

Do Households Suppress the Price of Tail Risk?

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The market for tail risk insurance

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⇒ **Which other agents can provide tail risk insurance?**

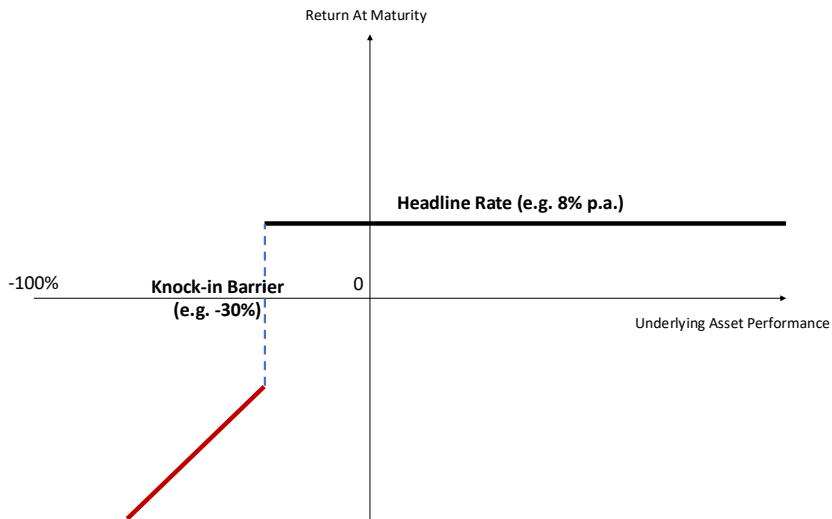
Households as insurers against tail risk?

- Households are unlikely candidates for providing tail risk insurance, as they are typically viewed as highly reluctant to take risk.
- Yet in the past two decades, households have increasingly allocated their savings to products that expose them to tail risk, such as:
 - retail structured products (Henderson and Pearson, 2011; Celerier and Vallee, 2017; Vokata, 2023),
 - structured funds (Gao, Hu, Kelly, Peng and Zhu, 2024),
 - annuities and life insurance products (Barbu and Sen, 2024).
- **This growing retail market expands the supply of tail risk insurance and may decrease its cost.**

Short put products (SPPs)

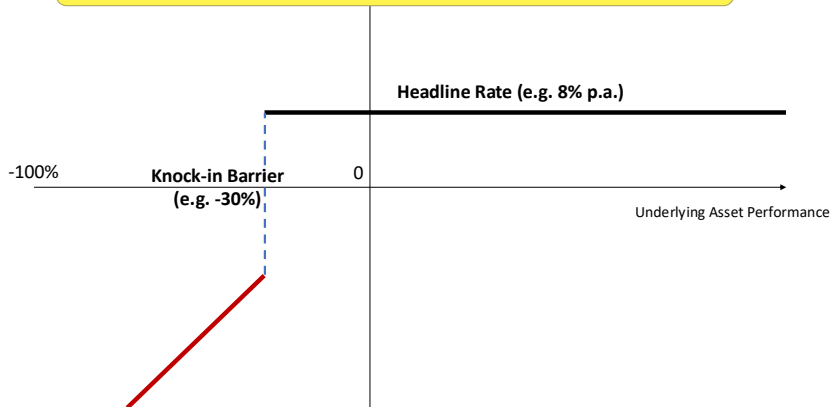
- The most widely sold retail structured products globally.
- SPPs embed a short position in **deep-out-of-the-money puts**.
 - SPPs offer **high headline rates**, or promised returns, as long as the underlying asset stays above a predefined **knock-in barrier**.
 - If the barrier is breached, the SPP owner **absorbs the losses**.
- SPPs represent a large market.
 - Outstanding volumes now exceed **1 trillion USD** across the U.S., Europe, and Asia.
 - SPPs account for up to **20% of open interest** in out-of-the-money puts with maturities of 3 months or more, and represent **end-user** transactions.

Payoff of a simple SPP at maturity



Payoff of a simple SPP at maturity

The investor is short a put option with a strike equal to 70% of the underlying.



Research questions

- Do SPP volumes **affect the price of tail risk insurance**?
- If so, what are the driving **mechanisms** on the demand and supply sides?
- Do these dynamics change during periods of market stress, and what are the implications for **financial stability**?

Preview of results

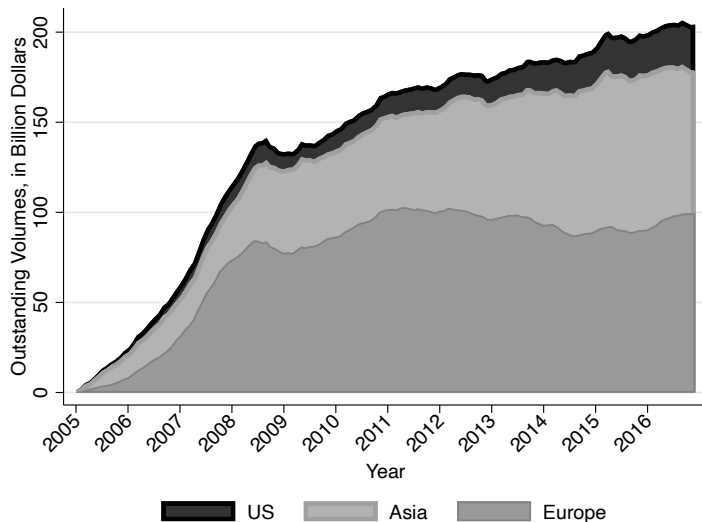
1. **Higher quantities of index-linked SPPs** are generally associated with **lower implied volatility and volatility skew** of corresponding puts.
 - Consistent with issuers' hedging, higher SPP quantities correlate with higher open interest in puts, and SPP vega exposures predict the puts' volatility skew.
2. However, when knock-in barriers are hit during periods of **severe market stress**, issuers' hedging activity induces **a sharp increase in the price of tail risk**.
 - The effect is amplified when **new SPP issuance stops**.
3. We develop and estimate a **structural model** that delivers the following results.
 - Households' underweighting of left-tail risk explains persistent demand for SPPs.
 - SPP quantities depress the cost of tail risk insurance.

Data

For the 12 main global indexes, representing over **70% of global market cap**, we collect data on:

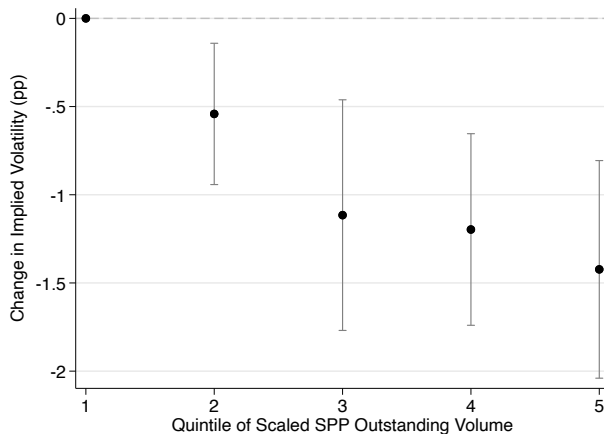
- **All issuances of index-linked SPPs from 2005 to 2019**
 - **180,000 products** and over **1.3 trillion dollars** in cumulative issuance volume across **53 countries**.
 - **Detailed product-level data**
- **Traded options**
 - Puts on the 3 main indexes, strikes of 50%-100% of underlying,
 - Puts on all 12 indexes, strikes of 80%-100% of underlying.

Outstanding quantities of SPPs across regions



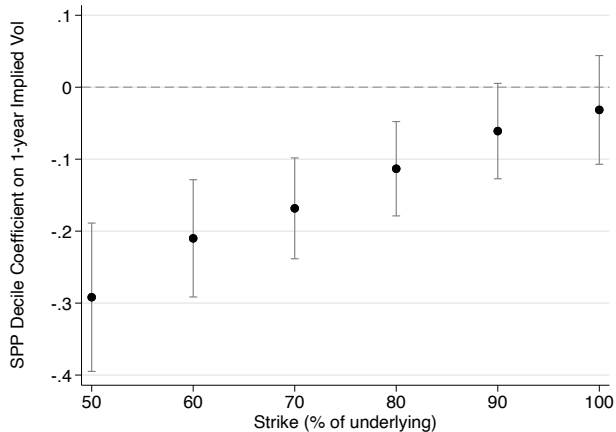
Sensitivity of implied volatility to SPP quantities

Puts on S&P500, Nikkei, and Euro Stoxx 50, with strikes from 50% to 100% of underlying



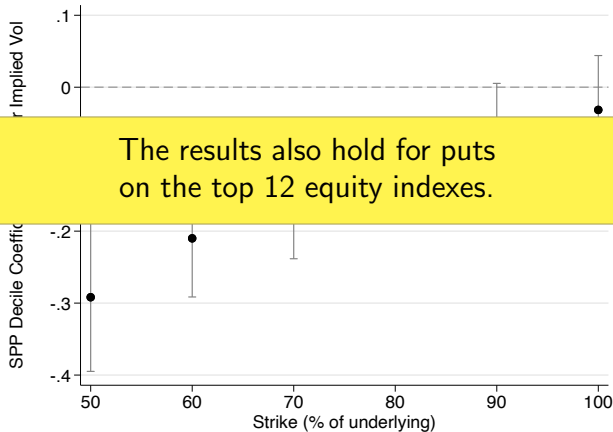
Sensitivity by strike

S&P 500, Nikkei, and Euro Stoxx 50



Sensitivity by strike

S&P 500, Nikkei, and Euro Stoxx 50



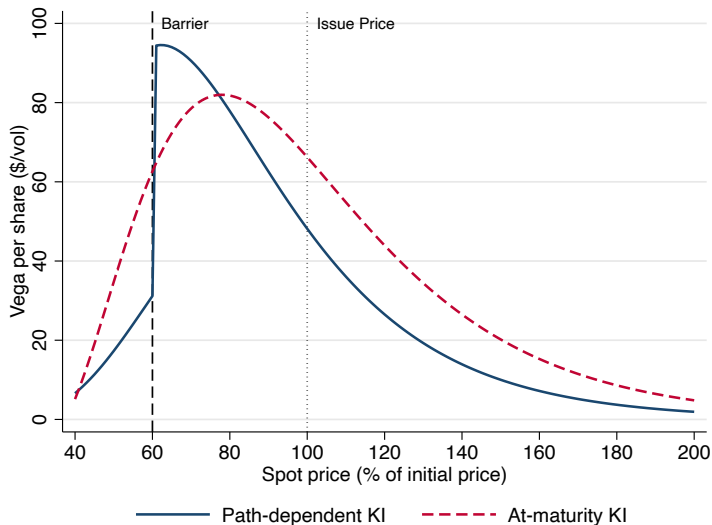
The results also hold for puts on the top 12 equity indexes.

Dynamics of SPP and Put Markets in Periods of Market Stress

Issuer's hedging strategy

- At the SPP's origination, the issuer is effectively **long a deep-out-of-the-money put** on the underlying.
- To hedge this exposure, the issuer may sell puts on the underlying through a **static hedge**, directly increasing the supply of tail risk insurance.
- Most SPPs embed features that introduce time variation in maturity and vega exposure (e.g., an autocall feature that redeems the product early if the underlying hits a knock-out barrier).
 - ⇒ Issuers typically complement the static hedge with **dynamic vega hedging**.

Vega of issuer's SPP position



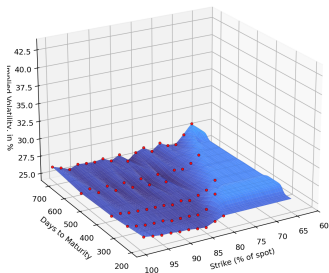
SPP and put markets in periods of market stress

- **When annual index returns are negative, SPPs further suppress put prices.**
 - The market downturn increases the vega of the issuer's SPP position.
 - Issuers seek to sell volatility protection (puts).
- **However, when the knock-in barriers of one or several SPPs are hit, SPP issuers' hedging activity can trigger a sharp increase in implied volatility.**
 - The vega of issuers' SPP positions goes down.
 - The issuers' previously accumulated put hedges leave them net short vega, requiring them to buy volatility protection.
 - **The increase in implied volatility is larger if SPP issuance stops.**

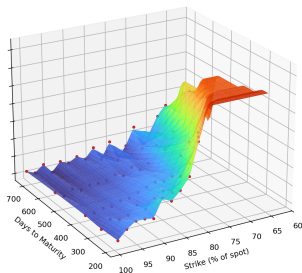
Case study: South Korea in 2015-2016

- In September 2015, following a **regulatory warning**, SPP providers in South Korea **stopped issuing SPPs** linked to a Chinese equity index.
 - HSCEI = Hang Seng China Enterprises Index.
- In January 2016, the index **hit the knock-in barriers** of a large quantity of SPPs.
- In a difference-in-differences analysis, we can show that the impact of knocked-in SPP quantities is higher after the regulatory warning.

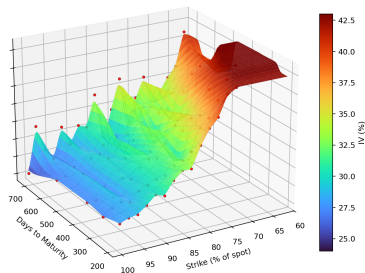
Implied volatility surface of HSCEI options



Before



Regulatory warning



SPP knocked-in

Structural Model

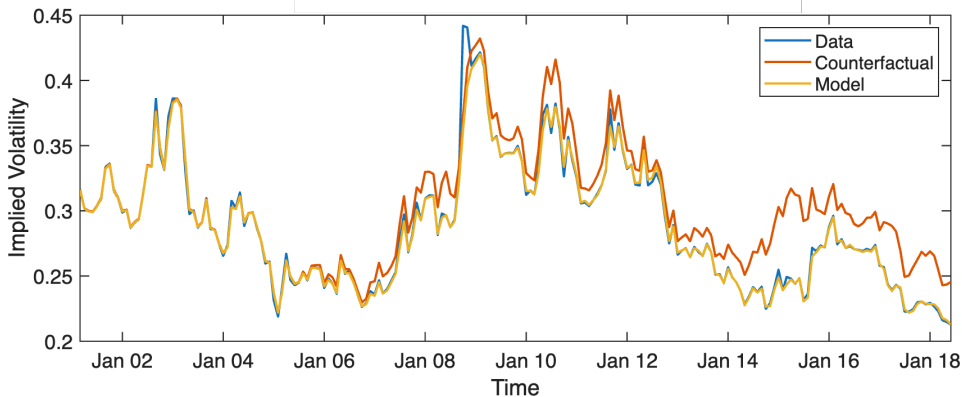
Structural model

- Dynamic equilibrium model à la Garleanu, Pedersen, and Potoshman (2009)
- Assets traded every period: an equity index, a short put product, a zero-coupon bond with the same maturity as the SPP, and European puts.
- Agents: a dealer, a representative household, and outside investors.
- SPP quantity enter the dealer's marginal utility and is therefore priced.

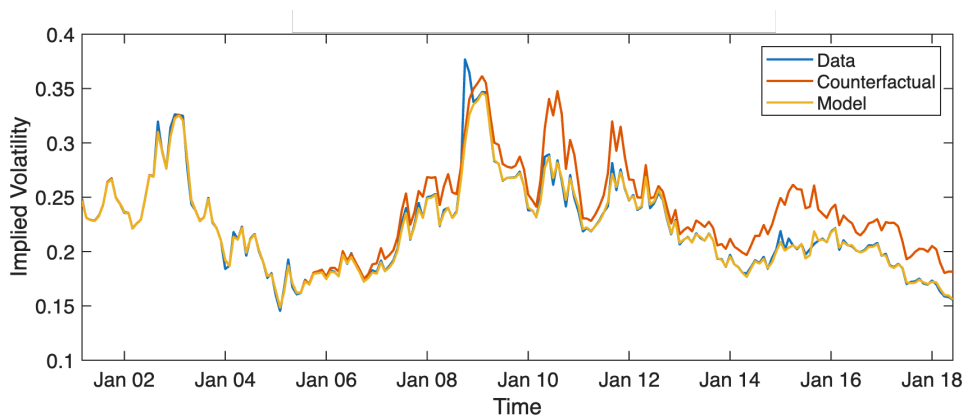
Estimation results

- The sensitivity of the SDF to SPP volume is **significantly different from 0** (t-test & likelihood ratio test).
- A household **underweighting left-tail risk** has a positive demand for the SPP, while a household with rational expectation does not.
- The next slides report in-sample diagnostics for the Euro Stoxx 50.

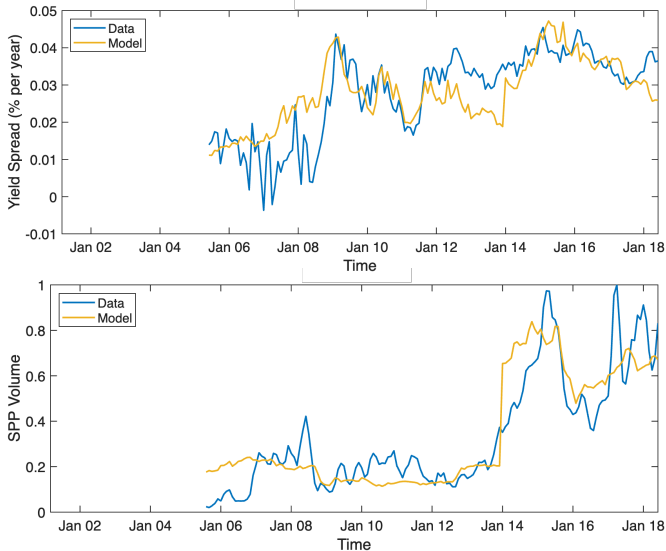
Implied volatility at 60% strike



Implied volatility at 100% strike



SPP yield spread and volume



Conclusion

- **Main Result:** Households can increase the supply of tail risk insurance.
 - Economically significant: SPP volumes **reduce implied volatility by up to 15%**.
 - May help explain the decline in the variance risk premium (Dew-Becker and Giglio, 2024).
 - Complements Parker Schoar and Sun (2024) by identifying a new channel through which retail products affect asset prices.
- **Implications**
 - **Efficient risk sharing?** Intermediaries can offload tail risk to households.
 - **Consumer protection:** SPPs raise welfare and regulatory questions.
 - **Financial stability:** SPPs lower the cost of insuring against tail risk in good times but can sharply increase it in periods of severe market stress.

Conclusion

- **Main Result:** Households can increase the supply of tail risk insurance.
 - Economically significant: SPP volumes **reduce implied volatility by up to 15%**.
 - May help explain the decline in the variance risk premium (Dew-Becker and Giglio, 2024).
 - Complete risk sharing channel through which

Thank you!

- **Implications**
 - **Efficient risk sharing?** Intermediaries can offload tail risk to households.
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Put prices and SPP quantities

We estimate monthly panel regressions across 12 indexes and strikes (2005-2019):

$$IV_{K,t}^u = \alpha + \beta SPP\ Quantities_t^u + \gamma RealizedVolatility_t^u + \eta SwapRate_t^u + \theta + \varepsilon_{K,t}^u,$$

where:

- $IV_{K,t}^u$ is the 1-year **implied volatility** or **volatility skew** of underlying asset u and strike K , observed in month t
- $SPP\ Quantities_t^u$ is the **outstanding quantity** of SPP with underlying asset u issued in month t , scaled by the index market capitalization
- θ is a set of fixed effects: underlying index, strike, and month
- Standard errors are clustered at the year-underlying index and month levels

Volatility prices, skew, and SPP quantities

Full sample

	<i>IV (Total)</i>	<i>IV (By strike)</i>			<i>Skew</i>			
	Pooled	K=80	K=90	K=100	80/100		90/100	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Decile rank	-0.33*** (0.07)	-0.37*** (0.08)	-0.24*** (0.07)	-0.18** (0.07)	-0.19*** (0.03)	-0.21*** (0.03)	-0.05*** (0.02)	-0.06*** (0.02)
Realized vol, 90d	0.40*** (0.04)	0.38*** (0.04)	0.44*** (0.03)	0.47*** (0.03)		-0.04*** (0.01)		-0.03*** (0.01)
1Y swap rate	0.07 (0.11)	-0.03 (0.11)	-0.05 (0.11)	-0.04 (0.11)		-0.04 (0.05)		-0.02 (0.02)
R^2	0.955	0.949	0.937	0.938	0.660	0.667	0.580	0.600
Observations	7,570	1,605	1,809	1,809	1,605	1,605	1,809	1,809
Fixed Effects								
Index	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Strike-Month	Yes							
Strike-Index	Yes							

SPP issuance volumes and implied volatility in times of market stress

Underlying Performance Window	80% Volatility Skew								
	-5% < Yearly Returns < -15%			-15% < Yearly Returns < -25%			Yearly Returns < -25%		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SPP deciles × Performance window		0.02 (0.03)	0.02 (0.03)		-0.08** (0.03)	-0.07** (0.03)		0.09* (0.05)	0.09* (0.05)
SPP deciles	-0.04** (0.02)	-0.04** (0.02)	-0.04** (0.02)	-0.04** (0.02)	-0.03* (0.02)	-0.03** (0.02)	-0.03** (0.02)	-0.05*** (0.02)	-0.05*** (0.02)
Performance window	-0.23* (0.12)	-0.36 (0.25)	-0.37 (0.24)	0.20* (0.12)	0.77*** (0.28)	0.74*** (0.28)	1.08*** (0.24)	0.45 (0.33)	0.44 (0.30)
Realized vol, 90d			-0.03** (0.01)			-0.03** (0.01)			-0.03** (0.01)
1Y swap rate	-0.01 (0.05)		-0.02 (0.05)	-0.01 (0.05)		-0.03 (0.05)	-0.02 (0.05)		-0.02 (0.05)
Fixed Effects									
Month	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Index	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,557	1,557	1,557	1,557	1,557	1,557	1,557	1,557	1,557
R ²	0.626	0.626	0.632	0.625	0.627	0.632	0.633	0.634	0.639

The European Liquidity Gap

Jonathan Brogaard (University of Utah)

Björn Hagströmer (Stockholm University / Sveriges Riksbank)

Abi Zareei (ESCP Madrid)

The views expressed in this presentation are solely the responsibility of the presenter and should not be interpreted as reflecting the views of Sveriges Riksbank.

