What's on the menu? Central Bank Lending, Banks, and Carry Trades

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[1]Views expressed are personal and do not reflect those of DNB nor the Eurosystem

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Roadmap

Motivation

- **Central bank lending operations** are a core instrument for rate steering and liquidity provision in many operational frameworks (e.g., ECB, BoE, BoC, Riksbank).
- Often aimed at short-term rates steering.
- Their design can be tweaked for easing or liquidity support (e.g., TLTRO) through **more attractive** (i) pricing, (ii) maturity, and/or (iii) accepted collateral.
- Relaxations away from "market neutral" increases demand, and potentially spillovers away from reserves, like **carry trades**.
- Use of central bank lending for carry trades has implications for:
  - Scalability of unconventional monetary policy; spillovers to other markets
  - Interaction and design of (un)conventional monetary policy instruments
  - Banks' HQLA portfolio decisions; bank-sovereign nexus

This paper

- **Main research question:** can the design of refinancing operations facilitate sovereign carry trades?
- **Model**: Explain bank's borrowing decision and the allocation of these funds between central bank reserves and sovereign bonds
- **Bond characteristics:** Bonds can be attractive and not-attractive for carry trades
- **Shock**: Recalibration of ECB's TLTRO III following the onset of the Covid crisis in March 2020
- **Micro & macro analysis:** Securities holdings at the banking group level to exploit heterogeneity in TLTRO borrowing, and at the institutional sector level to compare banks with other investor types and estimate aggregate effects
- For **identification** I use a maximum (per bank) borrowing allocation rule (Benetton and Fantino, 2021)

Policy shock: Recalibration of TLTRO III in 2020

Change in TLTRO III conditions in response to the Covid crisis

- **Interest Rate Reduction** by 0.50%, allowing rates as low as DFR - 50 basis points.
- **Credit growth conditionality was changed**, from 2.5% to 0%.
- **Increase in borrowing allowances** for banks to access more funds.
- **Broadening of the accepted collateral set**
- **Leverage ratio exemption** (from Sept. 2020) removed LR costs of carry trades.
- **Earlier voluntary repayment possibilities,** with options starting 1 year after the operation, down from 2.

The **tenor** of the loans (3 years) was kept.

Recalibration of TLTRO III in 2020

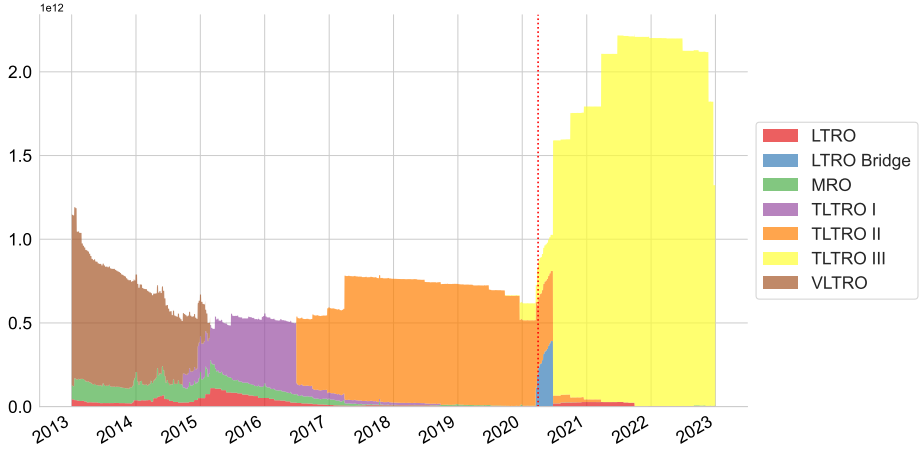


Figure: Amount outstanding of ECB refinancing operations (in EUR Tn)

Literature Review and Contribution

- **Central bank lending operations and sovereign exposure**:
  - Crosignani, Faria-e-Castro and Fonseca (2020)
    - PT banks. Carry with VLTRO on short-term bonds → Banks match Asset-Liability maturity
  - de Haan, Holton and van den End (2021)
    - Carry with VLTRO, not TLTRO II→ Conditionality prevents spillovers to bond market
  - **This paper:** Banks from all EA countries (sector- and individual-level); maturity *and* yield matter; carry-trades can happen with targeted operations too.
- **TLTROs: banks' borrowing, impact on lending and identification challenges**:
  - Sugo and Vergote (2020); Benetton and Fantino (2021); Andreeva and Garcia-Posada (2021); Laine (2021); Da Silva, et al. (2021); Sigmund et al. (2024).
- **Bank's liquid assets (HQLA) portfolio composition**:
  - Ihrig et al. (2019); Stulz et al. (2023); Hartung (2024).
- **Growing literature using granular Securities Holdings data**:
  - See Boermans (2022, DNB WP) for a survey.

