The term structure of interest rates in a heterogeneous monetary union

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Disclaimer: views expressed here are personal and do not necessarily coincide with official Eurosystem or Banco de España positions.
How do bond purchases transmit to the yield curve?

1. **Consensus view (largely US):** bond purchases modify term premium ("duration extraction channel")

2. Does this analysis extend to Europe?
   2.1 **Default risk** plays a major role in some countries (sovereign debt crisis, Draghi’s “whatever it takes”)

3. This paper: monetary policy transmission with default risk and country heterogeneity

4. Bonus: value of flexibility
Parallel shifts in yield curves in response to PEPP

Effect of PEPP announcement on European bond yields
Our modelling framework: a term structure model

We analyze the yield curves in a 2-country monetary union with safe and defaultable debt and limits to arbitrage.

- Affine term structure model à la Vayanos-Vila (2020)
  - Risk-averse arbitrageurs coexist with preferred-habitat investors
  - Bond prices are affected by future interest rates (conventional MP) and purchases by central bank

- Heterogeneous monetary union (two countries)
  - Core (denoted by *): default-free
  - Periphery: defaultable bonds
A two-country monetary union

- Zero-coupon bonds with face value one euro and maturity $\tau \in [0, T]$:
  - Gross bond supply: $f_t(\tau), f^*_t(\tau)$

- Prices and yields at time $t$:
  - Bond prices: $P_t(\tau), P^*_t(\tau)$
  - Bond yields:
    $$y_t(\tau) \equiv -\frac{1}{\tau} \ln P_t(\tau), \quad y^*_t(\tau) \equiv -\frac{1}{\tau} \ln P^*_t(\tau)$$

- Conjecture an affine solution:
  $$P_t(\tau) \equiv \exp \left( -A_t(\tau) r_t - C_t(\tau) \right), \quad P^*_t(\tau) \equiv \exp \left( -A^*_t(\tau) r_t - C^*_t(\tau) \right)$$
Why do central bank purchases affect default incentives?

- Dynamic version of Corsetti and Dedola (2016)

- Rollover crisis hits Periphery with Poisson arrival rate $\eta$.
  - To honor maturing bonds, must impose costly emergency taxation
  - Otherwise, default implies stochastic cost, with c.d.f. $\Phi$

- Redemptions of bonds that expire in the central bank balance sheet $f_{t}^{CB}(0)$ are repaid to the Treasury as seigniorage $\Gamma_t = f_{t}^{CB}(0) + \hat{\Gamma}_t$
Partial default depends on future net bond redemptions

- Hazard rate \( \psi_t \) of Periphery default is \( \psi_t \)

\[
\psi_t = \eta \Phi \left( \int_t^\infty e^{-(\bar{r} + \phi)(s-t)} \left\{ d_s + f_s(0) - f_s^{CB}(0) - \hat{\Gamma}_s \right\} ds \right),
\]

which depends on future net bond redemptions \( f_s(0) - f_s^{CB}(0) \) and primary deficit \( d_t \).

- Assume \( \hat{\Gamma}_t \), is roughly invariant to bond purchases (in near-zero interest rate environment)
  - Our measure of fiscal pressure

\[
F_t \equiv \int_t^\infty e^{-(\bar{r} + \phi)(s-t)} \left\{ d_s + f_s(0) - f_s^{CB}(0) \right\} ds.
\]

- Then Periphery restructures its debt by renouncing fraction \( \delta \) of all outstanding bonds.
Arbitrageurs’ problem

- Plugging in expected returns and variance, arbitrageur’s problem becomes:

$$
\max_{\{X_t(\tau), X_t^*(\tau)\}} \int_0^T \left[ X_t(\tau)(\mu_t(\tau) - r_t) + X_t^*(\tau)(\mu_t^*(\tau) - r_t) \right] d\tau
$$

$$
- \frac{\gamma \sigma^2}{2} \left[ \int_0^T (X_t(\tau) A_t(\tau) + X_t^*(\tau) A_t^*(\tau)) d\tau \right]^2
$$

$$
- \delta \psi_t \int_0^T X_t(\tau) d\tau
$$

$$
- \gamma \delta^2 \psi_t \left[ \int_0^T X_t(\tau) d\tau \right]^2
$$

- Returns are affected by two different types of risk:
  - Price risk (as in Vayanos/Vila ’20)
  - Default risk (Poisson arrival of partial default)
Investors and market clearing

- Bond demands $Z_t(\tau), Z^*_t(\tau)$ of preferred-habitat investors increase with yield:

  \[
  Z_t(\tau) = h_t(\tau) + \alpha y_t(\tau) \\
  Z^*_t(\tau) = h^*_t(\tau) + \alpha^* y^*_t(\tau).
  \]