Full text pdf available at <https://ssrn.com/abstract=5782262>



The European Liquidity Gap

- Two research questions
 - Are European equity markets really so illiquid?
 - What determines variation in illiquidity in the cross-section?
- Why the liquidity level is important
 - Lower cost of capital
 - More efficient pricing and capital allocation
 - Economic growth

Results

1. The European liquidity gap

- Significantly worse liquidity in Europe in all size segments
- Large-cap liquidity gap drops from 2010 to 2018, then flat
- Small-cap liquidity declines in both Europe and in the U.S.
- Small-cap trading costs almost twice of those in the U.S.

2. Determinants

- Retail trading
 - Exchange competition
 - Exchange group size
 - Free float
- } Good for liquidity, lower in Europe

Approach

(Big) Data

- **Global liquidity panel**

- 15 years of high-frequency data for thousands of stocks → ~50 TB
- Consolidated order book (regulated exchange + MTFs)
- Tick History + Google cloud → Panel with stock-day liquidity and efficiency measures

- **Turnover data from Xyt**

- 2018 onwards for Europe
- 2021 onwards for the US
- Industry standard

- **Other data sources**

- S&P Global: European and US stock level data
- Refinitiv: Consolidated holdings + Fund level holdings, Free Float

Liquidity gap

- Monthly matching
 - Eligible set
 - Volatility ($\pm 20\%$)
 - Size ($\pm 20\%$)
 - US stock price < \$100 (Bartlett, McCrary & O'Hara, RFS'25)
 - Match by size (nearest neighbor)

- Illiquidity

- Effective bid–ask spread = $\frac{D(\text{Price-Midpoint})}{\text{Midpoint}}$

- Liquidity gap = $\overline{\ln \text{Illiquidity}_{\text{Europe}}} - \overline{\ln \text{Illiquidity}_{\text{US}}}$



H&M B

Vola: 2.6%

Size: \$25.2 bn

EffSpr: 3.2 bps



D

Vola: 2.3%

Size: \$25.9 bn

EffSpr: 2.5 bps

Liquidity gap: 23%

Matched sample characteristics

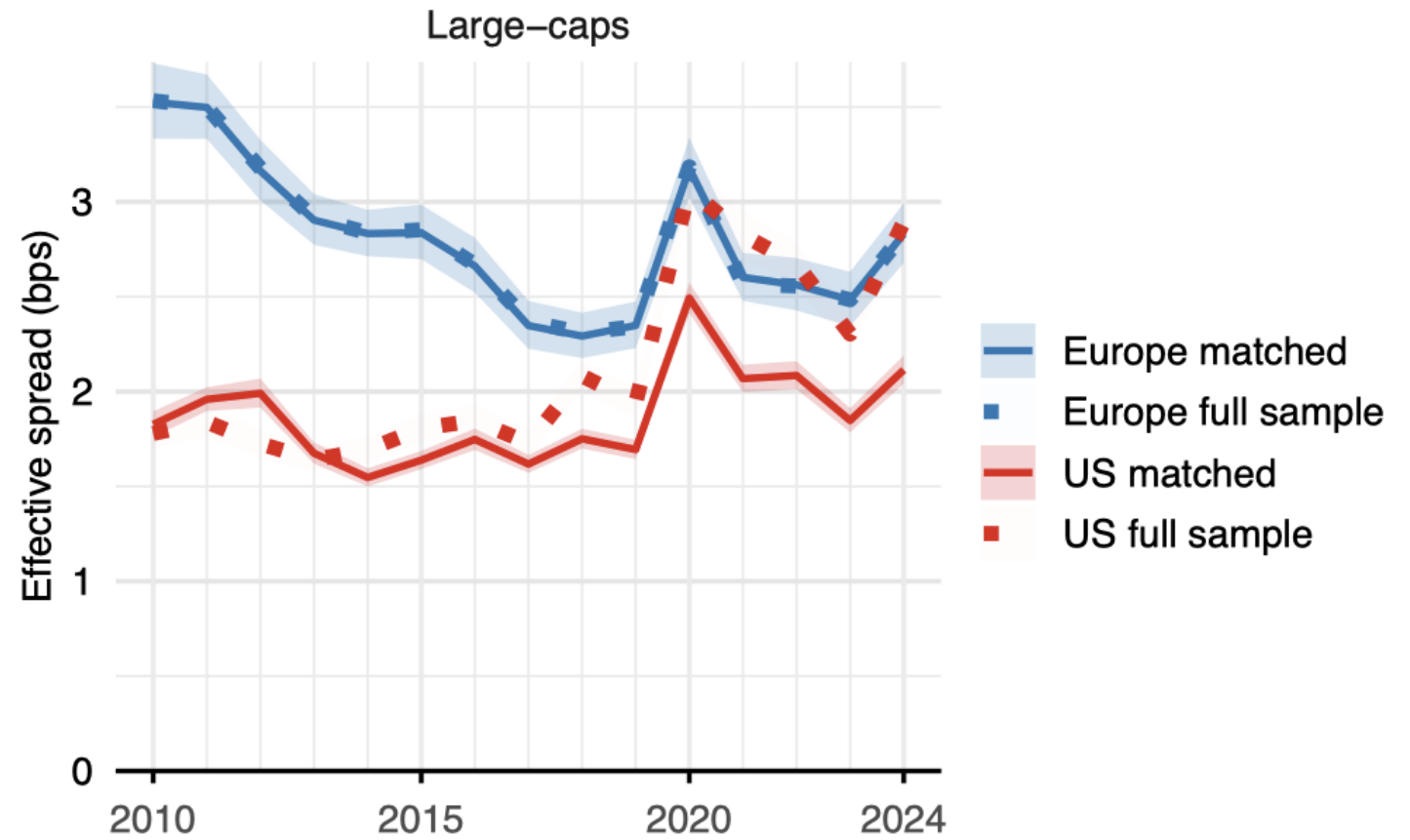
	Full sample Europe	Full sample US	Matched sample Europe	Matched sample US
Market cap (bn USD)	7.5	19.6	7.7	7.7
Volatility (%)	2.3	2.7	2.2	2.3
Effective spread (bps)	39.6	12.2	35.8	17.8

Results I: Liquidity gaps

Large-cap illiquidity development 2010 – 2024

Effective bid-ask spreads

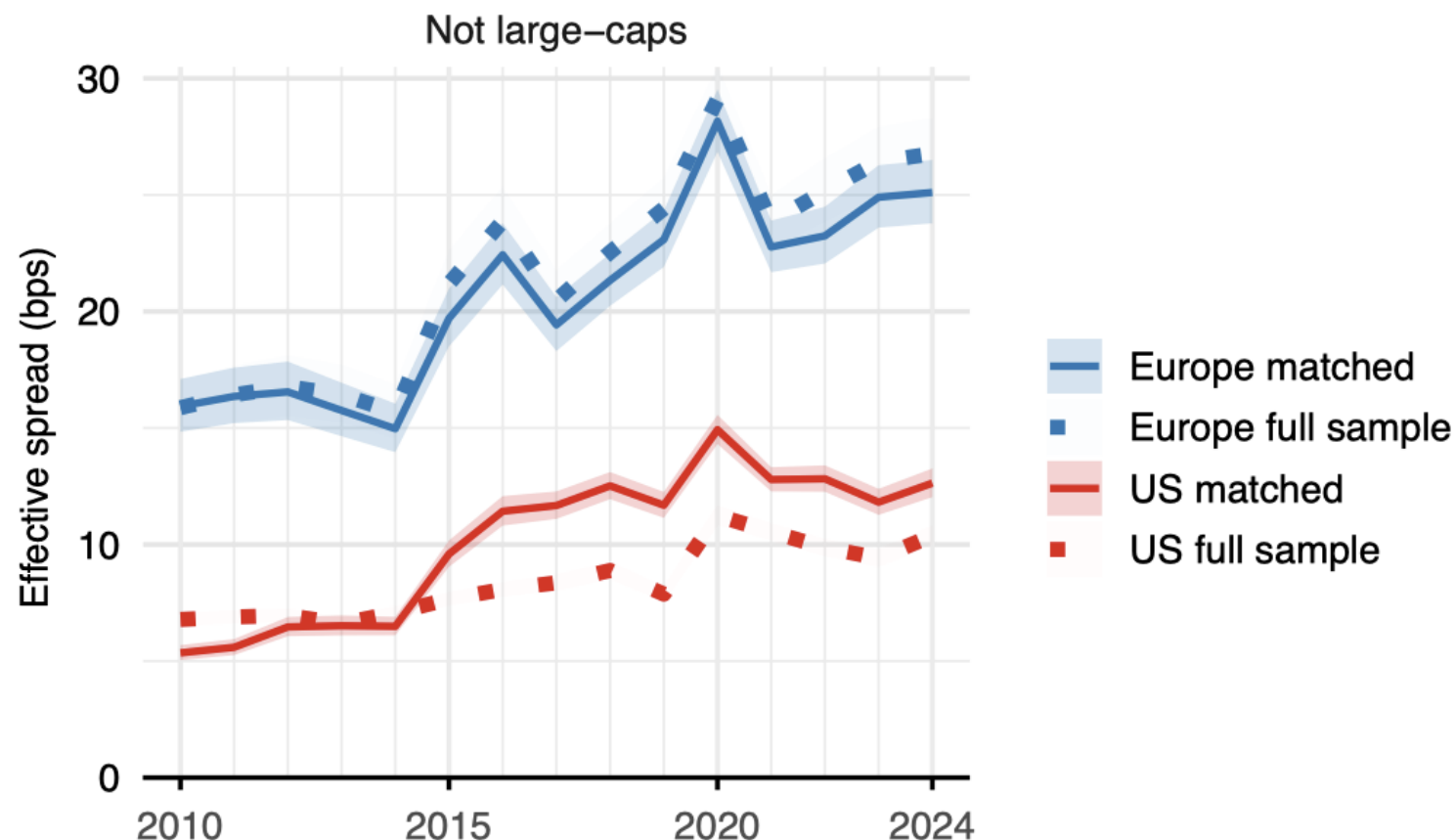
- Large-caps > \$5 billion
- Large European stocks have become substantially cheaper to trade
 - 93% more expensive in 2010
 - 34% more expensive in 2024



Not large-cap illiquidity development 2010 – 2024

Effective bid-ask spreads

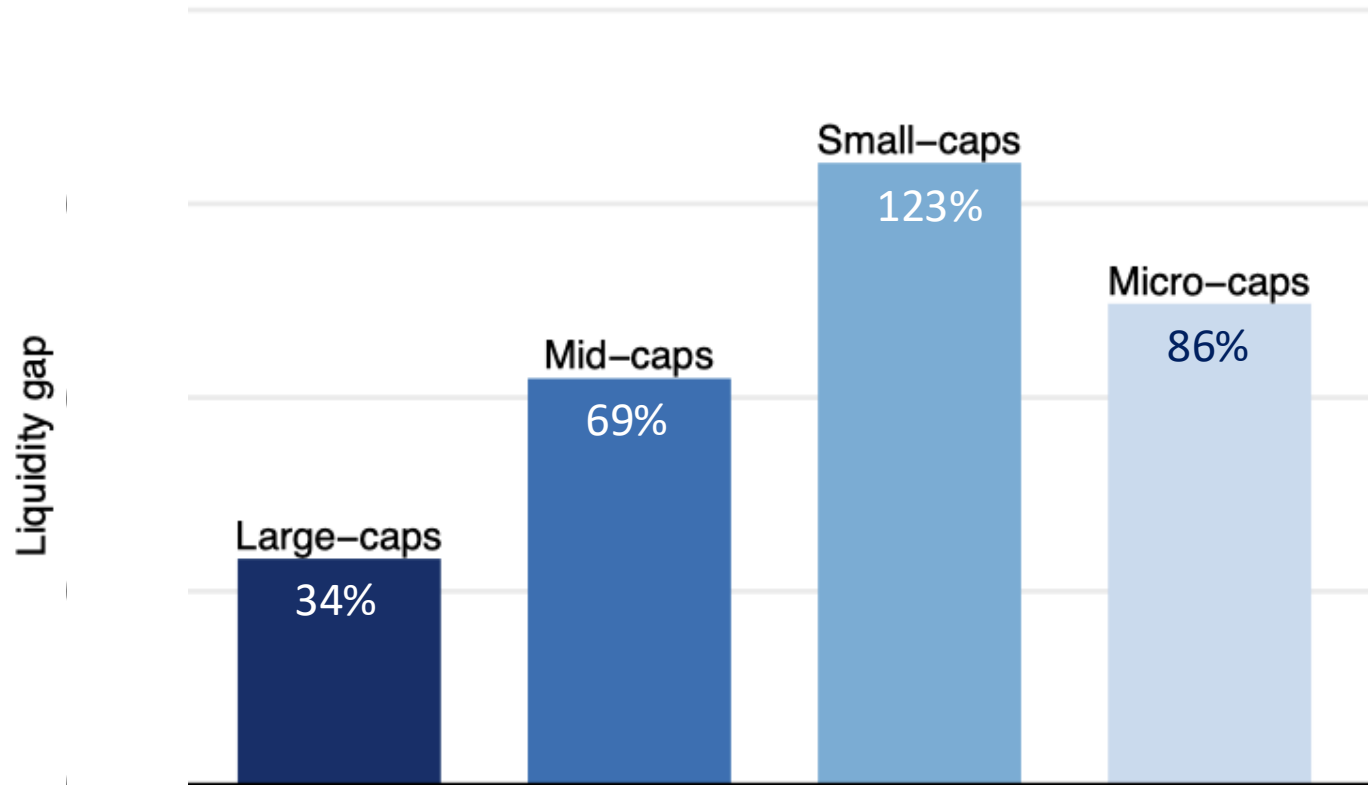
- Not large-caps < \$5 billion
- Illiquidity has gotten worse in both Europe and in the US
- The liquidity gap is shrinking
 - Almost 3x in 2010
 - Less than 2x in 2024
- Commission at online brokers for small trades in Nordics ~ 25 bps



Liquidity gaps

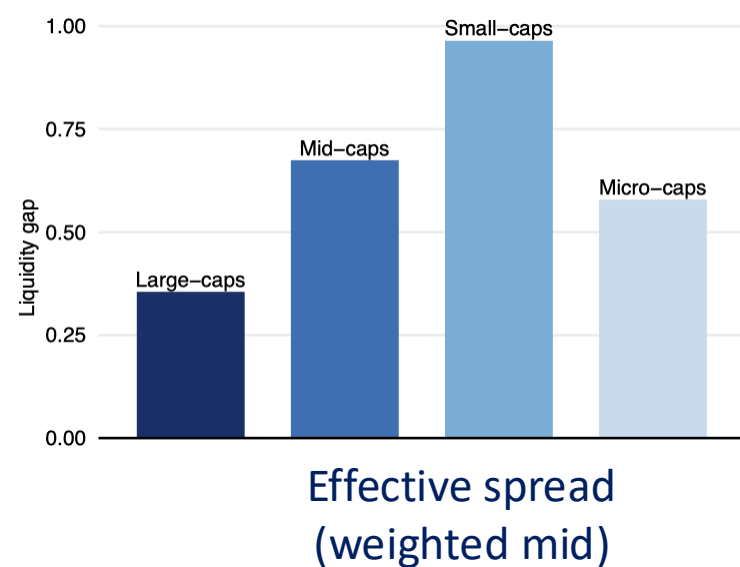
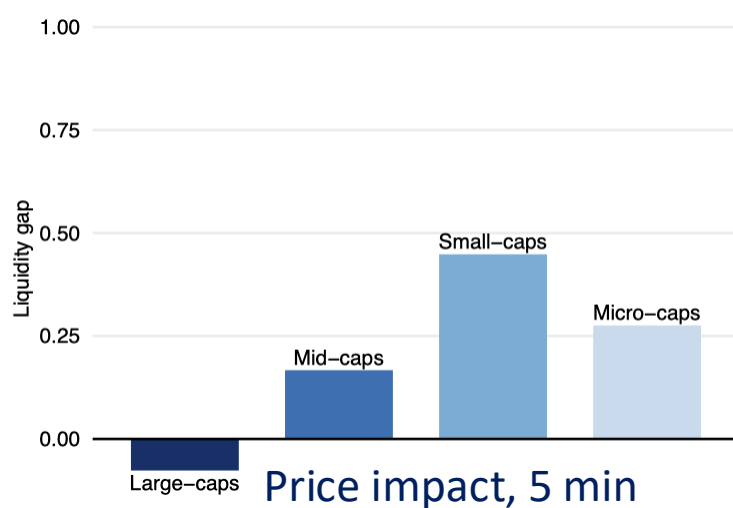
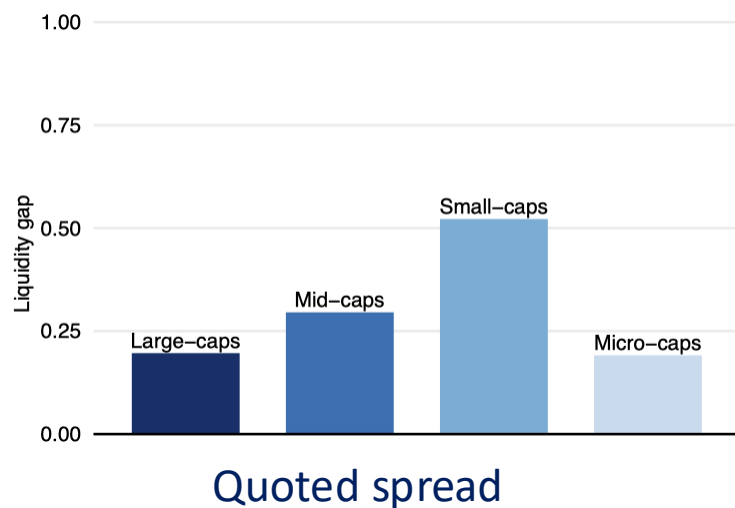
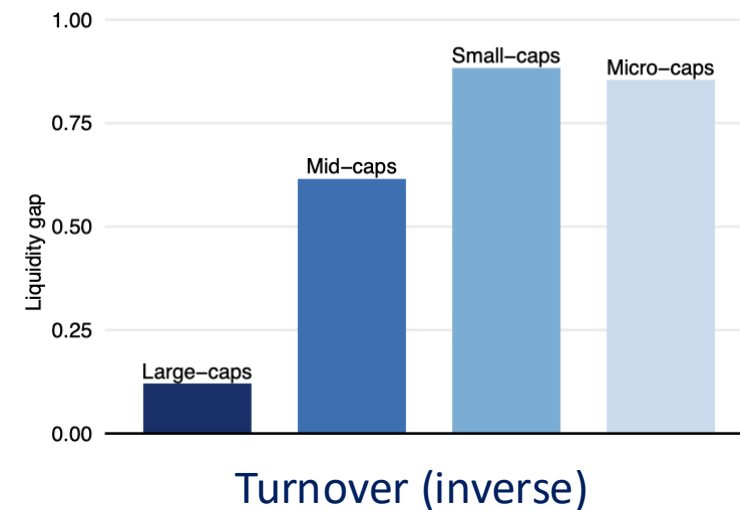
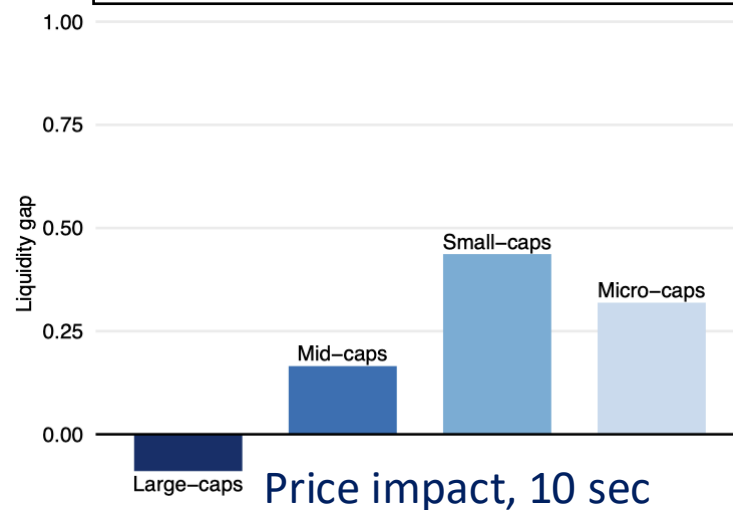
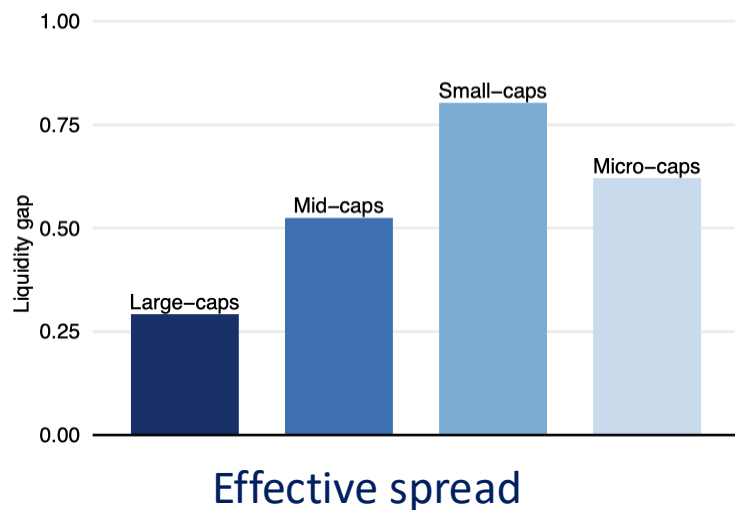
2024

Large-caps	> 5bn USD	487 stocks
Mid-caps	> 2bn USD	547
Small-caps	> 0.25bn USD	757
Micro-caps	< 0.25bn USD	322