Roadmap

Bank's Problem

Bank's balance sheet, comprising assets ($\mathbf{a}$) and liabilities ($\mathbf{l}$). Initial endowment of $\mathbf{a}_0$ and $\mathbf{l}_0$.

$$\underbrace{R}_{\text{Reserves}} + \underbrace{B}_{\text{Bonds}} + \underbrace{L}_{\text{Loans}} = \underbrace{D}_{\text{Deposits}} + \underbrace{O}_{\text{TLTRO}} + \underbrace{E}_{\text{Equity}}$$

- Bank chooses how much O to borrow and where to allocate these funds, based on (i) expected interest return $\rho^x(x)$; (ii) cost of borrowing $i^O(O)$; and (iii) regulatory cost $\ell(\mathbf{a}, \mathbf{l})$ of the trade.

$$\max_{R,B}\{\mathbb{E}[\Pi] = \rho^R(R) + \rho^B(B) - i^O(O) - \ell(\mathbf{a}, \mathbf{l})\}$$

subject to

$O = R + B - g(O)$	Balance sheet constraint
$L - D = g(O) = \min(\gamma O, \bar{O})$	**Assumption:** L and D allocation: only up to threshold $\bar{O}$
$0 \leq O \leq \omega L_0$	Borrowing allowance constraint
$O = (1 - \alpha^B)B_0 + (1 - \alpha^L)L_0$	Collateral constraint, including haircuts α^x

Bank's Problem: Deposit Facility Arbitrage

Profit from borrowing O, pledging B^P and L^P, and keeping R at the central bank is given by:

$$\Pi^R = \underbrace{O\left(i^R - \left(i^R - \mu + \mathbf{1}_{\{L<L_0\}} \cdot \phi\right)\right)}_{\text{Net interest income}} - \underbrace{\frac{\partial \kappa}{\partial B} B^P}_{\text{Opp. cost}} - \underbrace{\left(\int_0^{B^P} \frac{\partial \ell(\mathbf{a},\mathbf{l})}{\partial B} dB + \int_0^{L^P} \frac{\partial \ell(\mathbf{a},\mathbf{l})}{\partial L} dL + \int_0^{R} \frac{\partial \ell(\mathbf{a},\mathbf{l})}{\partial R} dR \right)}_{\text{Regulatory cost}}$$

TLTRO and regulatory recalibration in Spring 2020:

1. $i^R - (i^R - \mu + \mathbf{1}_{\{L_{j1} < \tilde{\bar{L}}_j\}} \cdot \phi) \geq 0$. Lower interest rate.
2. $\omega L_0 < (1 - \alpha^L) L^P$. Broader collateral framework, hence $\frac{\partial \kappa}{\partial B} B^P + \int_0^{B^P} \frac{\partial \ell(\mathbf{a},\mathbf{l})}{\partial B} dB + \int_0^{L^P} \frac{\partial \ell(\mathbf{a},\mathbf{l})}{\partial L} dL < 0$
3. $\frac{\partial \ell(\mathbf{a},\mathbf{l})}{\partial R} < 0$. Exemption of reserves from leverage ratio.

Thus, $\frac{\partial \Pi^R}{\partial O} > 0 \ \forall \ O \in [0, \omega L_0] \ \Rightarrow \ O^* = \omega L_0$

The TLTRO recalibration and regulatory changes created an arbitrage opportunity for all banks, even those below their lending benchmark, making it optimal to borrow up to the allowance regardless of other allocations.

Bank's Problem: Sovereign Carry Trade

- Abitrage opportunity led to banks maximizing TLTRO borrowing, resulting in abundant reserves.
- Banks may seek alternative allocations for these funds to enhance returns.
- **Euro sovereign bonds** are an attractive alternative due to their near-money characteristics:
  - Low risk, high liquidity (especially attractive in uncertain periods), favorable regulatory treatment (same as reserves).
- Banks will allocate TLTRO funds to bonds as long as $\partial \rho^B / \partial B > \partial \rho^R / \partial R$.
  - Earlier assumption: TLTRO borrowing is sufficiently plentiful that banks have an excess of cash for which purchasing bonds does not compete with other options, such as providing loans.