- Markets clear when net bond supply equals total demand:

  \[
  f_t(\tau) - f^\text{CB}_t(\tau) = Z_t(\tau) + X_t(\tau) \\
  f^*_t(\tau) - f^\text{CB*}_t(\tau) = Z^*_t(\tau) + X^*_t(\tau)
  \]
Decomposing yield curves

Solving by backwards induction, we can decompose peripheral yields:

\[ y_t(\tau) = y_t^{EX}(\tau) + y_t^{TP}(\tau) + y_t^{DP}(\tau) + y_t^{CR}(\tau) \]

\[ = \frac{1}{T} E_t \int_0^T r_{t+s} ds - \frac{1}{T} E_t \int_0^T A_{t+s}(\tau - s) \lambda_{t+s} ds \]

\[ \underline{\text{expected rates}} \hspace{5cm} \underline{\text{term premium}} \]

\[ + \frac{1}{T} \int_0^T \delta \psi_{t+s} ds - \frac{1}{T} E_t \int_0^T \zeta_{t+s} ds \]

\[ \underline{\text{expected default premium}} \hspace{5cm} \underline{\text{credit risk premium}} \]

Core yield curve is just \( y_t^*(\tau) = y_t^{EX}(\tau) + y_t^{TP^*}(\tau). \)
Calibration Italy-Germany pre-Covid

- **Steady-state (pre-Covid):** We match the yields and net supply of assets over the ELB period 2013-2019.
  - Risk-free rate dynamics match mean and variance of German 1m bonds. Monthly autocorrelation set to $\rho = 0.99$.
  - Risk aversion $\gamma = 0.16$ chosen to match the mean 10Y-1m term premium on German bonds.
  - Given haircut parameter $\delta = 0.25$, default hazard $\psi = 14$bp (annually), matches the IT-DE bond spread (mean of 10Y and 5Y).
Yield curve decomposition, 2013-2019

The effect of default on risk-averse arbitrageurs accounts for the lion’s share of the Italian yields.
The ECB introduced PEPP in March 2020

- **Sovereign yields surged** late Feb – early March across the euro zone
  - Fragmentation: rise in yields varied across countries, due to heterogeneous pandemic impact and heterogeneous fiscal capacity

- **18 March: ECB announces PEPP** (Pandemic Emergency Purchase Program)
  - Initial envelope: 750b to end of 2020...
  - ... envelope increased in June and again December up to 1850b (with reinvestments)

- Novel aspect of PEPP is flexible allocation, across time and jurisdictions
  - In contrast, APP imposes a fixed time path of purchases by capital key
Calibration: PEPP effects

- **Initial conditions of dynamic simulation**: Simulations start from risk-free rate and asset supply of March 2020, to model impact of the pandemic and the initial (18 Mar) PEPP announcement

- **PEPP simulation**
  - PEPP is assumed to be a surprise, with permanent effects on purchases and on default risk.
  - PEPP debt forecast is taken from actual PEPP purchases up to June (remaining purchases extrapolated to December)

- The change in the default probability depends on the change in fiscal pressure, $F_t$:
  \[ \Delta \psi_t = \theta (F_t^{post} - F_t^{pre}) \]

- We estimate $\theta \equiv \eta \Phi'$, the impact of fiscal pressure on the default probability, to match the shift in the Italian yield curve, 18-20 March
PEPP announcement had stronger effects on Italian yields due to default risk extraction.
How valuable is flexibility in asset purchase programs in an asymmetric monetary union?

1. **Flexibility over time**: how useful is the **frontloading** of purchases at reducing sovereign yields?

2. **Flexibility across countries**: how useful is it to **concentrate purchases** in countries with higher default probabilities?

3. How do these flexibility dimensions **interact** with each other? Are there any meaningful **nonlinearities**?

4. Further flexibility still available: **effects of announcing reinvestments**? (not today)
Counterfactual experiments: The role of flexibility

We compare PEPP with an “APP allocation”

![Graphs showing change in yields at t=1 and over time for German and Italian yields with different maturities and premium components.](image-url)
Effects of flexibility in allocation and timing
Impact and interaction of deviating from capital key (+/- 5%) and frontloading (all in first four months)

Figure:
Conclusions

▶ We extend the term structure model of Vyanos/Vila (2020) to a monetary union with sovereign default risk
  ▶ Default risk depends endogenously on fiscal pressure facing the sovereign

▶ Model points to default risk extraction as the main way asset purchases affect yields in the euro area, via two effects:
  ▶ reducing the peripheral default probability
  ▶ increasing private sector’s willingness to carry default risk

▶ Sovereign credit risk channel explains near-parallel shifts in peripheral yields caused by pandemic and PEPP announcement