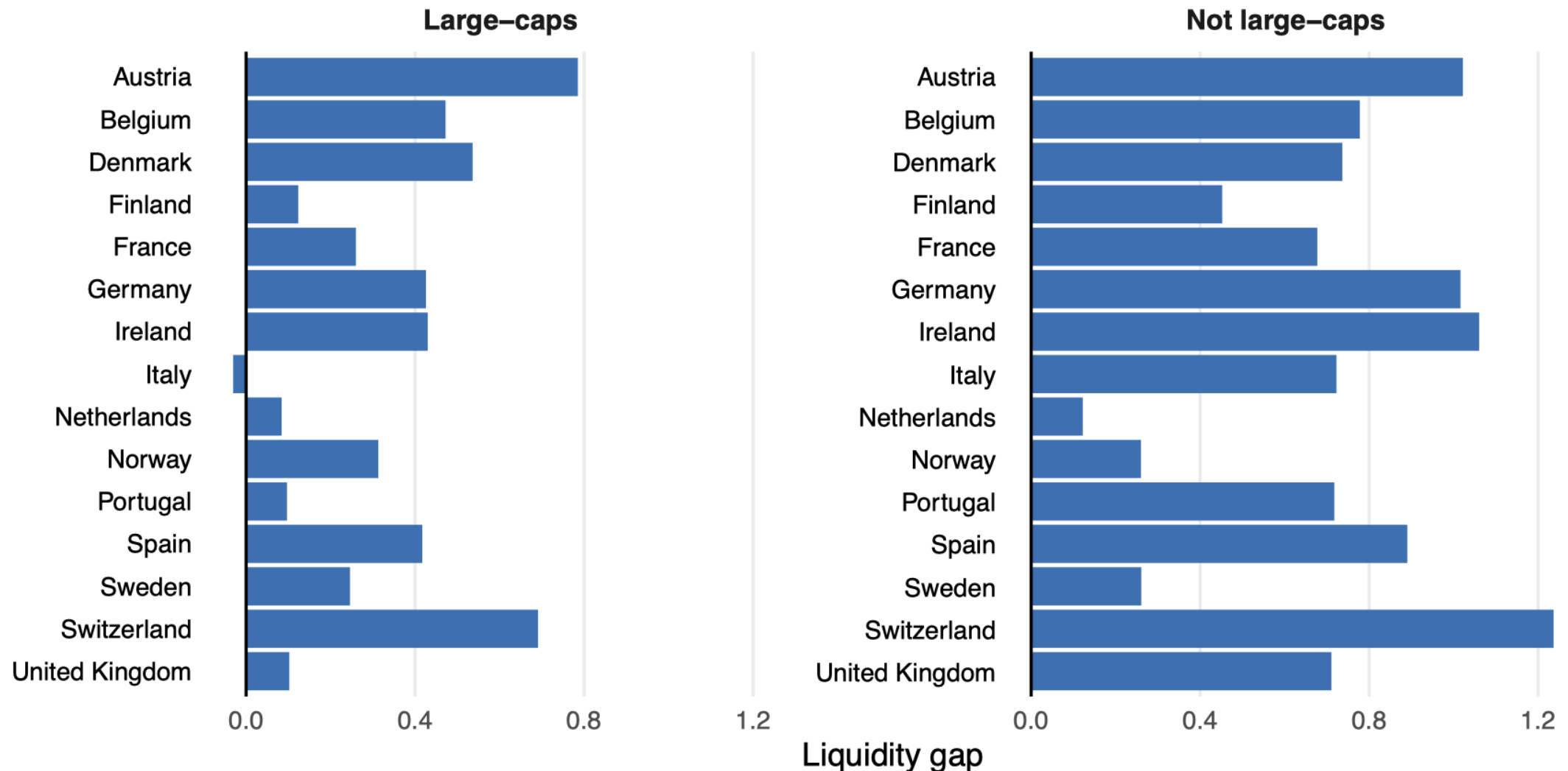
Liquidity gaps

Large-caps	>\$5bn
Mid-caps	>\$2bn
Small-caps	>\$0.25bn
Micro-caps	<\$0.25bn



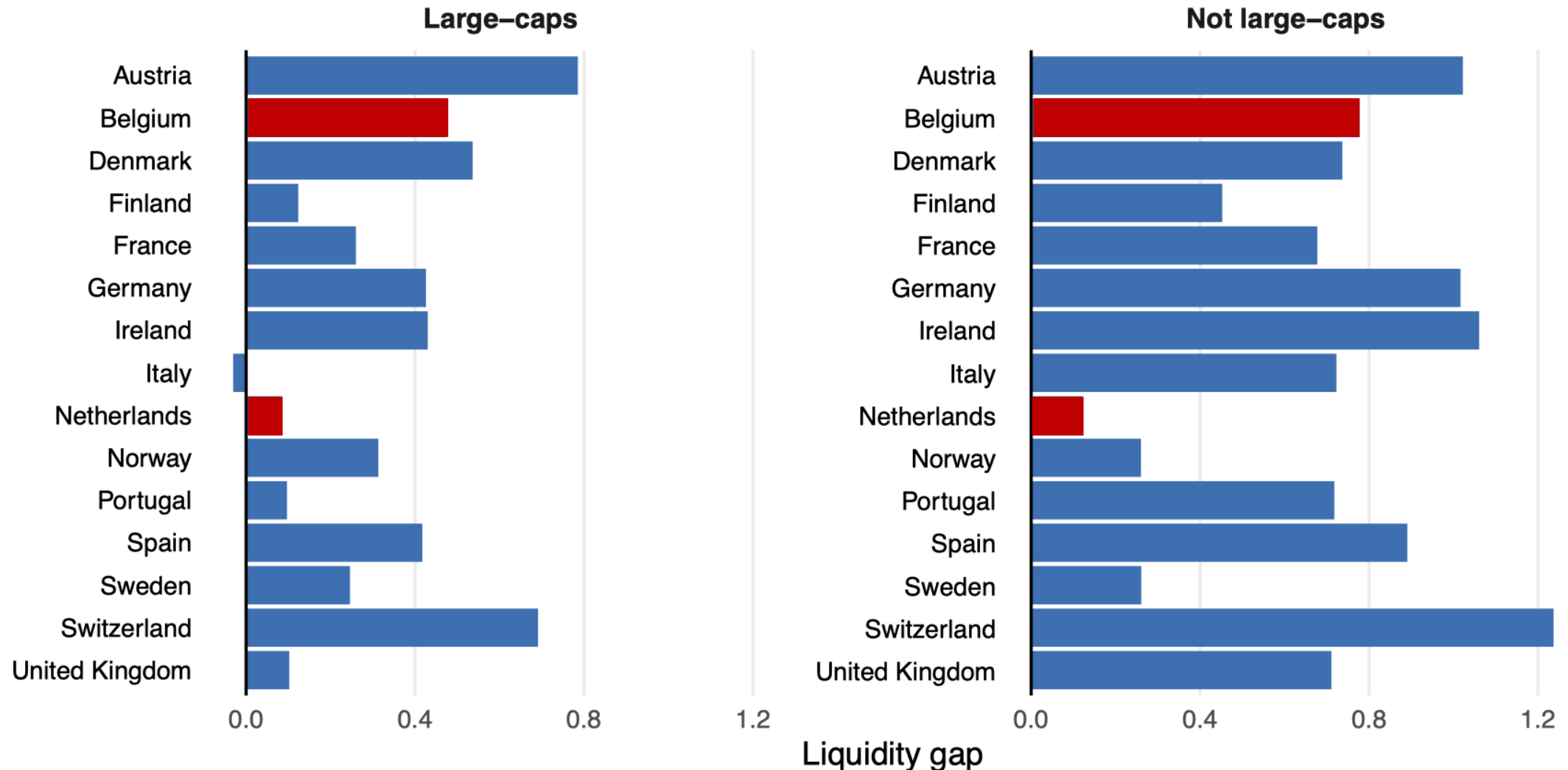
Variation across countries

Effective spread liquidity gaps, 2024



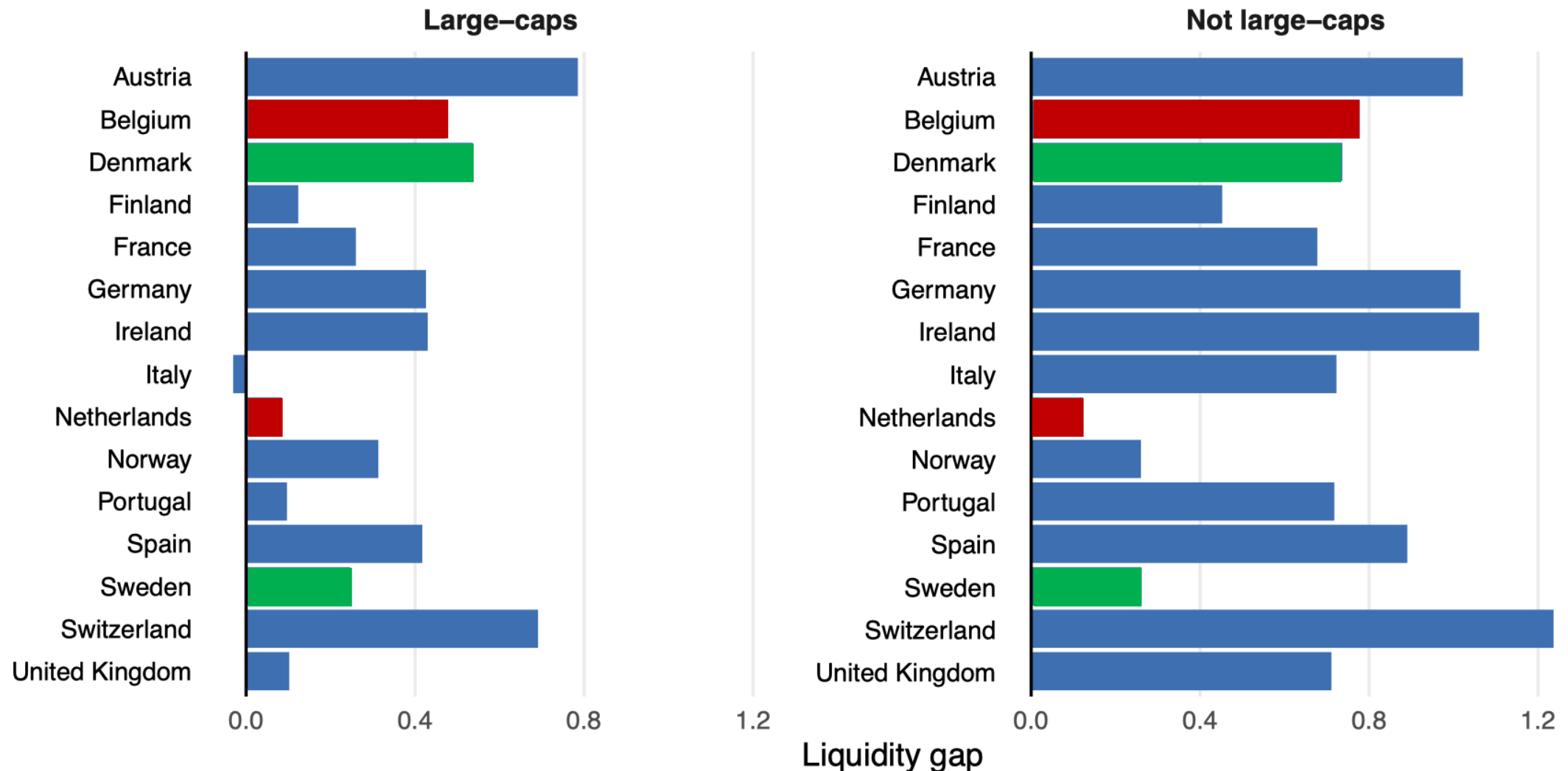
Variation across countries

Effective spread liquidity gaps, 2024



Variation across countries

Effective spread liquidity gaps, 2024



Results II: Determinants

What determines variation in the liquidity gap?

Approach

- Stock-level regression with European stocks and matched US stocks
- Consider variables shown *elsewhere* to have causal effect
- 2024 illiquidity regressed on 2023 characteristics

$$\ln \text{Illiquidity}_{i,2024} = \alpha_{Eu} + X\beta_{Eu} + D_{US}(\alpha^* + X\beta^*) + \varepsilon_i$$

stock-level characteristics ———— US dummy

Market microstructure

- Exchange competition
- Dark volume share
- AT/HFT (order-to-trade ratio)
- Exchange group size

Institutional context

- Retail ownership
- Long-term ownership
- Foreign ownership
- Passive ownership
- Good governance index

Firm characteristics

- Free float

Control variables

- Size
- Volatility

Four important factors for the liquidity gap

	Europe	United States
Free float	62%	86%
Retail investments / GDP	62%	119%
Exchange competition (MTFs vs RE) [Inverse HHI]	1.8	4.5
Average listing exchange group size	\$3 trillion (6 groups)	\$23 trillion (Nyse and Nasdaq)

Conclusions

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Policy implications

- **Focus on small stocks**
Smaller stocks experience rising illiquidity in both Europe and in the US.
- **Incentivize retail investments**
Retail participation in Europe is lower than in the US and known to boost liquidity.
- **Strengthen competition between exchanges (regulated exchanges and MTFs)**
European stocks trade at multiple venues, but competition is much stronger than in the US.
- **Facilitate larger exchange groups**
European listings rarely cross borders. Exchanges with pan-European reach market could increase the investor base and improve liquidity.
- **Encourage high free float**
High free float does not necessarily mean giving up control → dual-class shares



The European liquidity gap - Discussion

ESMA Research Conference 22 September 2026

Caroline Le Moign, ESMA- ESR

A timely paper on a central EU capital markets problem

- Always been a key question for policymakers: Are EU equity markets less liquid, and for whom?
- Particularly valuable because comprehensive stock-level evidence on EU liquidity remains limited relative to the U.S. literature
- “Deliberately descriptive” since the determinants exercise is associative, but highly relevant

Rich, innovative dataset

- **Very rich dataset:** Trade and quote data from 2010 to 2024, 2,200 EU stocks, harmonized high-frequency data. Large timespan encompassing pre-MiFID II and after, including Brexit
- Liquidity assessed on venue (in EU: RM+MTF, 15 countries including UK, CH; in US: Nyse + Nasdaq feeds)
- Matched comparison sample: Both logical but also from the point of view of EU stocks; segmentation by size and volatility
- Measure of illiquidity: Effective bid-ask spread, or cost of trading, but multiple liquidity metrics and robustness checks
- **Many drivers assessed, including innovative ones:** Firm ownership, free float, market microstructure (fragmentation, exchange group size, clearing preferences, order to trade ratio).

Immediate policy relevance I

← → ↺ eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025PC0943     

trv                               

Immediate policy relevance II

Stock exchange consolidation

+ Add to myFT

Euronext open to 'big bang' deal with rival Deutsche Börse

Chief executive Stéphane Boujnah's comments come as EU officials seek ways to make the bloc's capital markets more competitive



FT article 14 September <https://www.ft.com/content/cf0ee7e3-8634-4c1d-8a44-3b71acee1417?syn-25a6b1a6=1>

Main findings: The European liquidity gap is concentrated in smaller stocks

- **Not a uniform deficit:** For large caps, European price impact is slightly lower than in the U.S., while effective spreads are only modestly wider → This complicates a single “European liquidity deficit” narrative. But since large caps account for 90% of EU market cap., aggregate statistics can conceal substantial liquidity frictions for the majority of listed firms
- **Small-cap weakness:** The liquidity gap is concentrated outside the large-cap segment
- **Convergence masks deterioration:** The relative gap narrowed over time, but liquidity deteriorated in both regions for non-large-cap stocks
- **Main correlates:** Exchange-group scale, retail ownership, free float and exchange competition are most closely associated with lower illiquidity, especially outside the large-cap segment.
- **Clearing interoperability** associated with 23% higher effective spread for large caps, 9% for smaller ones
- **Open questions:** Surprisingly, dark trading is improving liquidity in EU (opposite in the US). Institutional trading? Similarly, wider liquidity gap in the last 2 hours of trading? Pointing to the importance of order-flow composition/market design. Understanding the economic mechanism behind would be necessary.

Main findings: Large differences in liquidity gaps across EU countries

- *Differences persist when looking at stocks listed in the same exchange group but in different countries*
- *NL, SE as examples, but models to look into in PT, IT, FR*

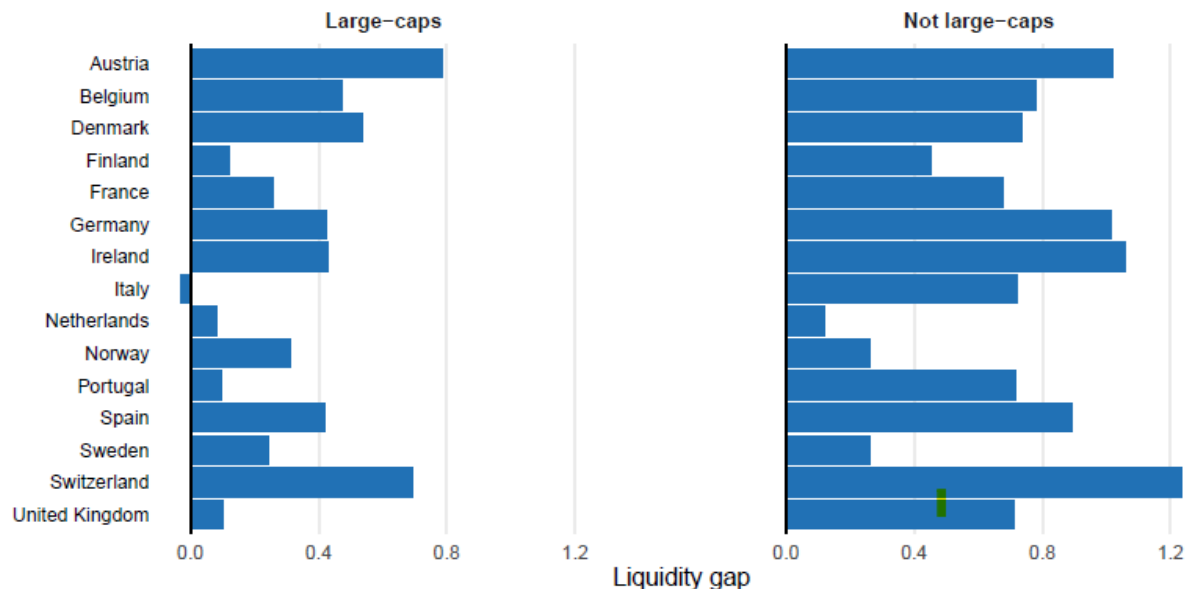


Figure 4: Liquidity Gap Across Countries of Listing

This figure shows the liquidity gap between European and U.S. equities in 2024, measured separately for different European countries and firm size segments. We consider a stock as belonging to the country where it has its primary listing. Stocks are categorized by size as either Large-cap ($> \$5\text{bn}$) or Not large-cap ($\leq \5bn). Liquidity gaps are computed in the same way as in Figure 1.

Some questions/ideas

- **Free float:** A valuable and relatively underexplored contribution to the policy debate
- **Depth:** Not considered among the liquidity measures, can add another liquidity dimension
- **Types of fragmentation:** The literature finds mixed liquidity effects. The analysis could distinguish lit-venue competition from dark pools, periodic auctions and OTC or SI trading.
- **Cross-border trading:** Could multiple listings and cross-border trading activity be incorporated?
- **Order-flow composition:** Similarly, separating dark pools, periodic auctions and OTC trading could help distinguish the underlying liquidity mechanisms.

Possible extensions and policy contribution

- **Identification:** Could exchange mergers, venue entry, Brexit or tick-size changes help move beyond the cross-sectional horse race?
- **Focus on EU sample:** How do the results change for EU Member States only, excluding the UK and Switzerland, and when smaller markets are included?
- **Additional drivers:** Report the corporate-governance results for the available subsample and consider **sectoral differences**, at least between financial and non-financial firms.
- Why should **exchange-group scale** improve liquidity independently of competition, investor reach and issuer composition? (price effect/multiple cross-border listings?)

Conclusion

- **Consolidated tape as a potential contribution.** A consolidated tape should provide investors with a comprehensive and integrated view of where liquidity exists across European markets, discussion ongoing on possible extension/restriction
- A strong paper that materially improves the evidence on European equity market liquidity, allowing for more nuanced vision.



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 [European Securities and Markets Authority \(ESMA\)](https://www.linkedin.com/company/european-securities-and-markets-authority-esma)

Local stock markets

Bajo

University of Zurich

Parry

Imperial College London

Presented by Igli Bajo

ESMA Research Conference, 2026.

Strong EU financial markets in a volatile world.

- Public equity markets foster growth ([Levine and Zervos, 1998](#); [Beck and Levine, 2004](#); [Brown et al., 2017](#)).

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European Union

German Chancellor Friedrich Merz calls for single European stock exchange

Proposal 1d. Increase the appeal of European stock markets for IPOs
Excerpt from the 'Draghi report' (2024)

We have seen this before: UK Provincial Stock Markets



Stock markets formation and closure

- In the 19th century, Scottish firms mainly traded on **Glasgow, Edinburgh, Aberdeen, Dundee.**
- Firms progressively listed to **London.**
- **None** of these Scottish exchanges exists today.

⇒ **Similar patterns in other european countries.**

1. Do local stock markets matter?

- Under what conditions do local stock markets exist?
- Does the existence of local stock markets facilitate business creation?

2. Should governments attempt to revive lagging markets?

- Are remedies warranted?
- What form should they take?

Theory of stock markets location

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— Michael Tory (Ondra Partners; [Financial Times 2023](#)),
on why UK firms are leaving the London exchange.

- ! We build a model of economies where regulation, investor protection, and disclosure are of the same standard, and the currency is the same.
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Two key assumptions underlying our theory

1. **Firm-to-market proximity (δ_x):** Equity analysts organise around the host market and produce better information about firms located near them.
 - Local analysts produce significantly more precise earnings forecasts about firms located near them than foreign analysts (Malloy, 2005; Bae et al., 2008), with one channel for this being firm visits (Cheng et al., 2016).
2. **Investor-to-market proximity (δ_e):** Conditional on information production, local investors are better informed, as they extract more usable content from the produced information.
 - Investors located near the exchange are more familiar with local accounting, regulation, and communication norms.
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Model



Setup

- Two countries $c \in \{A, B\}$; two periods $t = 0, 1$.
- Unit measure of households indexed by (a, c) : share h_A in country A.
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- $t = 1$
- Shocks are realized, entry and listings are executed as agreed, underwriters place the shares, and investors trade.