Bank's Problem: Sovereign Carry Trade

The *gross* expected return from doing carry trade by buying in $t = 0$ a bond $b \in B$, of duration D, remaining maturity M, and yield to maturity i^b, and holding until $t = 1$:

$$\rho^b(b) = \left(i^b - \underbrace{D_1 \cdot \mathbb{E}\left[r\{M-1\}_1 - r\{M-1\}_0\right]}_{\text{Interest rate risk}} \right) b - \underbrace{\int_0^b \lambda \cdot \delta \cdot (1 - \theta^b(b))\, db}_{\text{Expected loss given default}} - \underbrace{\int_0^b \ell(\mathbf{a}, \mathbf{l})\, dB}_{\text{Regulatory cost}}$$

The carry trade has two main risks:

- **Interest rate risk**: An increase (decrease) in market interest rates for maturity $M-1$, $r\{M-1\}$, would mean that the bank closes the position at a loss (gain).
- **Default risk**: With probability λ, the bank will lose a percentage δ of its investments.
  - **Assumption:** Bank appetite for sovereign default risk θ^b:

$$\theta^b(b) = \begin{cases} \left(1 + \alpha^b b\right)^{-1} \text{ with } \alpha^b > 0 & \text{High risk tolerance (e.g., bank-sovereign nexus)} \\ 0 & \text{Neutral risk tolerance} \end{cases}$$

▸ Home bias in sovereign bond holdings

Bank's Problem: Allocation Rule

- Since $\partial \ell(\mathbf{a}, \mathbf{l})/\partial R = \partial \ell(\mathbf{a}, \mathbf{l})/\partial B$, the carry trade is a preferred strategy over the DF arbitrage if:

$$\underbrace{i^b - i^R}_{\text{Interest differential}} > \underbrace{\lambda \cdot \delta \cdot \left(1 - \theta^b(b)\right) - D_1 \cdot \mathbb{E}\left[r\{M-1\}_1 - r\{M-1\}_0\right]}_{\text{Interest and default risk}}$$

$\Rightarrow$*For banks with a relatively high risk tolerance, $\theta^b > 0$, there exists a subset of* **carry-eligible** *bonds,* $\mathbf{C}$*, with which the carry-trade is a predictably profitable strategy.* $\mathbf{C}$ *is bounded by*

- **Yield**: $i^b > i^R$. Otherwise, the bank could earn a greater return at the central bank deposit facility.
- **Maturity**: $M \leq 1 \therefore D_1 = 0$. Bank gets par value at bond maturity and does not face interest rate risk. *Note: entering a payer OIS does not hedge against ASW risk.*

$$\mathbf{C} = \{(i^b, M) \in \mathbb{R}^2 \mid i^b > i^R \cap M \leq 1\}$$

$$\mathbf{N} = \mathbf{C}' = \{(i^b, M) \in \mathbb{R}^2 \mid i^b \leq i^R \cup M > 1\}$$

The menu

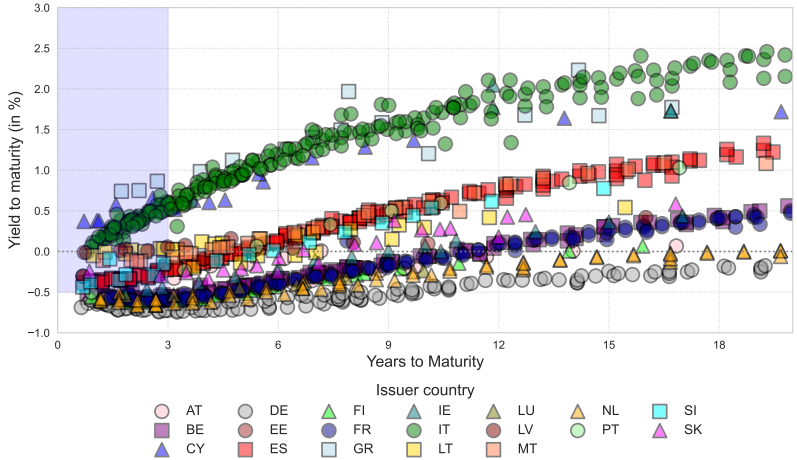


Figure: Average yield to maturity during 2020:Q2 for euro sovereign bonds

Roadmap

Data

Main Datasets:

- Securities Holding Statistics (Quarterly frequency)
  - By sector (SHS-S)
  - By banking group (SHS-G, largest euro area banks)
- ECB Credit Operations. Participation at the bank and banking group level.
- Banks' Balance Sheets
  - Total assets at the individual bank level. Also for bank-specific control variables.

