <sup>-5</sup> )	-6.17x10 <sup>-5</sup> ** (7.45x10 <sup>-6</sup> )	-7.04x10 <sup>-4</sup> ** (5.67x10 <sup>-5</sup> )
Adj. R-squared 80.25%	Jarque-Berra 64,226.3 [0.000]	ADF z-stat -10.451** [0.000]	LLC t-stat -10.918** [0.000]

- ❑ Increasing the assets-to-GDP ratio by one percentage point reduces AAA bond yields by 7.9 bps, slightly more than a reduction of the primary deficit by 1% of GDP.
- ❑ The effects are stronger for yields of lower rated sovereigns.
- ❑ Lowering primary budget deficits between 2009 and 2019 has contributed to a decline in bond yields of 25 bps for AAA rated sovereigns and 110 bps for B rated ones on average.
- ❑ During the Covid period, the net effect of expansionary fiscal and monetary policy on bond yields is negative, ranging from -90 bps for AAA to -360 bps for B rated sovereigns:
  - ❑ Primary deficits added 45-60 bps across ratings.
  - ❑ Global central banks' balance sheet effects subtracted 140 to 430 bps across ratings.

**Figure 6: Monetary and fiscal effects during the Covid-19 crisis**



# Controlling for forward guidance

□ **Forward guidance:** we extract the component of Wu and Zhang’s (2019 JIE) shadow rates, for the Fed and the ECB, that are related to forward guidance, net of asset purchases and conventional interest rate setting.

PD	Total assets-to-GDP	Total assets-to-GDP x PD	Forward guidance	Forward guidance x PD
$\beta_1$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$
0.002** (1.58x10 <sup>-4</sup> )	-7.23x10 <sup>-4</sup> ** (1.52x10 <sup>-5</sup> )	-2.43x10 <sup>-5</sup> ** (4.22x10 <sup>-6</sup> )	0.320** (0.023)	0.045** (0.005)
Adj. R-squared 82.52%	Jarque-Berra 44,678.5 [0.000]		ADF z-stat -13.991** [0.000]	LLC t-stat -14.901** [0.000]

□ Yields of AAA rated sovereign bonds decline by **7 bps** for every one percentage point rise of the total assets-to-GDP ratio, while, for comparison, B rated sovereign bond yields decline by **16 bps**.

□ The effects of forward guidance are also significant. A decline in the shadow rate due to forward guidance equivalent to CBs’ asset purchases of 1% of GDP

□ reduces yields of AAA rated bonds by **2.5 bps**

□ reduces yields of B rated bonds by **14 bps**.

□ Forward guidance has about 3x smaller effects on AAA yields, compared to outright asset purchases.

□ Forward guidance has roughly similar spillover effects with outright asset purchases.

# Controlling for foreign currency risk premia

We insert foreign exchange rates in the estimation:

$$r_{it}^{10} = \alpha_i + \beta_1 PD_{it} + \beta_2 \left( \frac{\text{total assets}}{\text{GDP}} \right)_t + \beta_3 \left( \frac{\text{total assets}}{\text{GDP}} \right)_t \times PD_{it} + \beta_4 FX_{i,t} + \beta_5 FX_{i,t} \times \left( \frac{\text{total assets}}{\text{GDP}} \right)_t \times PD_{it} + e_{it}$$

PD	Total assets-to-GDP	Total assets-to-GDP x PD	Exchange rate	Exchange rate x PD x Total assets-to-GDP
$\beta_1$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$
0.003** (2.11x10 <sup>-4</sup> )	-7.10x10 <sup>-4</sup> ** (1.78x10 <sup>-4</sup> )	-5.91x10 <sup>-5</sup> ** (5.89x10 <sup>-6</sup> )	-2.52x10 <sup>-3</sup> (1.5x10 <sup>-3</sup> )	1.13x10 <sup>-5</sup> ** (1.08x10 <sup>-6</sup> )
Adj. R-squared 80937%	Jarque-Berra 106,377.8 [0.000]	ADF z-stat -14.365** [0.000]	LLC t-stat -15.161** [0.000]	

- Asset purchases of central banks have reduced bond yields of high-risk countries with appreciating currencies ( $\Delta FX_{i,t} < 0$ ) relative to bond yields of low-risk countries with depreciating currencies ( $\Delta FX_{i,t} > 0$ ).
- Economic effect: over 2009-2021, bond yields of sub-IG sovereigns declined by 210bps, reflecting the reduction of FX premia due to the appreciation of their currencies (1/4 of total effect).



## Further controls & robustness checks

- ❑ **Conventional monetary policy:** (sample Jan-2001 to Jan-2021); extending the sample and controlling for short-term interest rates does not affect the statistical significance of central banks' balance sheet policies in global bond yields. But effects of CB balance sheet on bond yields are weaker. In line with Sims and Wu (2021) that QE is more effective when short rates are at the ZLB.
- ❑ **Global economic conditions:** We control for various measures of global economic conditions (Baumeister *et al.* 2020), global industrial production (Baumeister and Hamilton 2019) and the common component of inflation; our findings are by and large confirmed.
- ❑ **Sub-samples of countries:** We examine separately countries that participated in the CBs' purchase programs from those that did not; results show that BS policies have mostly benefitted countries which were directly affected by central banks' asset purchase programmes and more so those that are low-rated.



## Concluding remarks

- ❑ The size of the aggregate balance sheet of the major central banks is a global factor in sovereign bond markets.
- ❑ The increase in the size of central banks' balance sheet over the period 2009 to 2021 is related to a significant and permanent decline in global sovereign yields, ranging between 330 bps for AAA rated sovereign bonds and 800 bps for non-investment grade sovereign bonds.
- ❑ Our global monetary policy factor is not dominated by the Fed. However, Fed policies have stronger spillover effects on yields of high-risk sovereigns.
- ❑ Apart from the size, also the composition of global central banks' balance sheet matters. Purchases of private debt induce stronger portfolio rebalancing effects.
- ❑ The increase in global central banks' balance sheet during the Covid-19 crisis was significantly bigger than the increase in the aggregate primary deficit of the respective governments, driving global sovereign yields to even lower levels.
- ❑ The decline in currency risk premia explain about 25% of the decline in non-IG yields due to global QE (800 bps).
- ❑ **Policy implications:**
  - Scaling down the size of central banks' balance sheets (Quantitative Tightening, QT) is likely to lead to significant increases in sovereign bond yields, particularly for lower-rated sovereigns, capital outflows from Emerging Markets and depreciation of their currencies, with significant implications for the global economy and financial stability.
  - Closer coordination of fiscal and monetary policy can help contain the effects of QT on sovereign bond yields. For example, unwinding central banks' balance sheets at a similar pace as reducing fiscal deficits will likely mitigate the effects of QT on global bond yields, as the effect of the combined withdrawal of monetary and fiscal stimulus leaves the net supply of government debt unchanged.