Asset Pricing Block (APB): Setup

- Investor (a, c) maximizes expected CARA utility over terminal wealth.
- Each investor observes a private signal about asset payoffs

$$\tilde{Y}_{a,c} = \tilde{F} + \tilde{\varepsilon}_{a,c}, \quad \tilde{\varepsilon}_{a,c} \sim \mathcal{N}(0, S_c), \quad \tilde{F} \sim \mathcal{N}(0, V)$$

where $\tilde{F}$ is the random payoff, $\tilde{F} \perp \tilde{\varepsilon}_{a,c}$, S_c^{-1} is the precision of investors' signal.

- Noise traders: random demand $\tilde{\nu}_n \sim \mathcal{N}(0, U)$.
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Asset Pricing Block (APB): Link to Firm Cost of Capital

- The object linking the APB with the Firm Dynamics Block is the expected equilibrium price (**inverse demand schedule**)

$$\mathbb{E}[\tilde{P}] = \frac{1}{R} \left(\bar{F} - \Lambda^{-1} \bar{Z} \right), \quad \Lambda := \underbrace{\bar{\rho} V^{-1}}_{\text{CAPM term: risk}} + \underbrace{\bar{\rho} Q U^{-1} Q + Q}_{\text{New: Information}};$$

where

- $\bar{\rho} = h_A \rho_A + (1 - h_A) \rho_B$: average risk tolerance, where ρ_c is the risk tolerance of investors from country c .
- $Q = h_A \rho_A S_A^{-1} + (1 - h_A) \rho_B S_B^{-1}$: aggregate precision of private signals.
- $Q U^{-1} Q$: precision of the price as a signal (price informativeness).
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Firm Dynamics Block (FDB): Entry

- Business creation requires fixed capital k and effort (with idiosyncratic disutility $f_{e,c}$).
- Entrepreneur e from country c has profit:

$$\pi_{e,c} = \bar{\pi}_c + \eta_e, \quad \eta_e \sim \mathcal{N}(0, \Sigma_\eta),$$

where η_e is the firm-level profit innovation realized at $t = 1$ & unknown to e at $t = 0$.

- Entrepreneurs have no wealth and cannot borrow against future profits $\rightarrow$ equity.
- CARA utility (risk tolerance ρ_c^E) + normal random payoff $J_{e,c}$ imply

$$\text{Enter if } f_{e,c} \leq \mathbb{E}[J_{e,c}] - \frac{1}{2\rho_c^E} \text{Var}[J_{e,c}], \quad J_{e,c} = \underbrace{(1 - z_{e,c})\pi_{e,c}}_{\text{retained equity}},$$

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Firm Dynamics Block (FDB): Listing

- After deciding to enter, the entrepreneur chooses listing market $m \in \{A, B\}$.

- Fixed costs of listing:

$$f_c(m) = \begin{cases} f_D, & c = m \quad (\text{domestic listing}) \\ f_F, & c \neq m \quad (\text{foreign listing}) \end{cases}$$

- Financial intermediaries charge a % fee $\tau_c(m) \in [0, 1]$ on proceeds $p_{e,c}(m)z_{e,c}(m)$.

- Effective capital requirement: $\tilde{k}_c(m) = \frac{k+f_c(m)}{1-\tau_c(m)}$.

- Given offer price $p_{e,c}(m)$, the firm issues shares s.t.

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- Listing decision: List where it's cheapest to raise funds: $d_{e,c} = 1$ (list in the home market) if $z_{e,c}(H) \leq z_{e,c}(F)$, $d_{e,c} = 0$ (list in the foreign market) otherwise.

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- **Effective capital requirement:** $\tilde{k}_c(m) = \frac{k+f_c(m)}{1-\tau_c(m)}$.
- Given offer price $p_{e,c}(m)$, the firm issues shares s.t.

$$z_{e,c}(m) = \frac{\tilde{k}_c(m)}{p_{e,c}(m)} \quad (\text{firm supply curve}).$$

- **Listing decision:** List where it's cheapest to raise funds: $d_{e,c} = 1$ (list in the home market) if $z_{e,c}(H) \leq z_{e,c}(F)$, $d_{e,c} = 0$ (list in the foreign market) otherwise.

- The FDB feeds into the APB by determining
 - tradeable assets: N
 - supply: $\bar{Z} = z$
 - payoffs: $\tilde{F} = \bar{\pi} + \eta$
 - information structure of the economy: $\tilde{Y}_{a,c}$
- **Key Feature:** The signal of investor $\tilde{Y}_{a,c}$ is endogenous to the entry and listing choices of firms.
- Two proximity channels that reduce the signal noise:
 - Firm-to-market (information production): parameter $\delta_\chi \in (0, 1]$.
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$$\Delta_D = \sqrt{\delta_\chi} D + (I - D), \quad \Delta_{M_c} = \sqrt{\delta_\xi} M_c + (I - M_c);$$

- D is a diagonal matrix with ones if firm lists domestically and 0 otherwise. The diagonal matrix M_c has ones for firms listed on market c .
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Example

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- **Guarantee:** Prior to entry, underwriters post a menu of offer prices implied by investors' expected inverse demand:

$$p_{e,c}(m) = \mathbb{E}[\tilde{P}_{e,c}(m)], \quad m \in \{A, B\}.$$

- **Placement:** Underwriter matches with firm upon entry, buys at $p_{e,c}(m)$, resells after at $t = 1$ when shocks realize. Charges fee $\tau_c(m)$ on proceeds $p_{e,c}(m)z_{e,c}(m)$.
- **Firm's perspective:** Raises funds under certainty.
- **Underwriter ex-post profit:**

$$\underbrace{(\tilde{P}_{e,c}(m) - p_{e,c}(m)) z_{e,c}(m)}_{\text{Deviation from offer price}} + \underbrace{\tau_c(m) p_{e,c}(m) z_{e,c}(m)}_{\text{Service Fees}}.$$

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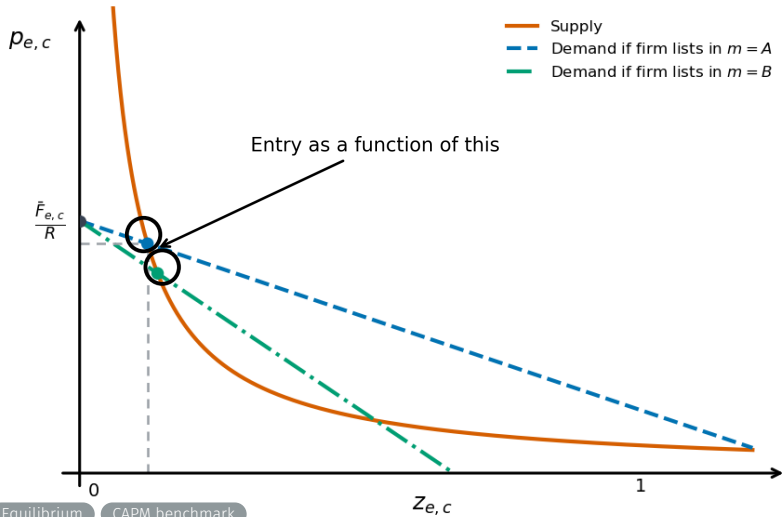
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The model in a picture



Theoretical Results

Tractable benchmark

Goal: closed-form results that isolate the direct information channel.

What we do:

1. **Diagonalize the asset structure:** V, S_A, S_B, U all diagonal $\Rightarrow$ asset demands separable across firms.
 - Preserves the endogenous feedback information $\leftrightarrow$ listing.
 - Removes the strategic component and the listing externalities.
2. Full symmetry across firms and markets: homogeneous variances, identical profits, identical fees and fixed costs across markets, homogeneous noise-trader variance, ...

What we get: a single sufficient statistic — the aggregate posterior precision

$$\lambda^c(m) = \frac{\bar{p}}{\sigma_\eta^2} + \frac{\bar{p} q_c(m)^2}{\sigma_U^2} + q_c(m), \quad q_c(m) = \frac{h_A p_A}{s_A^2(m)} + \frac{(1-h_A) p_B}{s_B^2(m)}.$$

Higher $\lambda^c(m) \Rightarrow$ flatter (more elastic) demand $\Rightarrow$ lower cost of capital

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Formal assumptions

Result 1: Listing and existence of local stock markets

- Relative investor share from A: $\tilde{h} = h_A/(1 - h_A)$
- Home-listing condition.** $q_c(H) \geq q_c(F)$:

$$\underbrace{h_H \rho_H [(\delta_x \sigma_x^2 + \delta_\xi \sigma_\xi^2)^{-1} - (\sigma_x^2 + \sigma_\xi^2)^{-1}]}_{\Delta_H} \geq \underbrace{h_F \rho_F [(\sigma_x^2 + \delta_\xi \sigma_\xi^2)^{-1} - (\delta_x \sigma_x^2 + \sigma_\xi^2)^{-1}]}_{\Delta_F}.$$

where $q_\delta = \Delta_H/\Delta_F > 1$.

Figure 1: Listing equilibrium regions



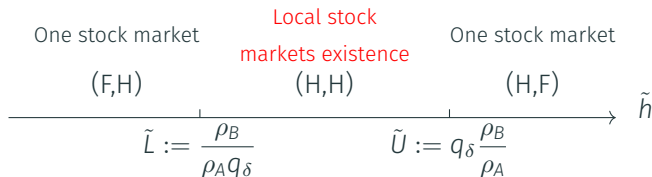
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Figure 1: Listing equilibrium regions



Derivation

Result 2: Entry and local economic activity

- (i) If the firm-to-market proximity benefit decreases then entry weakly decreases.
- (ii) If the investor-to-market proximity benefit decreases then entry weakly decreases.
- (iii) If the investor group in country i becomes more risk averse, then entry by firms from both countries c weakly decreases.

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Derivation

Result 3: Portfolio holdings and joint home bias

- Joint home bias can arise as an equilibrium outcome.
- This result rationalizes the empirical evidence of [Sarkissian and Schill \(2004\)](#), who document that international listing choices mirror investor home bias.

Setup and Proposition

Conclusion

Conclusion

- Local stock markets' existence is sustained only when the home effective investor base is large enough; when it shrinks (e.g., UK pension reforms), firms drift to foreign listings and domestic entry contracts.
- As proximity-based information advantages weaken—through info production or, more subtly, dissemination—local stock markets may cease to exist.
- The joint home bias from [Sarkissian and Schill \(2004\)](#) can arise as an equilibrium of the model.

Thank you!

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Appendix

Appendix: D , M_c , and S_c matrices — example

Four firms $\{(1, A), (2, A), (1, B), (2, B)\}$. $(1, A)$ and $(1, B)$ list at home ($d_{1,A} = d_{1,B} = 1$); $(2, A)$ and $(2, B)$ list abroad ($d_{2,A} = d_{2,B} = 0$). Then

$$D = \begin{pmatrix} D_A & \mathbf{0} \\ \mathbf{0} & D_B \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}, \quad M_A = \begin{pmatrix} D_A & \mathbf{0} \\ \mathbf{0} & I - D_B \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, \quad M_B = I - M_A.$$

With signal noise variance-covariance matrices $\Sigma_x = \sigma_x^2 I$ and $\Sigma_\xi = \sigma_\xi^2 I$, we have:

$$S_A = \begin{pmatrix} \delta_x \sigma_x^2 + \delta_\xi \sigma_\xi^2 & 0 & 0 & 0 \\ 0 & \sigma_x^2 + \sigma_\xi^2 & 0 & 0 \\ 0 & 0 & \delta_x \sigma_x^2 + \sigma_\xi^2 & 0 \\ 0 & 0 & 0 & \sigma_x^2 + \delta_\xi \sigma_\xi^2 \end{pmatrix}$$

Investors in A are:

best informed about $(1, A)$ (home-listed, market close to them)

least informed about $(2, A)$ (foreign-listed, market far from them).

Appendix: D , M_c , and S_c matrices — example

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$$D = \begin{pmatrix} D_A & \mathbf{0} \\ \mathbf{0} & D_B \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}, \quad M_A = \begin{pmatrix} D_A & \mathbf{0} \\ \mathbf{0} & I - D_B \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, \quad M_B = I - M_A.$$

With signal noise variance-covariance matrices $\Sigma_\chi = \sigma_\chi^2 I$ and $\Sigma_\xi = \sigma_\xi^2 I$, we have:

$$S_A = \begin{pmatrix} \delta_\chi \sigma_\chi^2 + \delta_\xi \sigma_\xi^2 & 0 & 0 & 0 \\ 0 & \sigma_\chi^2 + \sigma_\xi^2 & 0 & 0 \\ 0 & 0 & \delta_\chi \sigma_\chi^2 + \sigma_\xi^2 & 0 \\ 0 & 0 & 0 & \sigma_\chi^2 + \delta_\xi \sigma_\xi^2 \end{pmatrix}$$

Investors in A are:

best informed about $(1, A)$ (home-listed, market close to them)

least informed about $(2, A)$ (foreign-listed, market far from them).

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Appendix: Related Literature and Contribution

- **Public equity markets and growth** ([Levine and Zervos, 1998](#); [Beck and Levine, 2004](#); [Brown et al., 2017, 2013](#); [Hsu et al., 2014](#); [Acharya and Xu, 2017](#)).

⇒ We study when the geography of equity markets matters for local activity

- **Cross-listing and foreign listings:** empirical literature showing that firms list abroad for disclosure, investor protection, liquidity, and information reasons ([Coffee, 2002](#); [Reese Jr and Weisbach, 2002](#); [Doidge et al., 2004](#); [Hail and Leuz, 2009](#); [Fernandes and Giannetti, 2013](#); [Pagano et al., 2002](#); [Sarkissian and Schill, 2004](#); [Caglio et al., 2016](#)).

⇒ We provide a model to study the interaction of investor information and firm listing

- **Exchange concentration and market structure:** existing theory studies trading concentration or listing standards ([Pagano, 1989](#); [Chemmanur and Fulghieri, 2006](#)).

⇒ Our model integrates both sides of the market and not only the number of markets, but also their location

- **Noisy rational expectations:** asset prices aggregate dispersed information ([Grossman, 1976](#); [Grossman and Stiglitz, 1980](#); [Hellwig, 1980](#); [Admati, 1985](#)).

⇒ We endogenize assets, supply, and information through entry and listing.

Preview of Results

- **Existence of local stock markets.**

Local stock markets are sustained only when the effective local investor base is sufficiently large.

The threshold depends on the strength of proximity-based information advantages.

- **Local economic activity.**

The number of projects financed increases when information advantages are stronger and investor risk aversion is lower.

- **Joint home bias.**

Firm domestic listing and investor portfolio home bias can arise jointly as an equilibrium outcome.

Appendix: Entry rule

Disutilities $f_{e,c} = F^{-1}(e/\tilde{N}_c)$

Entrepreneurs enter in increasing order of disutility (economy-wide)

The number of entrants in country c satisfies

$$\frac{N_c}{\tilde{N}_c} \leq F\left(\mathbb{E}[J_{e,c}] - \frac{1}{2\rho_c^\mathbb{E}} \text{Var}[J_{e,c}]\right) < \frac{N_c + 1}{\tilde{N}_c}.$$

Appendix: Equilibrium listing regions

Firm's listing problem. In the tractable benchmark, firm c on market m issues

$$z_c^*(m) = \frac{\lambda^c(m) \bar{\pi} - \sqrt{(\lambda^c(m) \bar{\pi})^2 - 4R\lambda^c(m)\tilde{k}}}{2}, \quad \frac{\partial z_c^*}{\partial \lambda^c(m)} < 0.$$

$$\Rightarrow d_c^* = \arg \min_m z_c^*(m) \equiv \arg \max_m \lambda^c(m) \equiv \arg \max_m q_c(m)$$

Home-listing condition. $q_c(H) \geq q_c(F)$:

$$h_H \rho_H [(\delta_x \sigma_x^2 + \delta_\xi \sigma_\xi^2)^{-1} - (\sigma_x^2 + \sigma_\xi^2)^{-1}] \geq h_F \rho_F [(\sigma_x^2 + \delta_\xi \sigma_\xi^2)^{-1} - (\delta_x \sigma_x^2 + \sigma_\xi^2)^{-1}].$$

Rearrange in $\tilde{h} = h_A/(1 - h_A)$. For firm $c = A$, $h_H = h_A$, $h_F = 1 - h_A$:

$$d_A^* = 1 \iff \tilde{h} \geq \tilde{L} := \frac{\rho_B}{\rho_A q_\delta}.$$

Symmetrically, for $c = B$: $d_B^* = 1 \iff \tilde{h} \leq \tilde{U} := q_\delta \rho_B / \rho_A$.

Partition: $(F, H) : [0, \tilde{L})$, $(H, H) : [\tilde{L}, \tilde{U}]$, $(H, F) : (\tilde{U}, \infty)$.

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Appendix: Derivatives behind the entry result

Entry is pinned down by z_c^* , with $\partial z_c^* / \partial \lambda^c < 0$. So N_c moves in the same direction as λ^c .

Below, S_H and S_F denote the signal-noise variances faced by home and foreign investors, respectively, for a given listing configuration. The indicators I_H and I_F select the relevant branch: $I_H = 1$ if the firm lists at home, and $I_F = 1$ if it lists abroad.

$$\frac{\partial \lambda^c}{\partial \rho_H} = \frac{h_H}{\sigma_\eta^2} + \frac{h_H}{\sigma_u^2} q^2 + \left(1 + \frac{2\bar{\rho}}{\sigma_u^2} q\right) \frac{h_H}{S_H} > 0, \quad \frac{\partial \lambda^c}{\partial \rho_F} = \frac{h_F}{\sigma_\eta^2} + \frac{h_F}{\sigma_u^2} q^2 + \left(1 + \frac{2\bar{\rho}}{\sigma_u^2} q\right) \frac{h_F}{S_F} > 0,$$

$$\frac{\partial \lambda^c}{\partial \delta_x} = - \left(1 + \frac{2\bar{\rho}}{\sigma_u^2} q\right) I_H \sigma_x^2 \left(\frac{h_H \rho_H}{S_H^2} + \frac{h_F \rho_F}{S_F^2} \right) < 0 \text{ (when present),}$$

$$\frac{\partial \lambda^c}{\partial \delta_\xi} = - \left(1 + \frac{2\bar{\rho}}{\sigma_u^2} q\right) \sigma_\xi^2 \left[I_H \frac{h_H \rho_H}{S_H^2} + I_F \frac{h_F \rho_F}{S_F^2} \right] < 0,$$

Appendix: Portfolio weights and home bias

Market portfolio weight (with $p_c z_c = \tilde{k}$).

$$w_{\text{mkt}}^c = \frac{N_c p_c z_c}{N_A p_A z_A + N_B p_B z_B} = \frac{N_c}{N_A + N_B}.$$

Weight of country c in the portfolio of an investor from i .

$$w_i^c = \frac{N_c p_c \phi_i^c}{N_A p_A \phi_i^A + N_B p_B \phi_i^B} = \frac{N_c \phi_i^c / z_c}{N_A \phi_i^A / z_A + N_B \phi_i^B / z_B}.$$

Market-portfolio tilt and investor home-bias gap.

$$\Upsilon^c := w_{\text{mkt}}^c - w_{\text{mkt}}^{c'}, \quad \Gamma_c^c := w_c^c - w_{\text{mkt}}^c.$$

Appendix: Portfolio weights and home bias

Home bias (Proposition).

- (i) The market portfolio tilts toward the country with the larger effective investor base.
Formally,

$$h_c \rho_c > (1 - h_c) \rho_{c'} \Rightarrow \Upsilon^c \geq 0.$$

- (ii) There exist equilibrium configurations in which there is joint home bias.

Appendix: CAPM benchmark (location-irrelevance)

Setting. Homogeneous information $\Rightarrow$ no private signals beyond the common prior:

$S_A^{-1} = S_B^{-1} = \mathbf{0}$, hence $Q = \mathbf{0}$ and

$$\Lambda = \bar{\rho} V^{-1}.$$

(i) Inverse demand depends only on exogenous parameters $(\bar{F}, V, \bar{\rho})$:

$$\mathbb{E}[\hat{P}] = \frac{1}{R} (\bar{F} - \bar{\rho}^{-1} V \bar{Z}).$$

(ii) Each investor holds the market portfolio in proportion to her risk tolerance:

$$\mathbb{E}[\Phi_{a,c}] = \frac{\rho_c}{\bar{\rho}} \bar{Z}.$$

- No endogenous link from listing to investor demands.
- One integrated market or two local markets $\Rightarrow$ identical prices, issuance, entry, and market portfolio (holdings fees the same) $\Rightarrow$ local stock markets are irrelevant.

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Appendix: Equilibrium

For each active firm $(e, c) \in N$, issuance $z_{e,c}(m)$ solves

$$\underbrace{\frac{1}{R}(\bar{F}_{e,c} - [\Lambda(d_{e,c}; D_{-(e,c)}, N)^{-1} z]_{e,c})}_{\text{inverse demand (Admati, 1985)}} = \underbrace{\frac{\tilde{k}_{e,c}(d_{e,c})}{z_{e,c}}}_{\text{inverse supply (financing)}}.$$

Listing problem (each firm given others' listing $D_{-(e,c)}$ and entry N):

$$d_{e,c}^* = \arg \min_{d_{e,c} \in \{0,1\}} z_{e,c}^{\min}(d_{e,c}; D_{-(e,c)}, N).$$

Entry problem (given D^* and payoff $J_{e,c} = (1 - z_{e,c}^*)\pi_{e,c}$):

$$\frac{N_c^*}{\bar{N}_c} \leq F\left(\mathbb{E}[J_{e,c}] - \frac{1}{2\rho_c^*} \text{Var}[J_{e,c}]\right) < \frac{N_c^* + 1}{\bar{N}_c}.$$

Equilibrium = fixed point in (D, N) .



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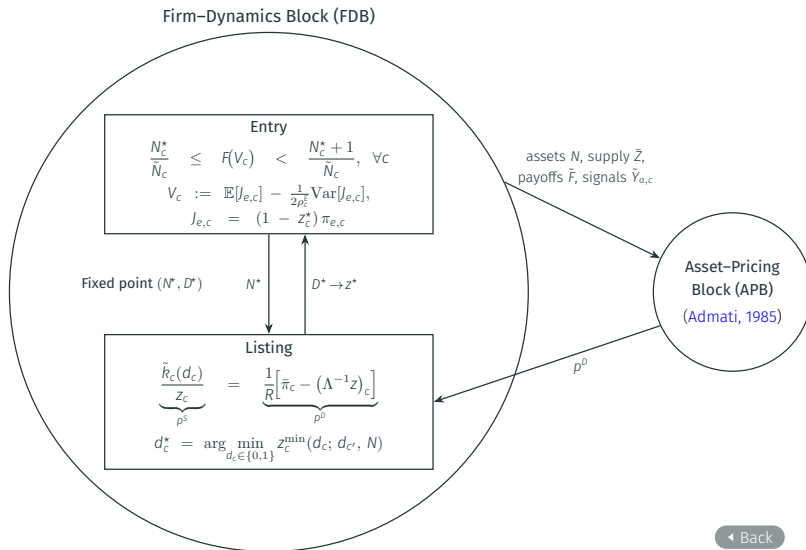
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Equilibrium = fixed point in (D, N) .