Other:

- ECB Purchases; Bloomberg; ECB securities Data Warehouse

Merging results in quarterly holdings at the individual bond level for each investor sector / banking group, for 2019:Q1-2021:Q4/2022:Q3

Summary statistics ▸ Main Variables ▸ Distribution of Holdings and TLTRO over assets ▸ Evolution of holdings by investor sector

Empirical approach

LP-DiD approach: Local projections based difference-in-differences (Dube, et al., 2023)

$$y^{s}_{i,t+h} - y^{s}_{i,t-1} = \underbrace{\beta^{s,h}}_{\text{LP Est.}} \underbrace{\Delta TLTRO_{i,t}}_{\text{Treatment Indicator}} + \underbrace{\gamma^{s,h}\mathbf{x}_{i,t}}_{\text{Covariates \& Lags}} + \underbrace{\delta^{s,h}_{t}}_{\text{Time FE}} + \underbrace{\alpha^{s,h}_{i}}_{\text{Country FE}} + e^{s,h}_{i,t} \quad \forall\ s = \{\mathbf{C}, \mathbf{N}\}$$

Where

$$y^{s}_{i,t} = \sum_{b=0}^{B} \frac{Holdings^{b}_{i,t} \cdot \mathbf{1}_{\{b \in s\}}}{TotalAssets_{i,Feb2020}} \quad \text{and} \quad TLTRO_i = \begin{cases} 1 & \text{if } \frac{TLTRO_i}{\text{Assets}_{i,Feb2020}} > \text{median}\left(\frac{TLTRO_J}{\text{Assets}_{J,Feb2020}}\right) \\ 0 & \text{otherwise} \end{cases}$$

- One cohort; absorbing treatment; sample restricted to newly- or never-treated (Dube et al, 2023)
- Outcome and treatment relative to February 2020 assets (clean of TLTRO-driven BS increase)
- Baseline $\mathbf{x_{i,t}}$ = [LCR (proxy); leverage ratio (proxy); deposit ratio; loans to HH+NFC; lags]
- Balanced panel: 141 banks, 12 quarters (2019:Q1-2021:Q4).
- DiD assumptions: No anticipation (nature of Covid shock); (conditional) parallel trends ▸ PT

Instrumental Variable approach

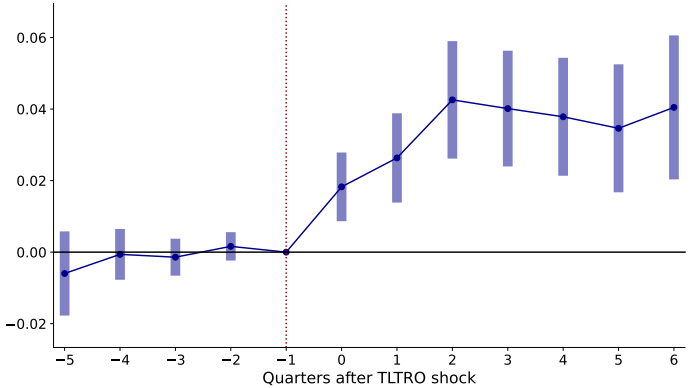
- Endogeneity risk
  - **Selection into treatment:** banks choose $TLTRO_i$, and might borrow more if they intend to buy government bonds
- **IV approach**: instrument TLTRO take-up with borrowing allowances (Benetton and Fantino, 2021)
- **Borrowing Allowances**: Exogenous rule based on banks' stock of TLTRO eligible loans in 2019.
- **Good Instrument Criteria**
  - **Exclusion restriction**: Borrowing allowance impacts bond purchases *only* through TLTRO
  - **Relevance:** Banks with higher borrowing allowances had greater TLTRO capacity. ▸ IV Relevance
  - **Independence:** The instrument is assumed to be independent of any other factors that might directly affect bond holdings
- **DDIV Approach**: Instrumenting the treatment variable in a difference-in-differences setup (Duflo, 2001)

Impulse response function: IV LP-DID

▸ Static regression output ▸ OLS

Following the recalibration of TLTRO in 2020:Q1, **banks with greater TLTRO takeup increased their holdings of carry-eligible bonds** up to 4% of their assets [...]

