The term structure of interest rates in a heterogeneous monetary union

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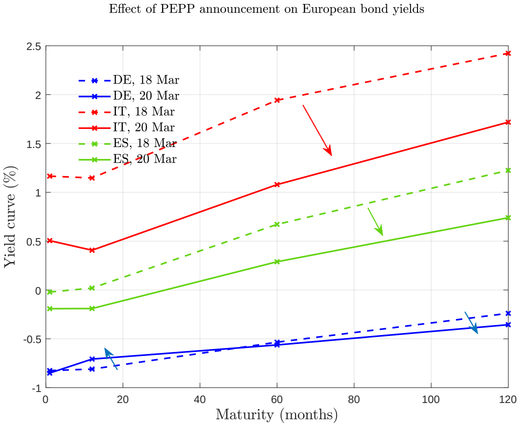
How do bond purchases transmit to the yield curve?

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



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 η .
  - To honor maturing bonds, must impose costly emergency taxation
  - Otherwise, default implies stochastic cost, with c.d.f. Φ
- 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 ψ_t of Periphery default is ψ_t

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

which depends on future net bond redemptions $f_s\left(0\right) - f_s^{CB}(0)$ 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

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

- Then Periphery restructures its debt by renouncing fraction δ of all outstanding bonds.

Arbitrageurs' problem

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

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

- 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:

$$\begin{aligned} Z_t(\tau) &= h_t(\tau) + \alpha y_t(\tau) \\ Z_t^*(\tau) &= h_t^*(\tau) + \alpha^* y_t^*(\tau). \end{aligned}$$

- Markets clear when net bond supply equals total demand:

$$\begin{aligned} f_t(\tau) - f_t^{CB}(\tau) &= Z_t(\tau) + X_t(\tau) \\ f_t^*(\tau) - f_t^{CB*}(\tau) &= Z_t^*(\tau) + X_t^*(\tau) \end{aligned}$$

Decomposing yield curves

- Solving by backwards induction, we can decompose peripheral yields:

$$
\begin{aligned}
y_t(\tau) &= y_t^{EX}(\tau) + y_t^{TP}(\tau) + y_t^{DP}(\tau) + y_t^{CR}(\tau) \\
&= \underbrace{\frac{1}{\tau} E_t \int_0^\tau r_{t+s} ds}_{\text{expected rates}} - \underbrace{\frac{1}{\tau} E_t \int_0^\tau A_{t+s}(\tau - s)\lambda_{t+s} ds}_{\text{term premium}} \\
&\quad + \underbrace{\frac{1}{\tau} \int_0^\tau \delta\psi_{t+s} ds}_{\substack{\text{expected default} \\ \text{premium}}} - \underbrace{\frac{1}{\tau} E_t \int_0^\tau \zeta_{t+s} ds}_{\substack{\text{credit risk} \\ \text{premium}}}
\end{aligned}
$$

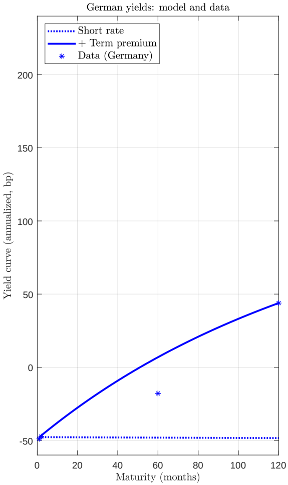
- Core yield curve is just $y_t^*(\tau) = y_t^{EX}(\tau) + y_t^{TP*}(\tau)$.

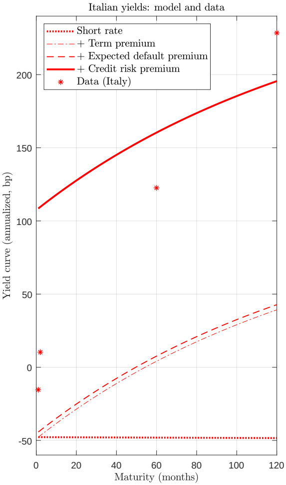
Calibration Italy-Germany pre-Covid

- 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

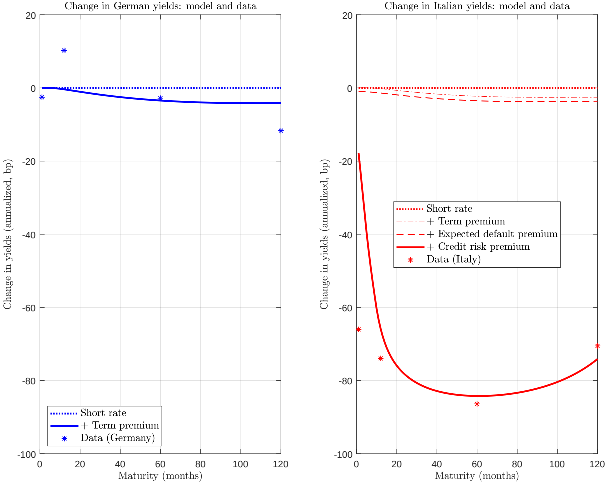
- **PEPP simulation**
  - PEPP is assumed to be a surprise, with permanent effects on purchases and on default risk.
  - PEPP debt forecast is taken from actual PEPP purchases up to June (remaining purchases extrapolated to December)

- The change in the default probability depends on the change in fiscal pressure, F_t:

$$\Delta\psi_t = \theta\left(F_t^{post} - F_t^{pre}\right)$$

- 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

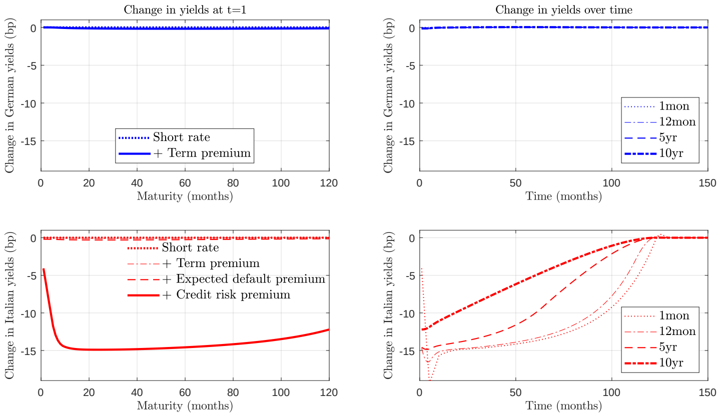


How valuable is flexibility in asset purchase programs in an asymmetric monetary union?

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)

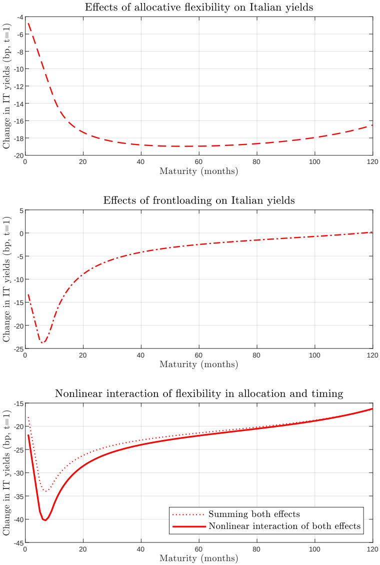
Counterfactual experiments: The role of flexibility

We compare PEPP with an "APP allocation"



Effects of flexibility in allocation and timing

Impact and interaction of deviating from capital key (+/- 5%) and frontloading (all in first four months)



Conclusions

- We extend the term structure model of Vayanos/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