Appendix: The model in a figure



Appendix: Formal assumptions of the tractable benchmark

Assumption A1 (feasibility). Market clearing admits $z_c(m) \in (0, 1]$ for both countries and both markets whenever

$$\forall c: \tilde{k} \leq \min_{m \in \{A, B\}} \begin{cases} \lambda^c(m) \bar{\pi}^2 / (4R), & \text{if } \lambda^c(m) \bar{\pi} \leq 2, \\ (\bar{\pi} - 1/\lambda^c(m))/R, & \text{if } \lambda^c(m) \bar{\pi} > 2. \end{cases}$$

Assumption A2 (non-trivial listing trade-off). Rules out the degenerate case where listing at home is always strictly better for every investor:

$$\delta_X \sigma_X^2 + \sigma_\xi^2 > \sigma_X^2 + \delta_\xi \sigma_\xi^2 \iff \frac{\sigma_\xi^2}{\sigma_X^2} > \frac{1 - \delta_X}{1 - \delta_\xi}.$$

Foreign investors get a more precise signal when the firm lists in their market than when it lists at home $\Rightarrow q_\delta > 1$ and a genuine listing trade-off exists.

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Foreign investors get a more precise signal when the firm lists in their market than when it lists at home $\Rightarrow q_\delta > 1$ and a genuine listing trade-off exists.



Local stock markets

ESMA Research Conference 22 September 2026

Lorenzo Danieli, ESMA – ESR

Table of Contents

1. Background
2. Contributions
3. Policy implications
4. Questions and potential extensions

Topic relevance

- Overall EU IPO issuance remained subdued in 2025 at ~EUR 7bn (Source: ESMA TRV)
- Decline in public listings in the EU since pandemic
 - EU firms are increasingly choosing to list in the US instead of their home country
- Delistings are also increasing due to regulatory burdens and costs
- EU listing act aims at making domestic markets attractive again

The paper's idea in a nutshell

The listing venue produces information on the firm; proximity sharpens investor signal

Where a firm chooses to list changes its cost of raising money — not just its domicile.

List at home

Domestic investors improve information capital; though domestic investor base may be small or risk-averse

List abroad

Foreign investors receive smaller improvement in information quality, but foreign investor base may be larger or more risk prone

- Listing outcome depends on both factors together:
 - Improvement in information quality
 - Size and risk appetite of the investor base that receives the signal

Main findings of the paper

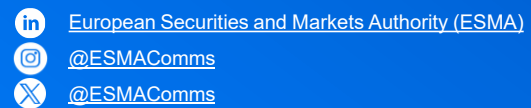
- Domestic exchanges survive only if its effective investor base is large enough relative to the foreign one
- Rising investor risk aversion reduces domestic listing and expands the foreign country's;
- Weaker proximity advantage reduce entry in both countries
- Same mechanism that drives listing location also generates investor home bias
- Without private information, listing location becomes irrelevant; information, not cost alone, drives local market existence

Potential extensions and questions

- Issuers vs. investors: current drain is due to lack of investor demand or due to challenging listing environment?
- Is the information channel stronger than liquidity or valuation channels?
- Fragmented EU setting: potential extension to a multi-market version?
- Framework treats local investor base as crucial. Though many EU listed firms are non-EU-owned. Can foreign ownership be an optimal substitute?
- SIU perspective
 - Example: DE pension fund buying IT equities → is it a loss of local capital?
 - Should EU aim to preserve national investor bases or build a single investor base capable of supporting all EU issuers?



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Discussion of “Cross-Market Hedging in High Frequency: Lessons from the Greeks”

L. Dekker, D. Dimitrov and O. Labout

ESMA Research Conference, 22 September 2026

Antoine Bouveret, ESMA

Key contributions

- Authors build a comprehensive dataset of options and futures positions by Proprietary Trading Firms acting as market makers
- Empirical work shows that PTFs tend to manage inventory risk on options by trading futures to mitigate (i) directional risk and (ii) higher order exposures
- Contribution to the debate on whether hedging occurs via active inventory reduction or delta hedging (Hu et al., 2023)

Identification: Who are the market makers?

- Sample of entities:
 - Who are the PTFs? Eurex points to 8 Market Makers, including one Primary Dealer
 - How concentrated is their activity?
 - Do aggregate results apply at individual entity level?
 - Any significant differences between PTFs and other participants?

Inventory management and delta hedging

- Three possibilities with different financial stability implications
- **Risk hedging across markets** (futures hedging): Stabilizes option liquidity but may transmit shocks to futures
- **Offsetting in options**: reduces net Greeks but may increase gross exposures and margin needs
- **Inventory unwinding**: reduces MM risk but may weaken market-making capacity and shift risk elsewhere
- Key equation (short-term hedging ratio):

$$\Delta\delta_{t,FUTR} = \gamma_0 + \underbrace{\gamma_1 \sum_{i \in N} \sum_{j \in J} \delta_{j,t-1} \Delta q_{i,j,t}}_{\text{Inventory}} + \gamma_2 \underbrace{\Gamma_{t-1} \Delta S_t}_{\text{Gamma}} + \gamma_3 \underbrace{\Lambda_{t-1} \Delta \sigma_t}_{\text{Vanna}} + \dots$$

No impact of price and volatility on hedging ratio

Predicted: -1

Estimated: -0.800*

Predicted: -1

Estimated: +0.008

Predicted: -1

Estimated: -0.001

How do market makers manage option inventory risk?

- Measure how much initial option inventory is still on the book at $t + h$ vs how much of its delta has already been offset in futures
- Use local projections over 1–60 minutes to trace option-inventory retention and futures hedging

$$\delta_{t+h,\text{OPTN}} - \delta_{t-1,\text{OPTN}} = \alpha_h^O + \theta_h^O I_t + u_{t+h}^O$$

$$\delta_{t+h,\text{FUT}} - \delta_{t-1,\text{FUT}} = \alpha_h^F + \theta_h^F I_t + u_{t+h}^F$$

$$R_h^O = \frac{\theta_h^O}{\theta_0^O}; R_h^F = -\frac{\theta_h^F}{\theta_0^O}$$

- (i) $R_h^O \rightarrow 1$ $R_h^F \rightarrow 1$ option inventory retained and risk hedged in futures
- (ii) $R_h \rightarrow 0$ and gross exposures $\uparrow$: hedge in options (offsetting)
- (iii) $R_h \rightarrow 0$ and gross exposures $\downarrow$: inventory management through unwinding
- Paper provides strong evidence of (i) and suggestive evidence of (ii). Estimations would cover all three channels

Measurement issues

- Authors put forward a Jump model but use Black-Scholes-Merton for estimating the sensitivities
- Sensitivities computed without volatility smile and term structure
- Dividend yield omitted even though the authors consider total return futures which provide exposure to dividend.
- No means or dispersions reported for Greek levels, so coefficient magnitudes in the regressions are hard to interpret.

Risk management under stress

- Paper claims that during stress the Vanna effect (sensitivity of option delta to volatility) surges resulting in higher delta hedging through futures
- The stress relationship changes both for level and change estimates:
 - Level: negative effect in normal times/positive effect in stress (-0.039/+0.157 with interaction)
 - Changes: positive effect in normal times/negative effect in stress (+0.005/-0.083 with interaction)
- The relationship changes, it is different from ‘an amplification’
- What economic mechanism explains why the Vanna relationship flips from negative to positive in levels, but from positive to negative in changes during the same stress episode?”

Summary of suggestions

- Risk management: Use local projections on option order flow to separate futures hedging from inventory management
- Stronger identification: Further information PTFs, robustness checks at entity level vs aggregated level
- Improve Greeks estimations: strike/maturity-specific IV, dividend yield.
- Explore further the Vanna effect during stress
- Conclusion:
 - Important paper and great data contribution
 - Identification of the hedging mechanism and measurement of Greeks need stronger robustness before interpreting higher-order channels



Discussion of “Cross-Market Hedging in High Frequency: Lessons from the Greeks”

L. Dekker, D. Dimitrov and O. Labout

ESMA Research Conference, 22 September 2026

Antoine Bouveret, ESMA

Cross-Market Hedging in High Frequency: Lessons from the Greeks

ESMA Research Conference 2026

Lennart Dekker, Daniel Dimitrov, **Okke Labout**

European Central Bank, **De Nederlandsche Bank**, University of Amsterdam, **Tilburg University**

Disclaimer: The views expressed in this presentation are those of the authors and do not necessarily reflect those of De Nederlandsche Bank (DNB), the European Central Bank (ECB), or the Eurosystem.

September 22, 2026

Importance of Understanding MMs' Inventory Management

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- How do they manage their risk?

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- Market makers (MMs) supply liquidity in the market.
- This exposes MMs' inventories to moves in market fundamentals and volatility.
- How do they manage their risk?
- Proprietary trading firms (PTFs) seem to “crowd out” traditional banks as MMs in electronic markets.
- Understanding how modern MMs (PTFs) manage inventory risk is therefore important for market functioning and stability.



Our Contribution

- Existing evidence on option market maker inventory management is mixed.
 - ◆ Classic inventory microstructure emphasizes on inventory reduction (i.e., zero inventory at end-of-day). (Hasbrouck and Sofianos, 1993; Madhavan and Smidt, 1993; Muravyev, 2016)
 - ◆ Others emphasize risk-based hedging (i.e., zero delta exposure at end-of-day). (Baldacci et al., 2021; Hull and White, 2017; Stoikov and Sağlam, 2009)
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- Direct evidence remains scarce because inventory positions are rarely observable.

Using account-level EMIR data, we:

- Construct intraday minute-by-minute inventories of designated MMs.
- Document the existence of cross-market delta hedging.
- Show that this hedging demand is affected by higher-order Greeks.
- Illustrate that the hedging ratio is not stable across market regimes.

Model Intuition

- Hedging $\Rightarrow$ Choose portfolio (options, Q , and futures, F) so that

$$Q \cdot \Delta V(S, \sigma) + F \Delta S \approx 0$$

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$$\Delta V \approx \underbrace{\frac{\partial V}{\partial S}}_{\text{Delta } (\delta)} \Delta S + \underbrace{\frac{\partial V}{\partial \sigma}}_{\text{Vega } (\nu)} \Delta \sigma + \frac{1}{2} \underbrace{\frac{\partial^2 V}{\partial S^2}}_{\text{Gamma } (\Gamma)} (\Delta S)^2 + \frac{1}{2} \underbrace{\frac{\partial^2 V}{\partial \sigma^2}}_{\text{Vomma } (\nu)} (\Delta \sigma)^2 + \underbrace{\frac{\partial^2 V}{\partial S \partial \sigma}}_{\text{Vanna } (\Lambda)} \Delta S \Delta \sigma$$

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- When price and volatility shocks are correlated or feature jumps, futures rebalancing may depend on higher-order Greeks.

Model Result

- We assume the MMs wants to minimize the variance of the hedging error, conditional on option order flow Q : Optimization

$$\min_F \text{Var}(Q \cdot \Delta V + F \cdot \Delta S)$$

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- Which collapses to:

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- So depending on the moments of the joint distribution of $(\Delta S_t, \Delta \sigma_t)$ certain Greeks affect the optimal hedge.

EMIR Data

- Contains all derivative transactions involving at least one European domiciled entity.
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- By combining end-of-day inventory positions (level) with intraday filed reports (flow), we can construct intraday, minute-level inventory positions of MMs in **all** Euro STOXX 50 derivatives.

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- With intraday inventory, we compute portfolio-wide Greeks.

Sample Selection of MMs

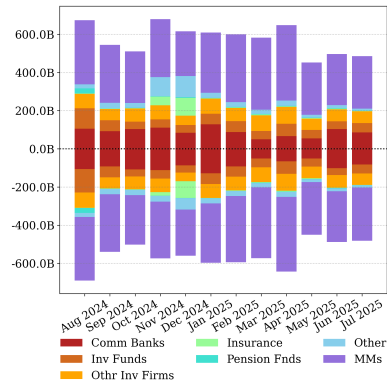
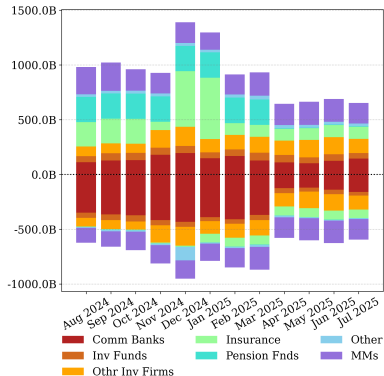
- When is an entity classified as a “market maker”:
 - ◆ Designated option market maker by the Eurex exchange.
 - ◆ Domiciled in the euro area.
 - ◆ Active during the analysis period (2025-02-04/2025-06-20).
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 - ◆ Cannot be a (subsidiary of a) commercial bank.
- The resulting MMs:
 - ◆ Low outstanding notional at any given point in time.
 - ◆ Large share of the monthly traded notional.
- In EMIR, we filter on these MMs through their LEIs.

Comparison MM vs Other Sectors (Options)

Futures



BOM outstanding notional in options (MMs hold 23.3%) Note: long-short doesn't align due to non-EU

Total monthly traded notional in options (MMs hold 54.5%)

Delta Hedging

Other Greeks

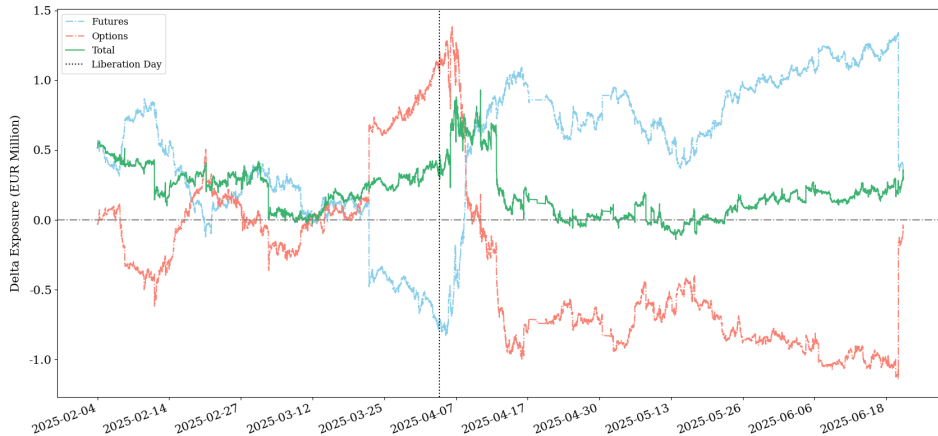


Figure: Aggregated (first-order) directional exposure of MM's active on the Euro STOXX 50 options and futures market for the period 2025-02-04/2025-06-20 on the minute level

Hedging with Higher-Order Greeks

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 - ◆ Model implied relation:

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◆ Delta-specific channel decomposition:

$$\begin{aligned} \Delta \delta_{t,FUTR} = \alpha_0 + & \left(\gamma_1 \left(\sum_{i \in \mathcal{N}} \sum_{j \text{ is option}} \delta_{j,t-1} \Delta q_{i,j,t} \right) + \gamma_2 \Gamma_{t-1} \Delta S_t + \gamma_3 \Lambda_{t-1} \Delta \sigma_t \right) \\ & + \alpha_2 \Delta \nu_t + \alpha_3 \Delta \Gamma_t + \alpha_4 \Delta \mathcal{V}_t + \alpha_5 \Delta \Lambda_t + u_t \end{aligned}$$

Regression Results over the Full Time Series

	$\delta_{t,FUTR}$
Intercept	$2.19 \times 10^5***$ (7,039.057)
$\delta_{t,OPTN}$	$-0.9079***$ (0.004)
ν_t	$0.0001***$ (4.25×10^{-6})
Γ_t	$-23.5293***$ (3.412)
$\mathcal{V}_t$	$4.151 \times 10^{-5}***$ (1.23×10^{-6})
Λ_t	$-0.0491***$ (0.003)
Observations	47,421
R^2	0.943

	$\Delta\delta_{t,FUTR}$	$\Delta\delta_{t,FUTR}$
Intercept	11.1574 (12.513)	15.9242 (11.290)
$\Delta\delta_{t,OPTN}$	$-0.6671***$ (0.021)	
ΔI_t		$-0.8011***$ (0.020)
$\Gamma_{t-1}\Delta S_t$		0.0077 (0.020)
$\Lambda_{t-1}\Delta\sigma_t$		-0.0578 (0.055)
$\Delta\nu_t$	$1.577 \times 10^{-5*}$ (9.03×10^{-6})	$2.242 \times 10^{-5}***$ (1.13×10^{-5})
$\Delta\Gamma_t$	$-0.8948*$ (0.524)	-0.0680 (0.137)
$\Delta\mathcal{V}_t$	$2.47 \times 10^{-6*}$ (1.42×10^{-6})	$5.375 \times 10^{-6}***$ (1.27×10^{-6})
$\Delta\Lambda_t$	-0.0013 (0.003)	$0.0240***$ (0.002)
Observations	47,421	47,421
R^2	0.500	0.581

Hedging in Times of Stress (April 2nd, 2025, “Liberation Day”)

	$\delta_{t,FUTR}$
Intercept	1.26×10^5 *** (8,230.92)
$\delta_{t,OPTN}$	-0.9729 *** (0.005)
ν_t	1.6×10^{-5} *** (5×10^{-6})
Γ_t	-36.194*** (4.259)
$\mathcal{V}_t$	2.1×10^{-5} *** (2×10^{-6})
Λ_t	-0.0499*** (0.004)
$\mathbb{1}_{\text{Lib Day}}$	-3.45×10^5 *** (2.186×10^4)
$\mathbb{1}_{\text{Lib Day}} \times \delta_{t,OPTN}$	0.164 *** (0.011)
$\mathbb{1}_{\text{Lib Day}} \times \nu_t$	0.0001*** (8×10^{-6})
$\mathbb{1}_{\text{Lib Day}} \times \Gamma_t$	32.912*** (6.178)
$\mathbb{1}_{\text{Lib Day}} \times \mathcal{V}_t$	9.4×10^{-5} *** (6×10^{-6})
$\mathbb{1}_{\text{Lib Day}} \times \Lambda_t$	0.073*** (0.009)
Observations	47,421
R^2	0.962

Note: Reduction in hedging ratio of 16.9%

	$\Delta\delta_{t,FUTR}$
Intercept	18.89* (11.458)
$\Delta\delta_{t,OPTN}$	-0.729 *** (0.0219)
$\Delta\nu_t$	-7×10^{-6} (1.4×10^{-5})
$\Delta\Gamma_t$	-1.360*** (0.396)
$\Delta\mathcal{V}_t$	7×10^{-6} *** (1×10^{-6})
$\Delta\Lambda_t$	0.0077*** (0.0029)
$\mathbb{1}_{\text{Lib Day}}$	5.336 (41.61)
$\mathbb{1}_{\text{Lib Day}} \times \Delta\delta_{t,OPTN}$	0.146 *** (0.043)
$\mathbb{1}_{\text{Lib Day}} \times \Delta\nu_t$	4.0×10^{-5} ** (1.6×10^{-5})
$\mathbb{1}_{\text{Lib Day}} \times \Delta\Gamma_t$	1.326 (0.819)
$\mathbb{1}_{\text{Lib Day}} \times \Delta\mathcal{V}_t$	-1.5×10^{-5} *** (4×10^{-6})
$\mathbb{1}_{\text{Lib Day}} \times \Delta\Lambda_t$	-0.046*** (0.011)
Observations	47,421
R^2	0.515

Note: Reduction of hedging ratio by 20.0%

Conclusion

- In this paper we:
 - ◆ Examined high-frequency hedging behavior of MMs
 - ◆ Showed that option-induced delta exposure is hedged through futures
 - ◆ Provided a stylized model to illustrate how higher-order Greeks affect hedging
 - ◆ Showed that higher-order exposures affect hedging, particularly during market stress.

Conclusion

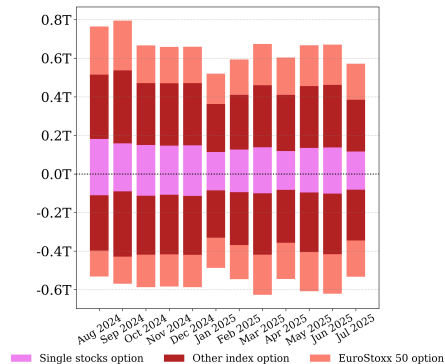
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 - ◆ Showed that higher-order exposures affect hedging, particularly during market stress.
- Results highlight: Investigating cross-market inventory dependencies is important
 - ◆ Options market activity can generate hedging demand in futures markets.
 - ◆ Shocks originating in one market may propagate to other markets through MMs' inventory management and risk-transfer activities.

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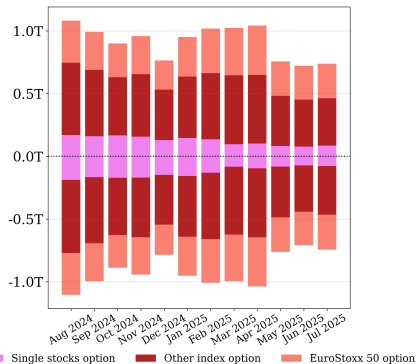
Why Euro STOXX 50 Derivatives?