Figure: Estimates of the effect of greater TLTRO III take-up on banks' **carry-eligible** holdings (95% CI)

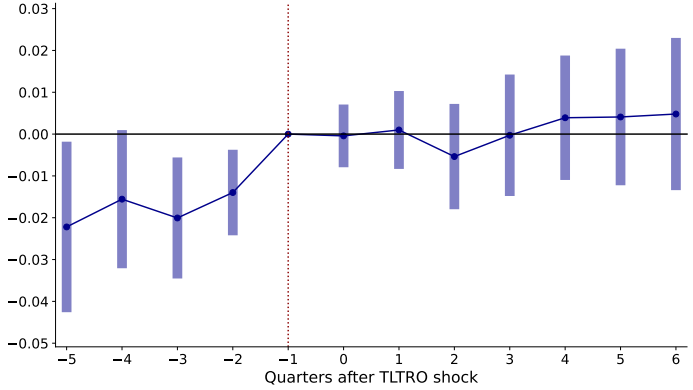


Impulse response function: IV LP-DID

▸ Static regression output ▸ OLS

[...] but not that of **non carry-eligible bonds**.

Figure: Estimates for the effect of greater TLTRO III take-up on banks' **carry non-eligible** holdings



Bank-country group zoom-in

- Greater TLTRO borrowing led to more carry trades
- Are these results homogeneous across banks?
- **Hypothesis:** Bank's risk appetite θ^b is shaped by home bias
- Carry eligible bonds are from non-core sovereigns

$$y^{\mathbf{C}}_{i,t+h} - y^{\mathbf{C}}_{i,t-1} = \beta_1^{\mathbf{C},h} \Delta TLTRO_{i,t} \times \text{Non-core bank}_i + \beta_2^{\mathbf{C},h} \Delta TLTRO_{i,t} + \gamma^{\mathbf{C},h} \mathbf{x}_{i,t} + \delta_t^{\mathbf{C},h} + \alpha_i^{\mathbf{C},h} + e_{i,t}^{\mathbf{C},h}$$

- Base effects, as well as double interaction terms are included

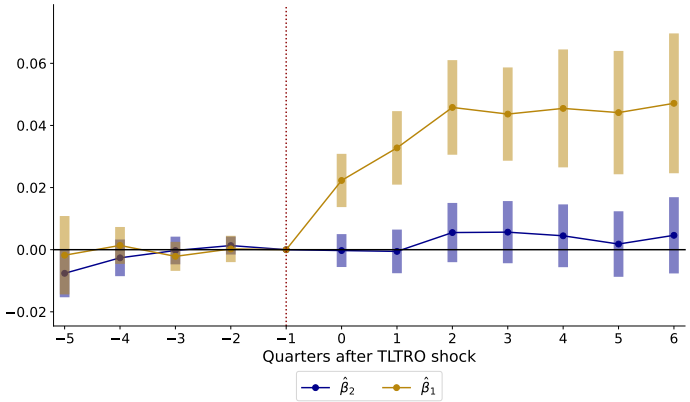
→ β_1 measures the impact of TLTRO on bond holdings of non-core, high TLTRO borrowing banks

→ β_2 measures the impact of TLTRO on bond holdings of core, high TLTRO borrowing banks

Impulse response function: IV triple interaction LP-DID

Static regression output OLS

Figure: Estimates for the effect of greater TLTRO III take-up on banks' carry eligible holdings (95% CI)



→ The increase in holdings of **carry-eligible bonds (non-core short-term)** is primarily driven by non-core banks

Roadmap

Carry trades: empirical approach

- Estimate with LP-DiD the impact of TLTRO on the banking sector's market share in the sovereign bond market (now using SHS-S data)

$$m^{s}_{i,t+h} - m^{s}_{i,t-1} = \beta^{s,h}\Delta D_{i,t} + \gamma^{s,h}\mathbf{x}_{i,t} + \delta^{s,h}_{t} + \alpha^{s,h}_{i} + e^{s,h}_{i,t} \quad \forall\, s = \{\mathbf{C}, \mathbf{N}\}$$

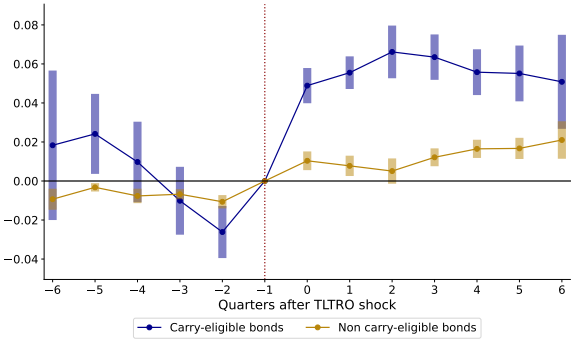
Where

$$m^{s}_{i,t} = \frac{\sum_{b=0}^{B} Holdings^{b}_{i,t} \cdot \mathbf{1}_{\{b \in s\}}}{\sum_{b=0}^{B} Outstanding_{b} \cdot \mathbf{1}_{\{b \in s\}}} \quad \text{and} \quad \Delta D_{i} = \begin{cases} 1 & \text{if } i = \text{Banks and } t = \text{2020:Q2} \\ 0 & \text{otherwise} \end{cases}$$

- Unit i = Banks, Insurers, Pension Funds, ...
  - Baseline control group: 6 remaining "major" ESA 2010 institutional sectors, excl. central bank
- Baseline $\mathbf{x_{i,t}} = [\frac{\sum_{b=0}^{B} QEpurchases_{b,t}}{\sum_{b=0}^{B} Outstanding_{b,t}} \# Sector_{i}, Assets_{i,t}]$
- Baseline sample: 2018:Q4-2021:Q4. $h = 0, 1, ..., 7$

Carry trades: banking sector (as a whole) bought carry-eligible bonds

Figure: Estimates for the effect of TLTRO III recalibration on banks' sovereign bond holdings



→ Banks **increased their holdings of carry-eligible bonds** up to 6% of the amount outstanding, and not of other type of sovereign bonds

- Economic significance: (i) ECB purchased ∼ 12% of amt. out. during 2020-2021; (ii) Carry-eligible segment represents ∼ 20% of euro sovereigns amt. out.

Carry trades: mostly domestic purchases?

- From earlier: TLTRO carry trade was mainly done by non-core banks, whose domestic sovereign issued carry eligible bonds
- SHS-S contains information on holder jurisdiction, so we can do a similar exercise at the sector level

$$m^{\mathbf{C}}_{i,t+h}(d) - m^{\mathbf{C}}_{i,t-1}(d) = \beta^{\mathbf{C},h}(d)\Delta D_{i,t} + \gamma^{\mathbf{C},h}(d)\mathbf{x}_{i,t} + \delta^{\mathbf{C},h}_t(d) + \alpha^{\mathbf{C},h}_i(d) + e^{\mathbf{C},h}_{i,t}(d) \quad (1)$$

$$m^{\mathbf{C}}_{i,t+h}(f) - m^{\mathbf{C}}_{i,t-1}(f) = \beta^{\mathbf{C},h}(f)\Delta D_{i,t} + \gamma^{\mathbf{C},h}(f)\mathbf{x}_{i,t} + \delta^{\mathbf{C},h}_t(f) + \alpha^{\mathbf{C},h}_i(f) + e^{\mathbf{C},h}_{i,t}(f) \quad (2)$$

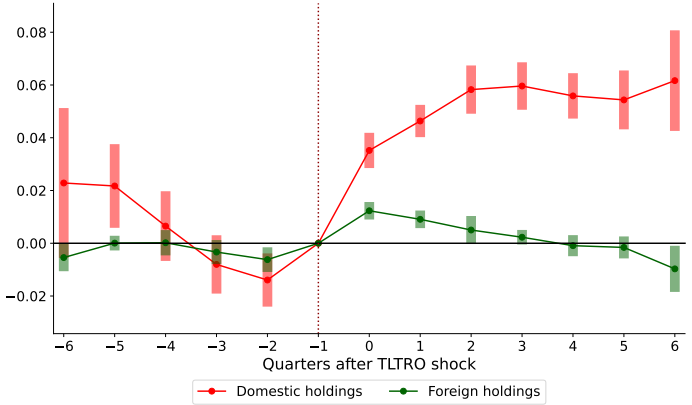
Where

$$m^{\mathbf{C}}_{i,t}(d) = \frac{\sum_{b=0}^{B} Holdings^{b}_{i,t} \cdot \mathbf{1}_{\{b \in \mathbf{C} \cap \text{domestic}\}}}{\sum_{b=0}^{B} Outstanding_b \cdot \mathbf{1}_{\{b \in \mathbf{C} \cap \text{domestic}\}}} \quad \text{and} \quad m^{\mathbf{C}}_{i,t}(f) = \frac{\sum_{b=0}^{B} Holdings^{b}_{i,t} \cdot \mathbf{1}_{\{b \in \mathbf{C} \cap \text{foreign}\}}}{\sum_{b=0}^{B} Outstanding_b \cdot \mathbf{1}_{\{b \in \mathbf{C} \cap \text{foreign}\}}}$$

Carry trades: mostly domestic purchases

→ Most of the purchases of carry-eligible bonds were done by **domestic banks**

Figure: Estimates for the effect of TLTRO III recalibration on banks' **carry-eligible** bond holdings



Roadmap

Concluding

Main findings

- The banking sector increased its exposure to (relatively) high yield, short-term government bonds following the recalibration of TLTRO in March 2020.
- TLTRO carry trades were mainly done by banks from non-core countries.