[Back](#)
[Futures](#)

- Euro STOXX 50 derivatives are (on average) responsible for around 31% of the complete portfolio of equity derivatives of these MMs (stocks only 10%):



BOM outstanding notional in options

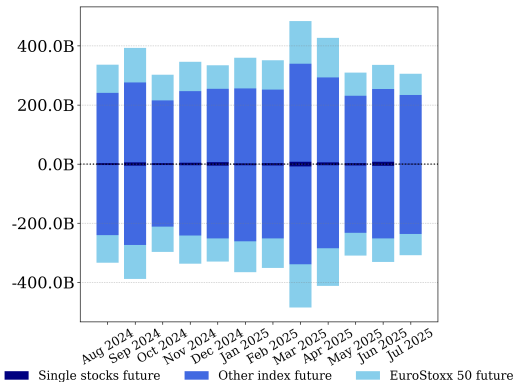
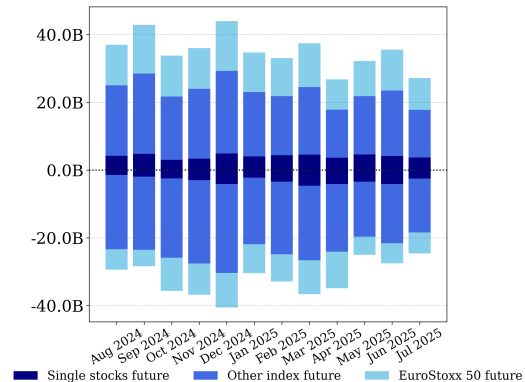


Monthly traded notional in options

Why Euro STOXX 50 Derivatives?

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■ For futures we have:



BOM outstanding notional in futures

Monthly traded notional in futures

MM's Optimization (1/2) [Back](#)

$$\Pi = mQ + Q\Delta V + F\Delta S$$

- Mean of P&L is given by:

$$E[\Pi] = mQ + Q^2 E[\Delta V] + F E[\Delta S] = Q^2 E[\Delta V]$$

- Variance is given by:

$$\text{Var}(\Pi) = Q^2 \text{Var}(\Delta V) + F^2 \text{Var}(\Delta S) + 2F \text{Cov}(\Delta V, \Delta S)$$

- Since mean is independent of F, we get

$$\max_F E[\Pi] - \lambda \text{Var}(\Pi) = \min_F \text{Var}(\Pi) \quad \underbrace{=}_{\text{Conditional on } Q} \min_F \text{Var} \underbrace{(Q\Delta V + F\Delta S)}_{\Delta S \text{ dependent on } \Delta V}$$

MM's Optimization (2/2) [Back](#)

$$\min_F \text{Var}(\Pi) = \min_F Q^2 \text{Var}(\Delta V) + F^2 \text{Var}(\Delta S) + 2F \text{Cov}(\Delta V, \Delta S)$$

■ FOC:

$$F^* = -Q \frac{\text{Cov}(\Delta V, \Delta S)}{\text{Var}(\Delta S)}$$

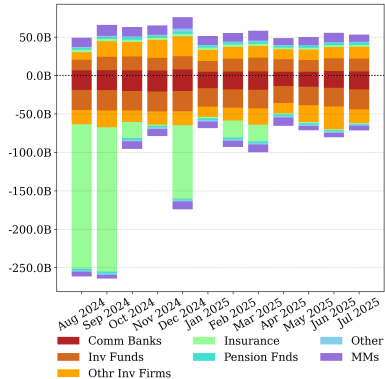
■ Given dynamics of V

$$\Delta V = \delta \Delta S + \nu \Delta \sigma + \frac{1}{2} \Gamma (\Delta S)^2 + \frac{1}{2} \mathcal{V} (\Delta \sigma)^2 + \Lambda \Delta S \Delta \sigma$$

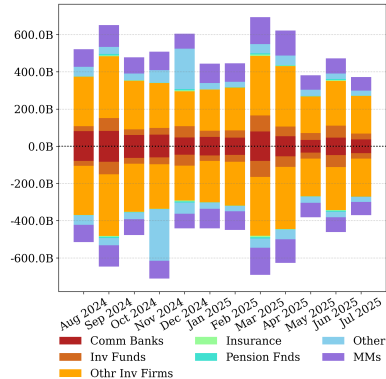
■ We find:

$$\begin{aligned} F^* &= -Q \frac{\delta \text{Var}(\Delta S) + \nu \text{Cov}(\Delta \sigma, \Delta S) + \frac{1}{2} \Gamma \text{Cov}((\Delta S)^2, \Delta S) + \frac{1}{2} \mathcal{V} \text{Cov}((\Delta \sigma)^2, \Delta S) + \Lambda \text{Cov}(\Delta S \Delta \sigma, \Delta S)}{\text{Var}(\Delta S)} \\ &= -Q\delta - Q\nu \frac{\text{Cov}(\Delta S, \Delta \sigma)}{\text{Var}(\Delta S)} - Q\Gamma \frac{E[(\Delta S)^3]}{2\text{Var}(\Delta S)} - Q\mathcal{V} \frac{\text{Cov}((\Delta \sigma)^2, \Delta S)}{2\text{Var}(\Delta S)} - Q\Lambda \frac{\text{Cov}((\Delta S)^2, \Delta \sigma)}{\text{Var}(\Delta S)} \end{aligned}$$

Comparison MM vs Other Sectors (Futures) [Back](#)



BOM outstanding notional in futures (MMs hold 11.3%)



Total monthly traded notional in futures (MMs hold 19.6%)

Vega Hedging (First-Order Volatility Effect) [Back](#)

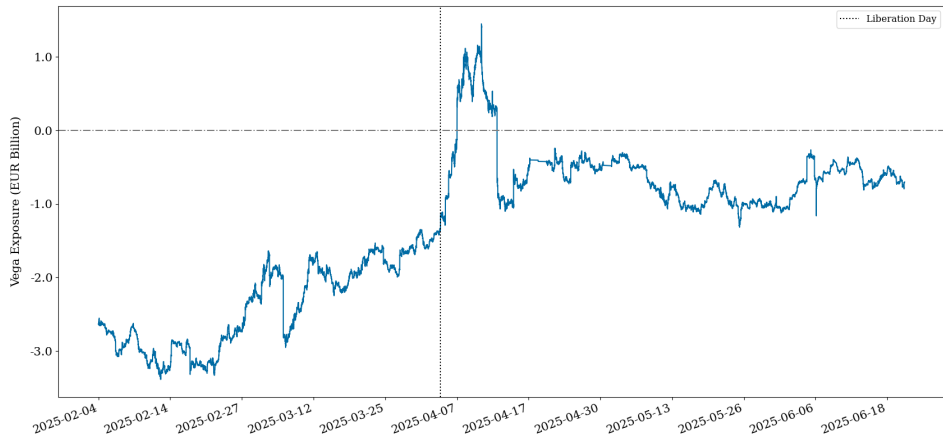


Figure: Aggregated (first-order) volatility exposure of MMs active on the Euro STOXX 50 options and futures market for the period 2025-02-04/2025-06-20 on the minute level

Gamma Hedging (Second-Order Price Effect)

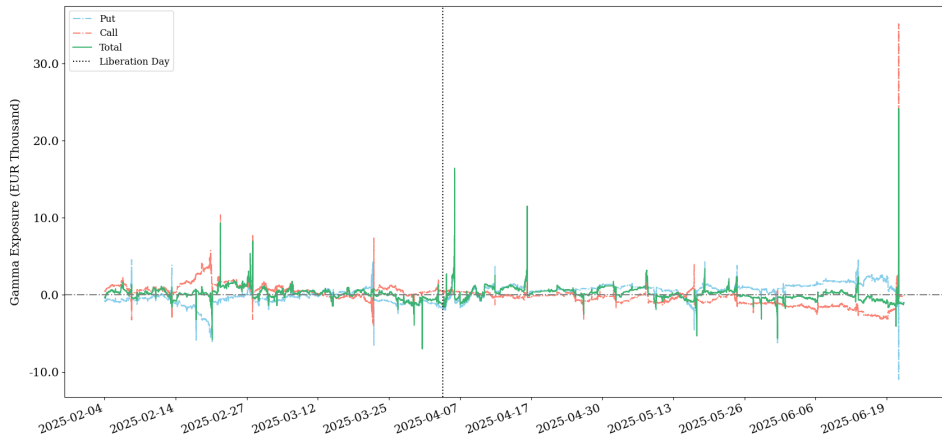
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Figure: Aggregated (second-order) directional exposure of MMs active on the Euro STOXX 50 options and futures market for the period 2025-02-04/2025-06-20 on the minute level

Vomma Hedging (Second-Order Volatility Effect)

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Figure: Aggregated (second-order) volatility exposure of MMs active on the Euro STOXX 50 options and futures market for the period 2025-02-04/2025-06-20 on the minute level

Vanna Hedging (Cross Effect)

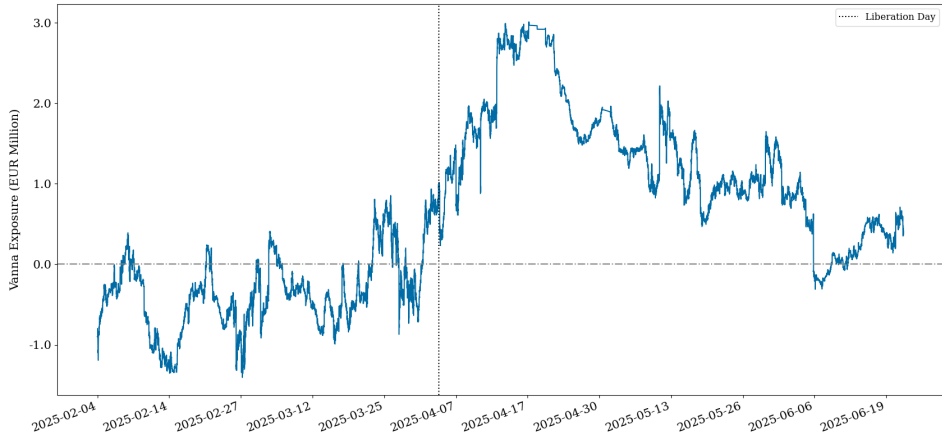
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Figure: Aggregated sensitivity of delta towards volatility of MMs active on the Euro STOXX 50 options and futures market for the period 2025-02-04/2025-06-20 on the minute level

Who Benefits from Capital Market Integration in a Monetary Union?

Naomi Cohen

Copenhagen Business School

ESMA Research Conference, September 2026

- [Mundell \(1961\)](#): monetary unions require **risk-sharing** to absorb asymmetric shocks.
- Limited **risk-sharing** $\Rightarrow$ the euro area exposed to asymmetric shocks: e.g. sovereign crisis.
- **Capital market integration** as a substitute: **foreign equity = insurance against domestic shocks**.
- **Classic prediction**: deeper integration smooths consumption and stabilizes the union.
- **But in practice**: households and countries differ sharply in **participation** and **portfolios**.

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$\hookrightarrow$ When an asymmetric shock hits, who actually benefits from financial integration?

- Revisit Mundell's risk-sharing mechanism when **households and portfolios are heterogeneous**.

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- **Two dimensions of heterogeneity, jointly:**
 - **Within countries:** unequal financial participation $\Rightarrow$ Savers vs. Non-Savers.
 - **Between countries:** asymmetric portfolios $\Rightarrow$ **Core** vs. **Periphery**.

- Revisit Mundell's risk-sharing mechanism when **households and portfolios are heterogeneous**.
- **Two dimensions of heterogeneity, jointly:**
 - **Within countries:** unequal financial participation $\Rightarrow$ Savers vs. Non-Savers.
 - **Between countries:** asymmetric portfolios $\Rightarrow$ **Core** vs. **Periphery**.
- **Three complementary approaches:**
 - **Empirics:** document heterogeneity in financial participation and portfolios in the euro area.
 - **Theory:** isolate the channels in a tractable two-country monetary union model.
 - **Quantification:** quantify the channels in a full heterogeneous-agent framework.

Preview of Results

- Integration does smooth shocks **between** countries... but also increases inequality **within** them.

Preview of Results

- Integration does smooth shocks **between** countries... but also increases inequality **within** them.
- ① **Diversification channel:** portfolio composition → average exposure to shocks.
 - Foreign assets **insure** households against domestic income shocks.
 - Shocks are spread across countries through **financial income**.
 - **Benefits Savers** and **reduces between-country inequality** ⇒ confirms Mundell prediction.

Preview of Results

- Integration does smooth shocks **between** countries... but also increases inequality **within** them.
- ① **Diversification channel**: portfolio composition → average exposure to shocks.
 - Foreign assets **insure** households against domestic income shocks.
 - Shocks are spread across countries through **financial income**.
 - **Benefits Savers** and **reduces between-country inequality** ⇒ confirms Mundell prediction.
- ② **(New) Reallocation channel**: portfolio reshuffling → flexibility to adjust portfolio after shocks.
 - **Capital flows away** from the country hit by a negative shock.
 - **Amplifies downturns and real wage losses** for all households in the shocked economy.
 - **Hurts Non-Savers** and **raises within-country inequality** ⇒ challenges Mundell prediction.

- **Cluster** in two groups reflecting pre-crisis imbalances in 2010: [▶ PCA, K-min, Rob.](#) [▶ Lit.](#) [▶ Pre-crisis imb.](#)
 - **Core**: Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands.
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 - **Within**: **Core** became uniformly wealthier; **Periphery** became more unequal, as the bottom fell behind. [▶ More](#)
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- **Two integration dimensions** that help explain these facts:
 - **Within:** in 2010, 43% of **Core** hhs. held no financial assets (excl. deposits) vs. 67% in the **Periphery**. [▶ More](#)
 - **Between:** from 2010 to 2021, **Core** home bias stayed at 87% vs. fell from 85% to 76% in the **Periphery**. [▶ More](#)

Theory: Model with Two Countries & Two Household Types

- Two countries in a monetary union: **Core** and **Periphery**.
 - Consumption of domestic and foreign goods with import share. [▶ Preferences](#)
 - Flexible prices and nominal wage rigidity through unions. [▶ Production](#) [▶ Unions](#)
 - Common monetary policy. [▶ Taylor rule](#)
- **Within countries: heterogeneous agents** $\Rightarrow$ unequal portfolio exposure. [▶ Agent Maximisation](#)
 - **Non-Savers:** labor income only.
 - **Savers:** labor and financial income via a mutual fund.
- **Between countries: domestic risk-neutral mutual fund** $\Rightarrow$ country-specific portfolios.
 - **Savers** choose how much to save in equity and in union bonds.
 - Mutual fund collects **Savers'** equity and allocates it between domestic vs. foreign capital.

Theory: Key Equations

- Aggregate production & Technology:

$$Y_t^i = Z_t^i \left(K_{t-1}^i\right)^\alpha \left(L_t^i\right)^{1-\alpha}, \quad Z_t^i = Z_0^i e^{-u_t^i}, \quad u_t^i = \rho^i u_{t-1}^i + \epsilon_t^i, \quad \rho^i \in (0, 1)$$

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- Portfolio: [Lit.](#) [Portfolio determination](#)

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- Return composition:

$$\underbrace{r_t^i E_{t-1}^i}_{\text{Portfolio gross return}} = (r_t^{K,i} + 1 - \delta^i) K_{i,t-1}^i + (r_t^{K,j} + 1 - \delta^j) K_{i,t-1}^j S_t - \underbrace{\frac{\kappa^i}{2} \left(\frac{K_{i,t-1}^i}{E_{t-1}^i} - \zeta^i \right)^2}_{\text{Portfolio adjust. costs to steady-state deviations}} E_{t-1}^i$$

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- Capital market integration channels:

- Diversification:** average exposure to shocks $\Rightarrow$ domestic portfolio share: $\zeta^i = \frac{\bar{K}_i^i}{E^i}$.
- Reallocation:** flexibility to reshuffle after shocks $\Rightarrow$ adjustment costs to ζ^i deviations: κ^i .

Three Integration Cases

- **How does capital market integration shape shock transmission and inequality?**
 - **TANK**: two-agent framework, Savers and Non-Savers, with constant share.
 - **Symmetric countries**: identical structures of wage rigidity, 30% import share, 50% Savers.
 - **Asymmetric shock**: 1% negative technology shock in the **Periphery only** (MIT shock).

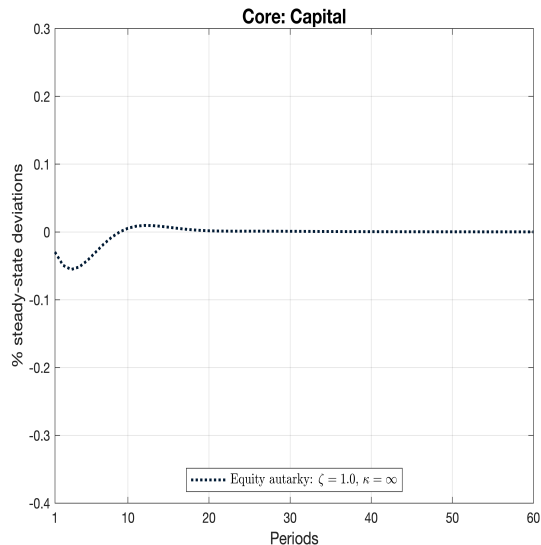
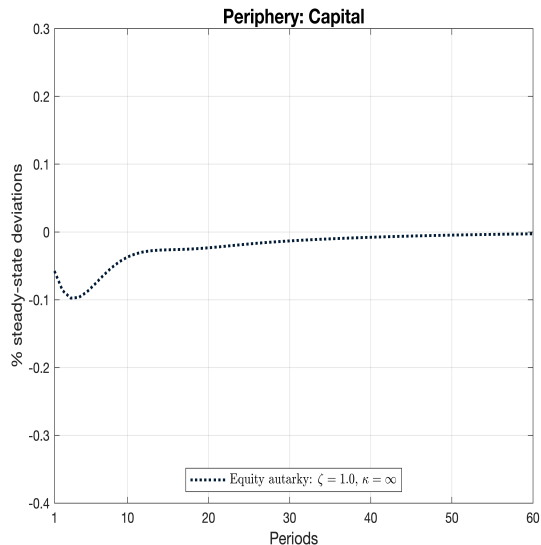
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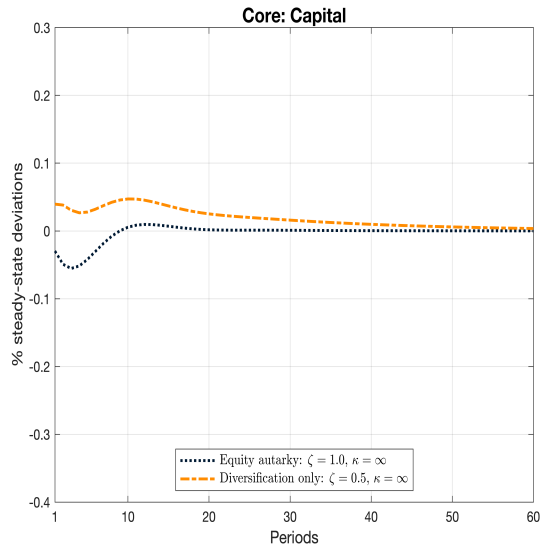
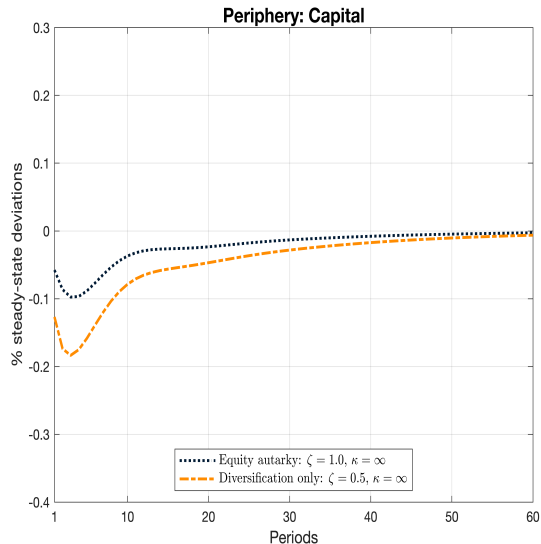
Case	ζ (domestic portfolio share)	κ (portfolio adjustment cost)
Equity autarky	1.0 (full home bias)	∞
Diversification only	0.5	∞
Capital market integration	0.5	0.1

► Calibration

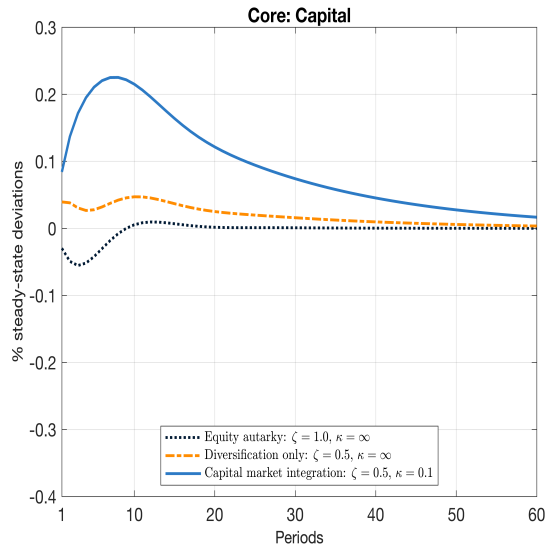
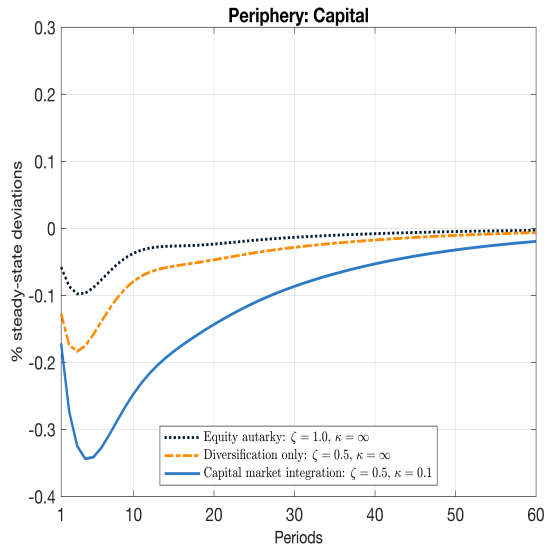
Equity Autarky: Capital Falls in Both Countries