Implications

- Endogeneity of the demand for reserves to the design of monetary policy instruments
- Scalability of reserve-based credit operations may lead to increasing distortions, including financial spillovers and arbitrage incentives
- Interconnectedness and potential conflict with other instruments and stance
- Maturity of central bank lending matters
- Subsidized lending operations might strenghten the sovereign-bank nexus
  - Domestic bonds as a quasi-money alternative for TLTRO liquidity management
- Targeted nature of the operations does not prevent carry trades

Roadmap

Home bias in sovereign bond holdings

Bank country	Issuer country						Total
	BeNeLux	France	Germany	Italy	Spain	Other	
BeNeLux	29%	18%	19%	14%	8%	12%	100%
France	8%	62%	3%	11%	9%	7%	100%
Germany	14%	15%	18%	14%	16%	23%	100%
Italy	1%	2%	1%	87%	6%	2%	100%
Spain	1%	2%	1%	19%	75%	3%	100%
Other	5%	12%	8%	17%	12%	45%	100%

This table shows the share of euro area banks sovereign bond holdings by issuer jurisdiction.
Source: Securities Holding Statistics.

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Summary statistics - Bank level data (SHS-G)

Table: Summary Statistics

	N	Mean	Std	p25	p50	p75
TLTRO borrowing (EUR mn)	141	13,277	21,200	1,044	5,959	14,500
TLTRO allowance (EUR mn)	141	14,915	23,620	1,547	6,776	16,291
Total assets (EUR mn)	141	168,067	311,599	15,604	54,645	135,181
Carry-eligible holdings (EUR mn)	141	15.21	39.03	0.00	3.20	12.39
Non-carry-eligible holdings (EUR mn)	141	41.98	71.69	3.62	14.20	52.30
Loan-to-deposits ratio	*To be added following confidentiality clearance*					
Capital ratio	*To be added following confidentiality clearance*					
Liquidity ratio	*To be added following confidentiality clearance*					

Note: Standard deviations (Std), and percentiles (p25, p50, p75) are based on the sample distribution on 2022:Q2.

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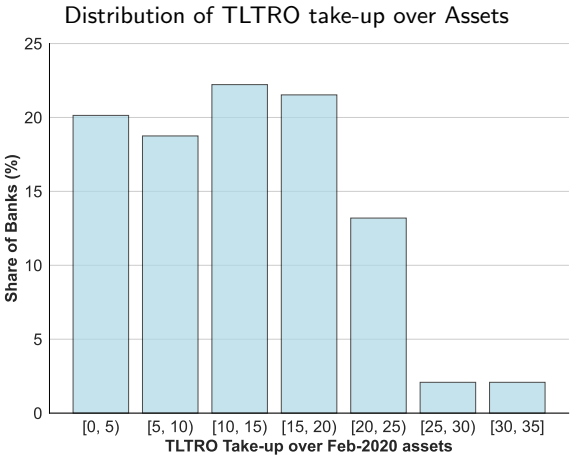
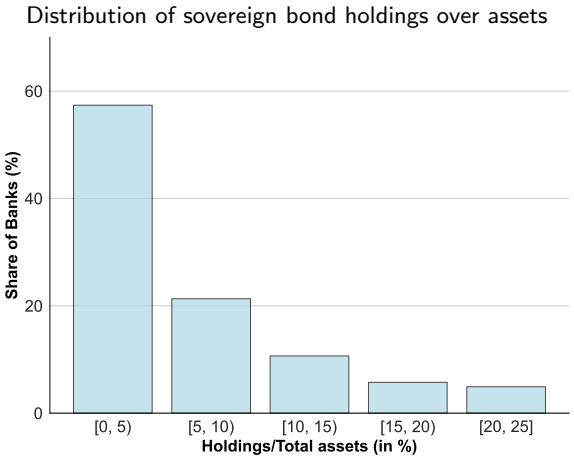
Micro lens: Distribution of main variables of interest