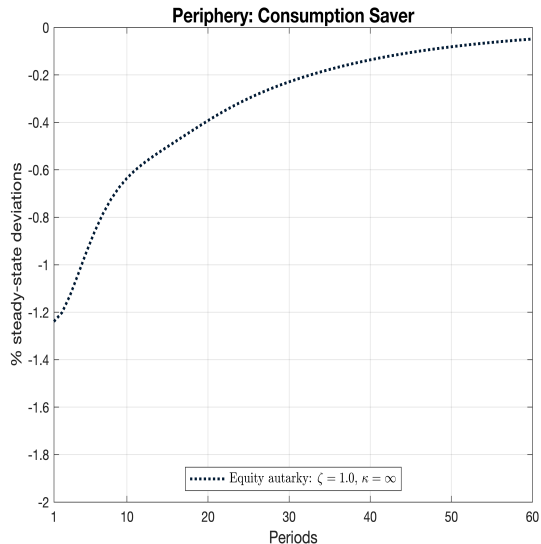
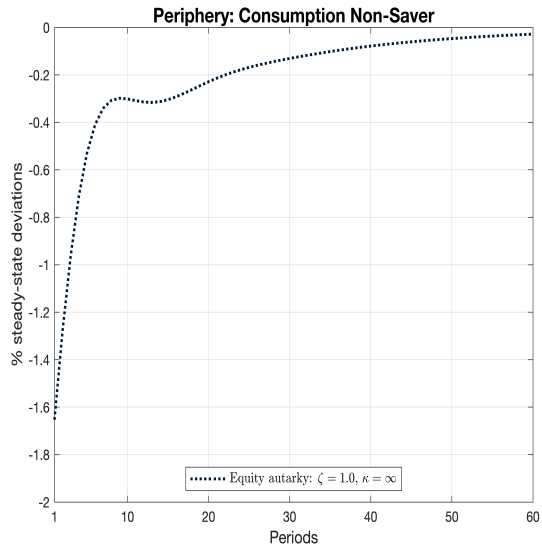
Diversification Only: Capital Moves in Opposite Directions



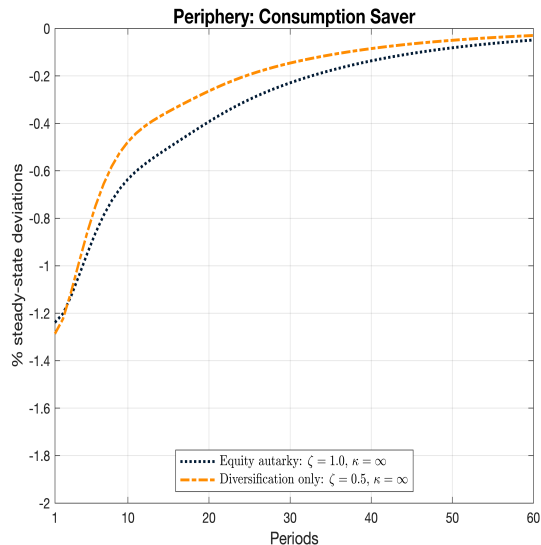
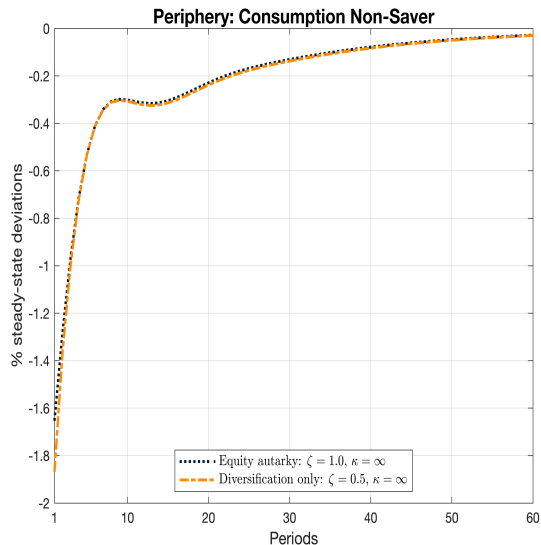
Full Integration: Reallocation Amplifies Asymmetry



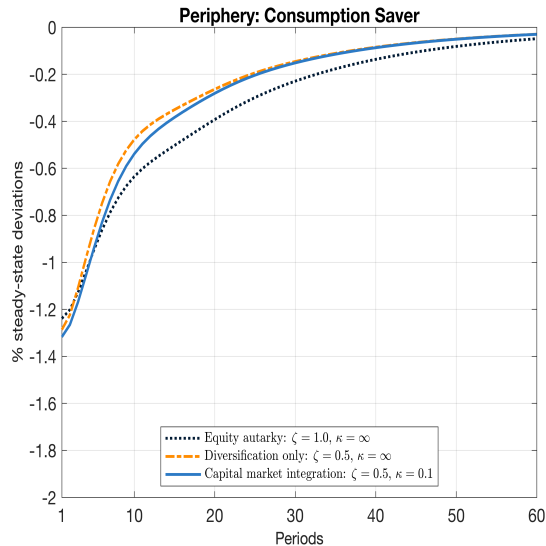
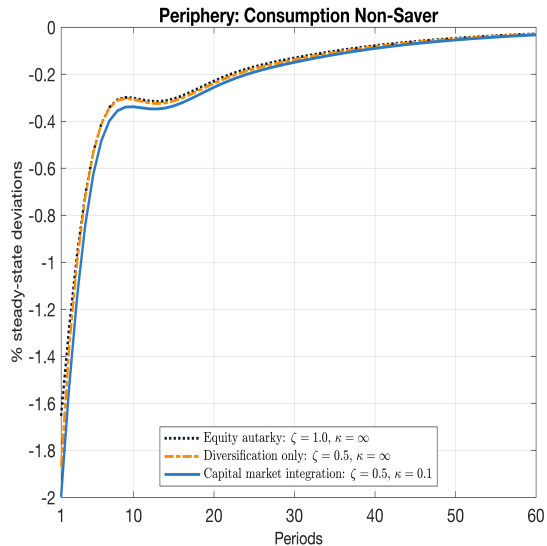
Periphery: Both Groups Fall Together Under Autarky



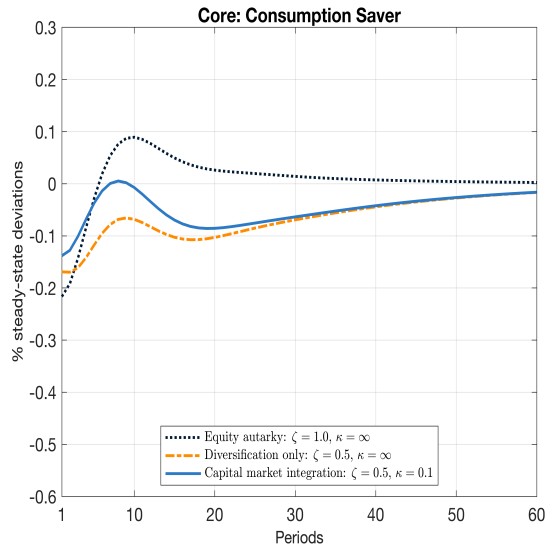
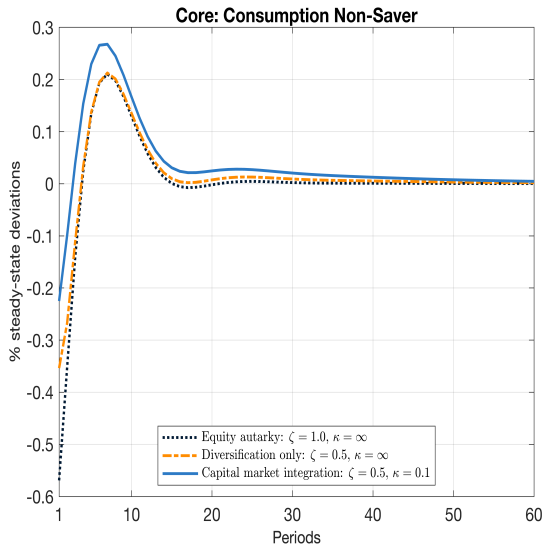
Periphery: Diversification Cushions Savers, Not Non-Savers



Periphery: Reallocation Deepens Non-Saver Losses



Core: Similar Mechanisms, Opposite Direction



► More variables

- Calibrate a **HANK model** to **2010 euro-area data**: portfolio shares and financial participation
 - Idiosyncratic income risk generates endogenous financial participation. [▶ Risk](#) [▶ Tightening](#) [▶ Switchers](#)
 - **Core** capital remains close to steady-state, while **Periphery** capital collapsed. [▶ HANK results](#)
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↪ **Which matches the two empirical stylized facts.**

Conclusion

- **Financial vs. labor income** through two key channels of capital market integration:
 - **Diversification** enables **Savers** to smooth shocks via portfolios, stabilizing the union.
 - Capital **reallocation** shifts adjustment to real wages for all hhs. but mainly hurting **Non-Savers**.
- Affects both **within-country** and **between-country** inequality.
- **Policy implications**: deeper integration has potential benefits, but must address:
 - **within-country unequal exposure**, leading to unequal distribution of gains.
 - **between-country home bias**, which may amplify cross-country heterogeneity.
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- **Agenda**: tractable framework to analyze inequality and capital flows in any bilateral setting.
 - ↪ Next step: Euro area/United States. ▶ Portfolio Share ▶ Portfolio Value ▶ Liabilities Share ▶ Liabilities Value

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Thank you!

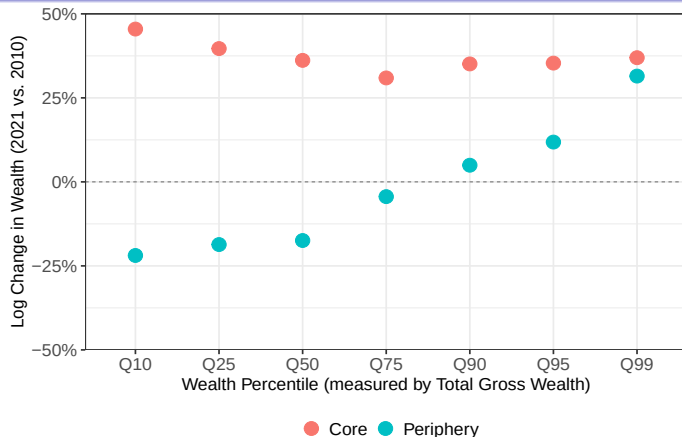
Appendix

Contributions

- **Household heterogeneity and macro transmission:** introduces **cross-border portfolio heterogeneity**, linking within-country inequality to international capital allocation ([Kaplan et al. 2018](#); [de Ferra et al. 2020](#); [Auclert et al. 2021](#); [Oskolkov 2023](#); [Guo et al. 2023](#); [Bayer et al. 2024](#); [Acharya & Challe 2025](#)).
- **International risk sharing and portfolio diversification:** shows that with **heterogeneous participation**, financial integration no longer stabilizes all households equally ([van Wincoop 1999](#); [Obstfeld & Rogoff 2001](#); [Heathcote & Perri 2013](#); [Coeurdacier & Rey 2013](#); [Corsetti et al. 2008](#); [Auray & Eyquem 2014](#); [Farhi & Werning 2017](#); [Senay & Sutherland 2019](#); [Cimadomo et al. 2020](#)).
- **Capital flows, portfolio rebalancing and the euro area:** quantifies how **portfolio structures and participation gaps** drive asymmetric adjustment ([Mundell 1961](#); [Lane 2012](#); [Blanchard et al. 2017](#); [Rey 2015](#); [Broner et al. 2014](#); [Caballero et al. 2017](#); [Maggiori 2017](#); [Almgren et al. 2022](#); [Martín Fuentes et al. 2023](#); [Ferrari & Rogantini Picco 2023](#); [Davis & van Wincoop 2024](#); [Beck et al. 2024](#)).

- Cluster data for 2010: [▶ More](#)
 - GDP per capita - Eurostat,
 - Net International Investment Position (NIIP) - Eurostat,
 - Current account (% of GDP) - ECB and Eurostat.
- Cluster methodology: two-step approach
 - Principal Component Analysis (PCA): reduce dimensionality, capture main cross-country variation.
 - K-means: 2 clusters, 50 random starts for robustness.
- Robustness checks:
 - Adding on top: market capitalization (% GDP, CEIC & WFE), equity return (ECB), portfolio domestic share (author's), number of investment partners (author's), openness (% GDP, Eurostat). [▶ More](#)
 - Adding on top: unemployment rate (age 15-74, % labor force, Eurostat), financial account (% GDP, ECB), real GDP growth (Q4/Q4, 2009-2010). [▶ More](#)
 - Subsample: EA members in 2010 only (excl. Estonia, Latvia, Lithuania). [▶ More](#) [▶ More: Robust. 1](#) [▶ More: Robust. 2](#)
- Additional exercise: replication with 2021 data. [▶ More](#) [▶ More: Robust. 1](#) [▶ More: Robust. 2](#)

Stylized Fact 1: Diverging Wealth Distributions



- In 2010 (resp. 2021), 97% (97%) of EA wealth inequality is due to within-country differences. [▶ More](#)
- Core has become uniformly richer, Periphery has become more unequal $\Rightarrow$ divergence at the bottom.

▶ Corr. Net/Gross

▶ Years

▶ Values x Years

▶ Full x Years

▶ Countries x Years

▶ Countries x Full x Years

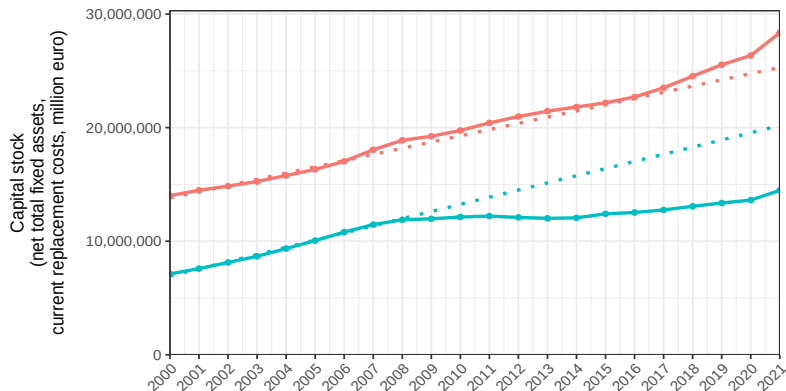
▶ Financial wealth

▶ Excl. housing

▶ Equiv. percentiles

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Stylized Fact 2: Diverging Capital Stocks



• Group pre-crisis (2000–2007, linear) trend — Core — Periphery

- In 2010 (2021), Periphery was 9pp (50pp) below Core relative to their pre-crisis trend.

► Gross

► Housing (Net)

► Housing (Gross)

► Capital stock x Equity stock

► Ratios

► Countries

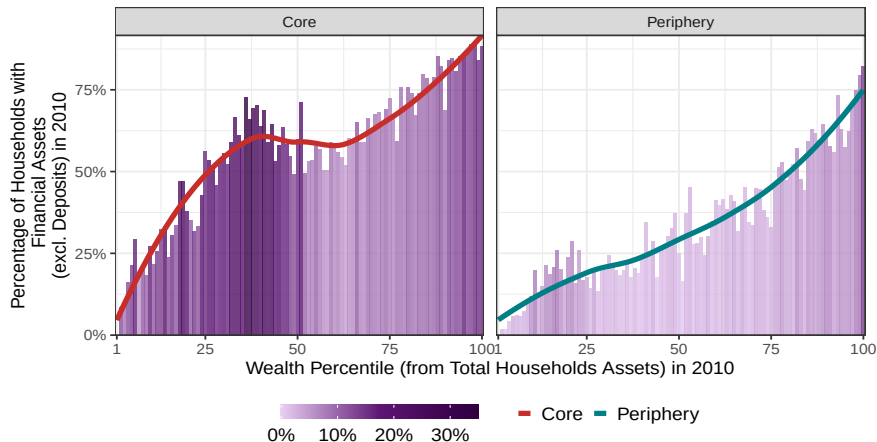
► Countries x Gross Equity Liabilities

► Fixed scale

► Average corr.

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Poor households are less financialized, especially in Periphery



- Extensive (curve): in 2010, 43% of Core hhs. had no financial assets (excl. deposits) vs. 67% in Periphery.
- Intensive (light to dark): in 2010, financial assets averaged 14% of wealth in Core vs. 4% in Periphery.

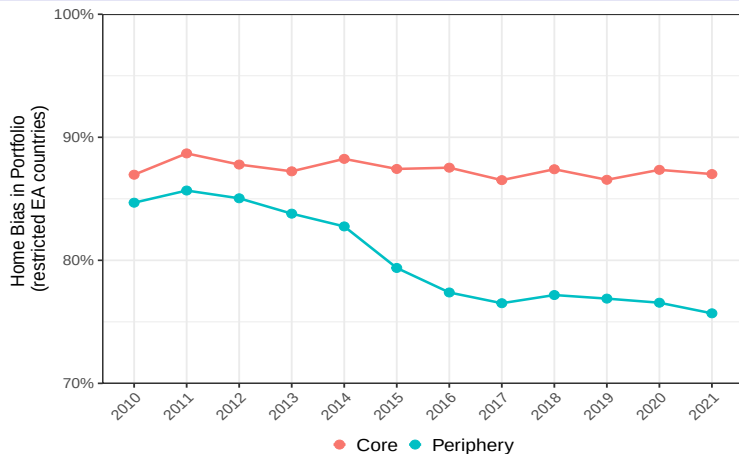
► [Wealth decomposition](#)

► [\(Limited\) Evidence of diversification](#)

► [Alternative extensive margin](#)

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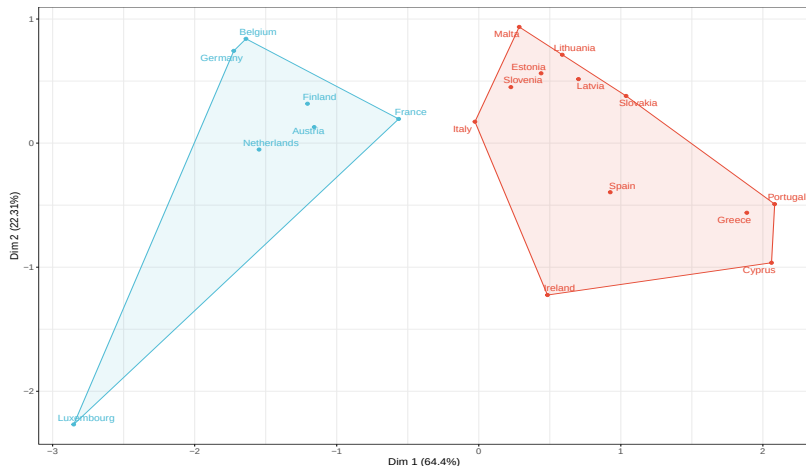
Diversification remains limited, especially in Core



- Equity Home Bias: $1 - \frac{\text{Share of Foreign Equities in Country } i \text{ Equity Holdings}}{\text{Share of Foreign Equities in the World Market Portfolio}}$ (0 = optimally diversified, 1 = full equity home bias).
- In 2010 (2021), home bias is 87% (87%) in Core vs. 85% (76%) in Periphery.

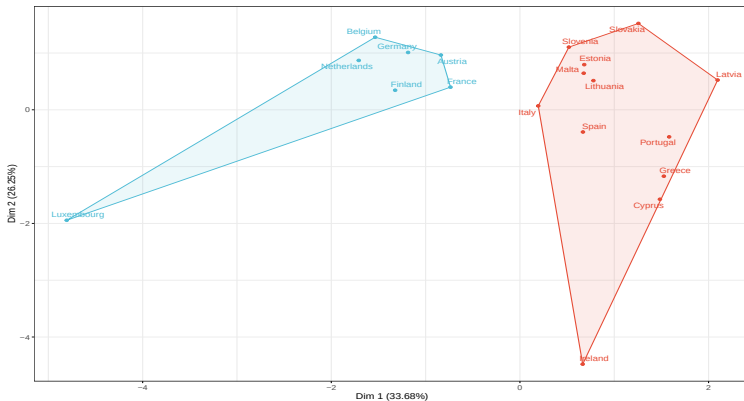
[► With RoW](#)[► Dom. share](#)[► Dom. share with RoW](#)[► Countries](#)[► Countries with RoW](#)[► Portfolios & Liabilities](#)[► Financial analysis](#)[Go back: Empirics Summary](#)

Cluster for 2010



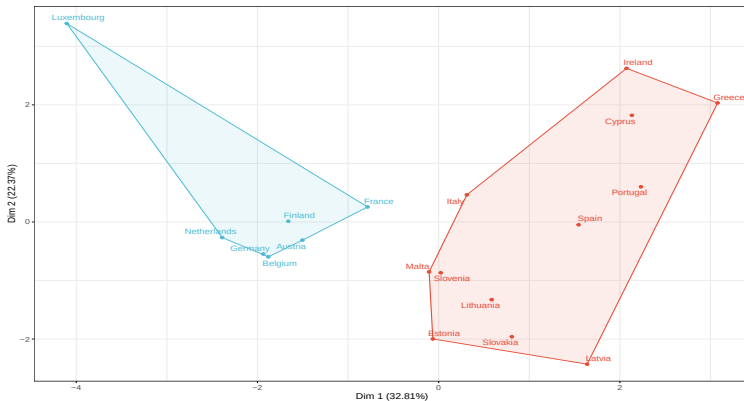
- Contributions to Dimension 1 (% of total): CA/GDP (38.7%), NIIP (33.7%), GDP per capita (27.6%).
- Contributions to Dimension 2 (% of total): GDP per capita (66.1%), NIIP (31.2%), CA/GDP (2.71%).

Cluster Robustness 1 for 2010



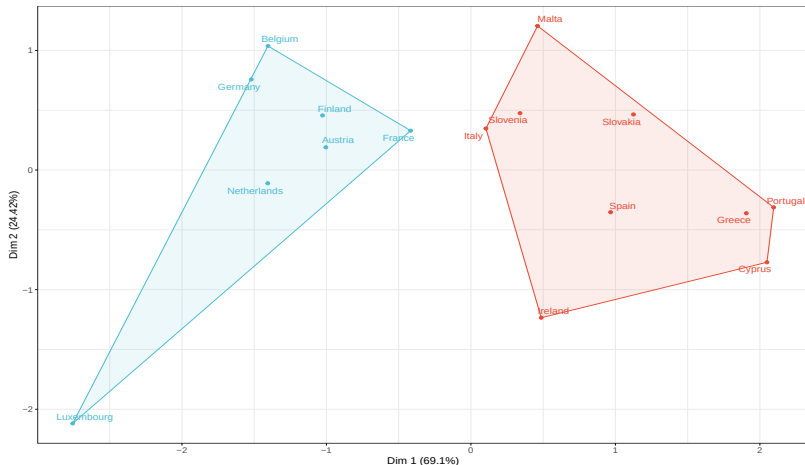
- Contributions to Dimension 1 (% of total): GDP per capita (29.9%), Market Cap/GDP (26.9%), CA/GDP (17.9%), NIIP (15.9%), Number of Investment Partners (5.1%), Domestic Share (2.5%), Equity Return (1.3%), Openness (0.5%).
- Contributions to Dimension 2 (% of total): Domestic Share (34.7%), Equity Return (24.2%), NIIP (14.5%), Openness (13.7%), GDP per capita (7.1%), CA/GDP (3.3%), Market Cap/GDP (2.4%), Number of Investment Partners (0.1%).