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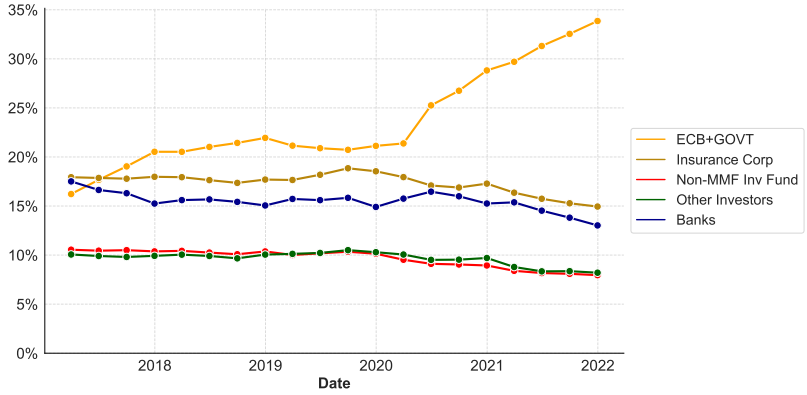
Macro lens: sovereign debt holdings by sector

Figure: Holdings of euro sovereign bonds by euro area investors (over amount outstanding)



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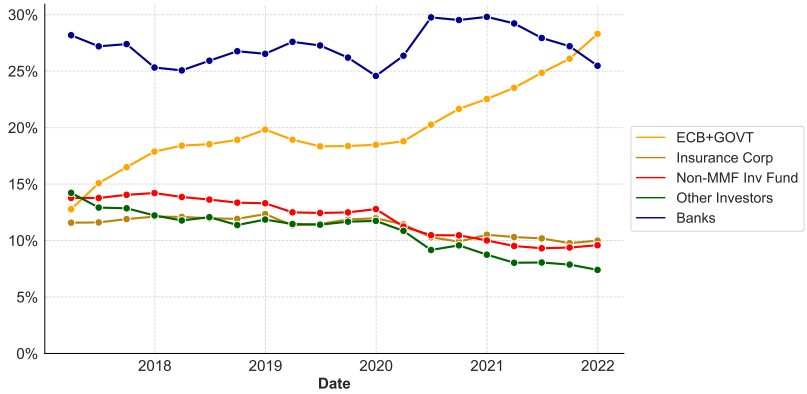
Macro lens: sovereign debt holdings by sector

Figure: Holdings of **carry-eligible** euro sovereign bonds by euro area investors (over amount outstanding)



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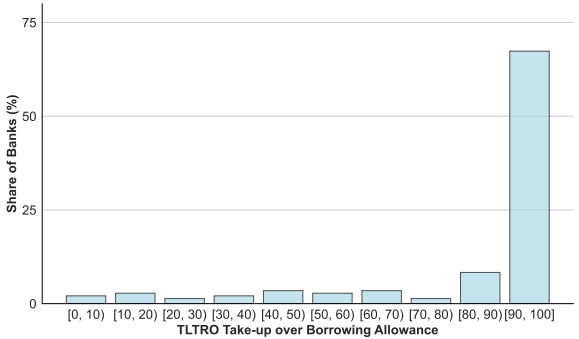
Borrowing allowances - Instrument relevance

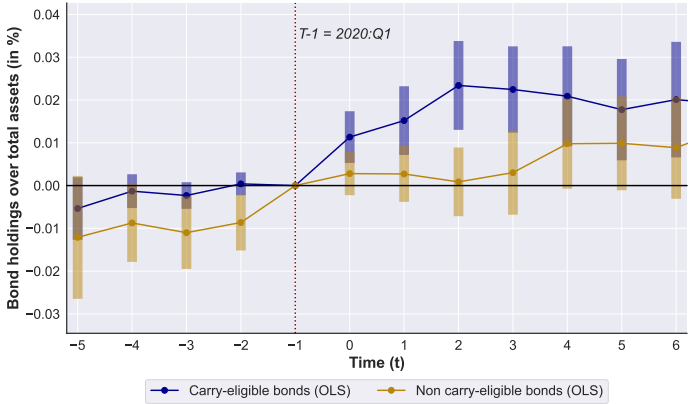
Figure: Distribution of TLTRO borrowing over borrowing allowance for banks in the sample



Most banks tapped almost entirely their borrowing allowance Back to Main Slide

Impulse response function: OLS LP-DID

Figure: Estimates for the effect of greater TLTRO III take-up on banks' sovereign bond holdings



Impulse response function: triple interaction OLS LP-DID

Figure: Estimates for the effect of greater TLTRO III take-up on banks' carry eligible holdings