Cluster Robustness 2 for 2010



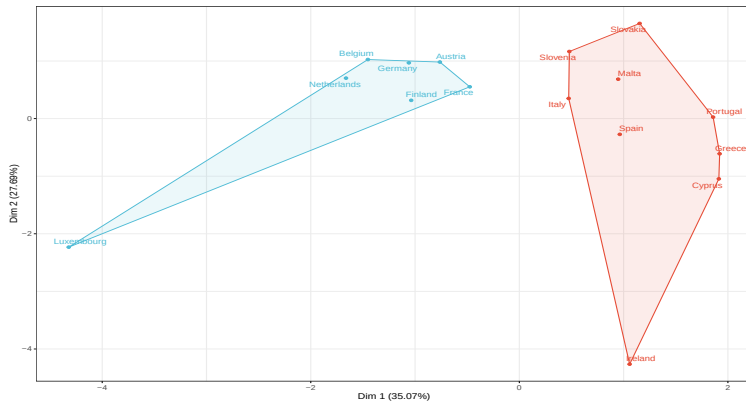
- Dim. 1: NIIP (18.3%), CA/GDP (18.0%), FA/GDP (14.6%), GDP per capita (13.0%), Market Cap/GDP (12.4%), Unempl. (10.7%), Real GDP (4.5%), Openness (3.1%), Equity Return (3.0%), Nbr. of Invest. (2.6%), Domestic Share (0.0%).
- Dim. 2: Domestic Share (24.2%), GDP per capita (19.1%), Openness (13.1%), FA/GDP (8.1%), Real GDP (7.1%), Unempl. (5.6%), Nbr. of Invest. (3.9%), Equity Return (3.8%), Market Cap/GDP (11.3%), NIIP (2.0%), CA/GDP (1.8%).

Cluster for 2010 (EA members in 2010 only)



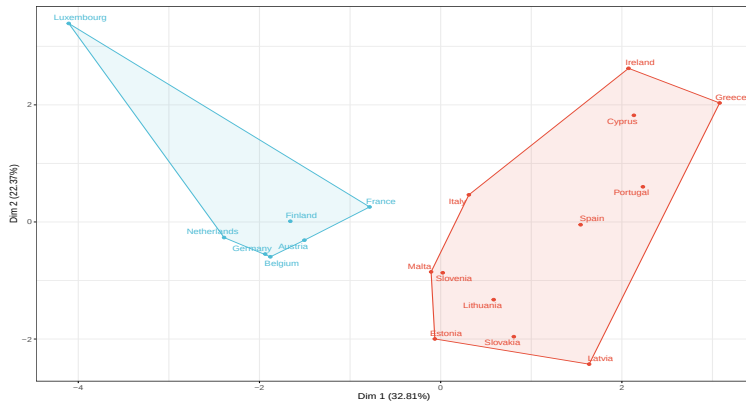
- Contributions to Dimension 1 (% of total): CA/GDP (42.9%), NIIP (29.3%), GDP per capita (27.8%).
- Contributions to Dimension 2 (% of total): GDP per capita (52.7%), NIIP (47.3%), CA/GDP (0.0%).

Cluster Robustness 1 for 2010 (EA members in 2010 only)



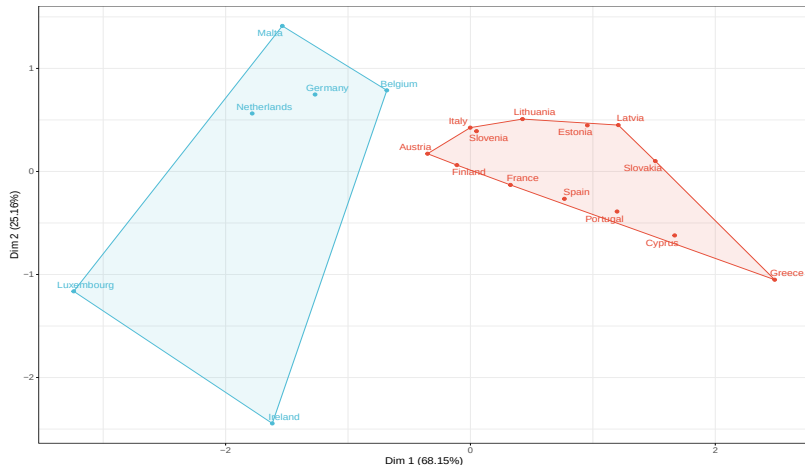
- Contributions to Dimension 1 (% of total): CA/GDP (27.1%), GDP per capita (26.5%), Market Cap/GDP (22.7%), NIIP (15.7%), Openness (3.2%), Nbr. of Invest. Partners (3.1%), Portf. Dom. Share (0.6%), Equity Return (1.1%).
- Contributions to Dimension 2 (% of total): Portf. Dom. Share (37.8%), Equity Return (26.3%), NIIP (12.6%), GDP per capita (9.6%), Openness (8.8%), Market Cap/GDP (3.6%), Nbr. of Invest. Partners (1.0%), CA/GDP (0.4%).

Cluster Robustness 2 for 2010 (EA members in 2010 only)



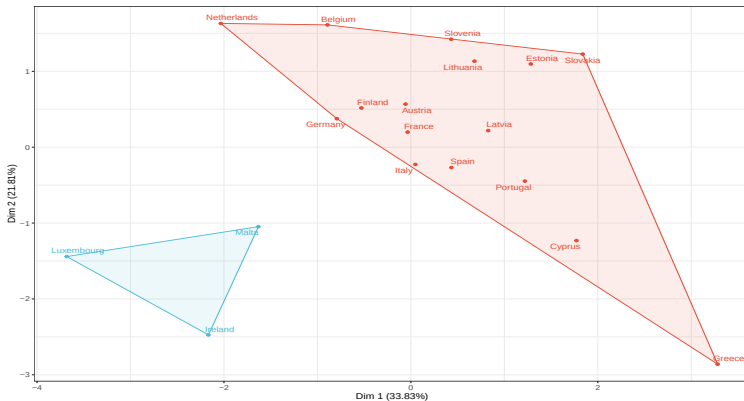
- Dim. 1: NIIP (18.3%), CA/GDP (18.0%), FA/GDP (14.6%), GDP per capita (13.0%), Market Cap/GDP (12.4%), Unempl. (10.7%), Real GDP (4.5%), Openness (3.1%), Equity Return (3.0%), Nbr. of Invest. (2.6%), Dom. Share (0.0%).
- Dim. 2: Dom. Share (24.2%), GDP per capita (19.1%), Openness (13.1%), Market Cap/GDP (11.3%), FA/GDP (8.1%), Real GDP (7.1%), Unempl. (5.6%), Nbr. of Invest. (3.9%), Equity Return (3.8%), NIIP (2.0%), CA/GDP (1.8%).

Cluster for 2021



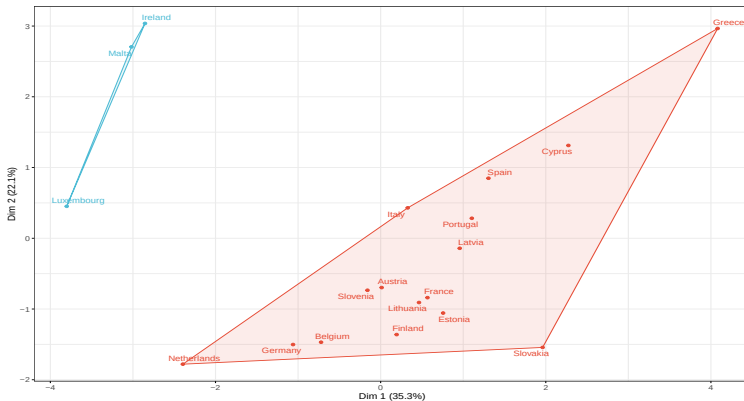
- Contributions to Dimension 1 (% of total): CA/GDP (43.1%), GDP per capita (32.9%), NIIP (23.9%).
- Contributions to Dimension 2 (% of total): NIIP (64.6%), GDP per capita (34.7%), CA/GDP (0.7%).

Cluster Robustness 1 for 2021



- Contributions to Dimension 1 (% of total): CA/GDP (31.2%), GDP per capita (25.7%), NIIP (15.7%), Portfolio Domestic Share (10.6%), Market Cap/GDP (9.1%), Equity Return (6.1%), Openness (0.9%), Nbr. of Investment Partners (0.7%).
- Contributions to Dimension 2 (% of total): Openness (31.9%), Equity Return (28.3%), NIIP (16.0%), Portfolio Domestic Share (10.7%), GDP per capita (5.4%), Nbr. of Investment Partners (5.2%), Market Cap/GDP (2.1%), CA/GDP (0.5%).

Cluster Robustness 2 for 2021



- Dim. 1: CA/GDP (23.1%), FA/GDP (21.2%), GDP per capita (14.6%), NIIP (11.9%), Unempl. (11.5%), Portf. Dom. Share (7.6%), Equity Return (4.3%), Market Cap/GDP (3.1%), Real GDP (1.4%), Nbr. of Invest. (1.4%), Openness (0.1%).
- Dim. 2: Real GDP (28.0%), Openness (16.0%), Equity Return (14.2%), Nbr. of Invest. (13.2%), NIIP (9.2%), Portf. Dom. Share (7.1%), Unempl. (5.5%), Market Cap/GDP (4.8%), FA/GDP (0.9%), GDP per capita (0.7%), CA/GDP (0.6%).

Core-Periphery in the Literature (1/2)

- Very similar clusters:

- Cimadomo et al. (2018), Kaufmann et al. (2020), Comunale & Mongelli (2021), Ferrari & Rogantini Picco (2023), Martín Fuentes et al. (2023), Gatti et al. (2024), Mazzocchi & Tamborini (2019), Alesina et al. (2017).
- **Core**: Austria, Belgium, Finland, France, Germany, Luxembourg, Netherlands;
- **Periphery**: Greece, Ireland, Italy, Portugal, Spain.

- Slightly different clusters:

- Bayoumi & Eichengreen (1992, 1997), Artis & Zhang (1997-2002); Giannone et al. (2010), Makarski et al. (2013), Eggertsson et al. (2014), Gaulier & Vicard (2012), Hülsewig & Rottmann (2022), Botta et al. (2018), Engler et al. (2014), Gros (2012), Jaumotte & Sodsriwiboon (2010), Hale & Obstfeld (2016), Pasch & Tervala (2024).
- **Core**: Germany, France, Austria, Belgium, Netherlands (+ sometimes Italy, Finland, Luxembourg, Ireland);
- **Periphery**: Spain, Portugal, Greece, Italy, Ireland (+ sometimes UK, Cyprus, Malta, Slovenia).

- More geographic approach:

- Chisiridis, Mouratidis & Panagiotidis (2018).
- **North-East Area**: Austria, Belgium, Finland, Germany, Netherlands;
- **South-East Area**: Greece, Italy, Portugal, Spain.

Core-Periphery in the Literature (2/2)

- Alternative clusters:

- Campos & Macchiarelli (2021):

- **Hard Core**: Austria, Belgium, Germany, Netherlands;
 - **Soft Core**: France, Italy, Denmark, Spain, United Kingdom;
 - **Extended Periphery**: Greece, Sweden, Finland, Ireland, Norway, Portugal, Switzerland.

- Bayoumi & Eichengreen (1997):

- **Rapidly converging**: Germany, Austria, Belgium, the Netherlands, Ireland and Switzerland;
 - **Little convergence**: United Kingdom, Denmark, Finland, Norway and France;
 - **Gradually converging**: Sweden, Italy, Greece, Portugal and Spain.

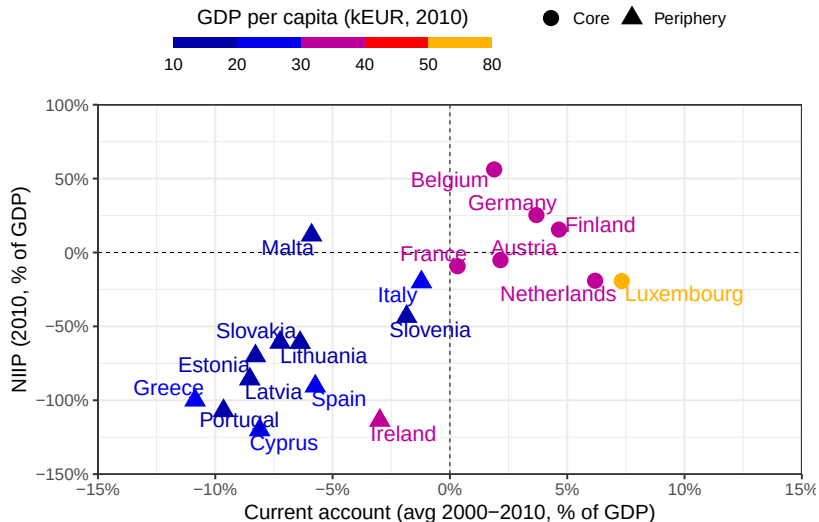
- Artis & Zhang (1997-2002):

- **Core**: Germany, France, Austria, Belgium, Netherlands;
 - **Northern Periphery**: Denmark, Ireland, United Kingdom, Switzerland, Sweden, Norway, Finland;
 - **Southern Periphery**: Spain, Italy, Portugal, Greece.

- Gräbner & Hafele (2020): Four-cluster structure

- **Core**: Austria, Belgium, Denmark, Finland, France, Germany, Sweden;
 - **Periphery**: Cyprus, Greece, Italy, Portugal, Spain;
 - **Catch-Up**: Bulgaria, Romania, Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Slovenia, Slovakia;
 - **Finance**: Luxembourg, Netherlands, Malta, Ireland.

Pre-crisis imbalances in 2010

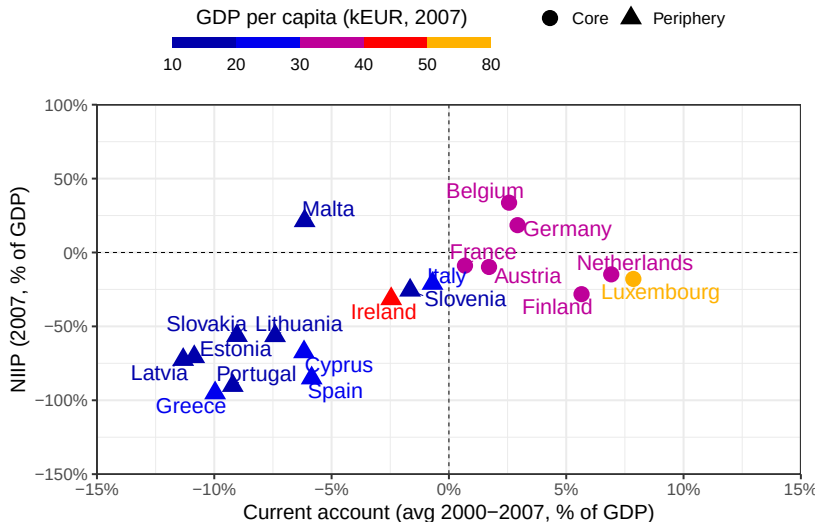


► Pre-crisis imbalances in 2007

► Financial account: net positions (since 2008)

Go back: Empirics

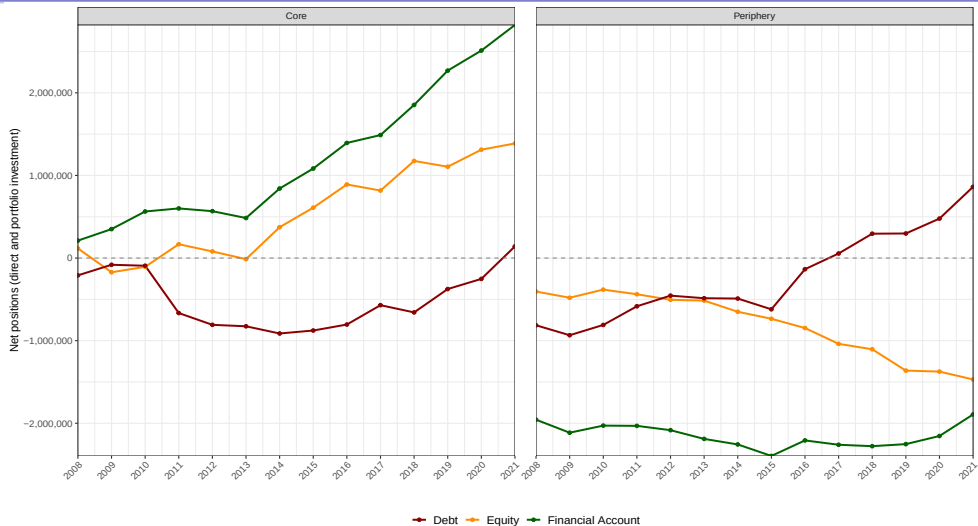
Pre-crisis imbalances in 2007



[Go back: Pre-crisis imbalances in 2010](#)

[Go back: Empirics](#)

Financial account: net positions (since 2008)



[Go back: Pre-crisis imbalances in 2010](#)

[Go back: Empirics](#)

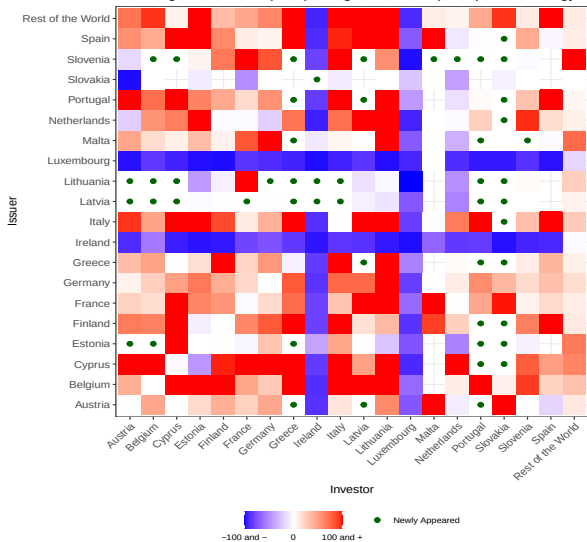
Augmented and corrected CPIS

- Coordinated Portfolio Investment Survey (CPIS) from the IMF (USD),
- Augmented with domestic holdings:
 - Listed shares and investment fund shares from the European System of Central Banks (ESCB),
 - Converted to end-of-year USD for comparability,
 - Linearly retropolated for 2010-2011.
- [Beck et al. \(2024\)](#) correction (Netherlands, Ireland and Luxembourg):
 - Replace with corrected values when available,
 - Implement most used method: additive (shift from 0) or multiplicative (coefficient change),
 - Adjust 2010-2011 using 2014-2015 estimates; adjust 2021 using 2019-2020 estimates.

► [Average correction](#)

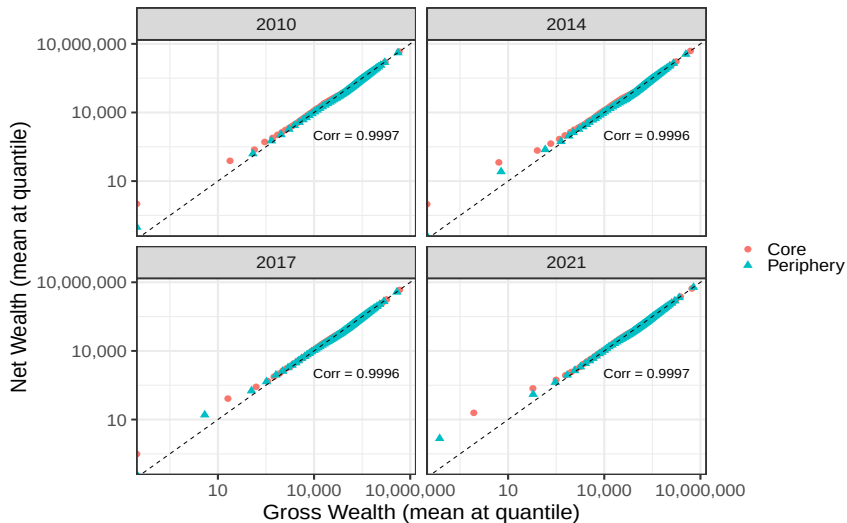
[Go back: Empirics](#)

Average Correction (in %) using Beck et al. (2024) methodology

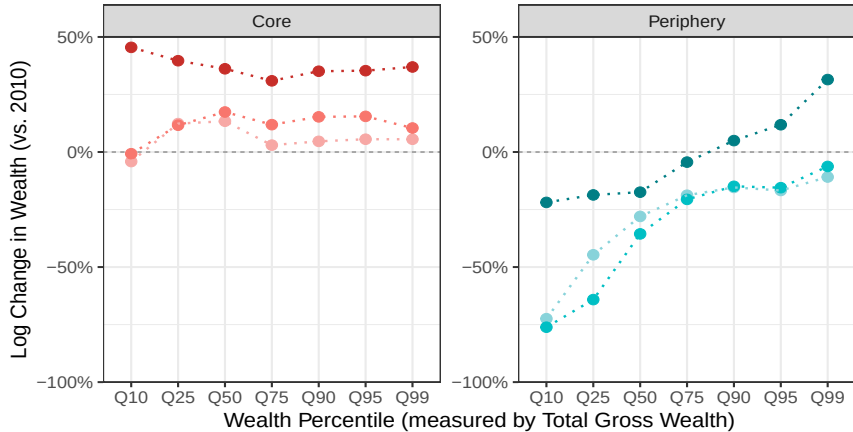


[Go back: Empirics](#)

Correlation Net/Gross Wealth

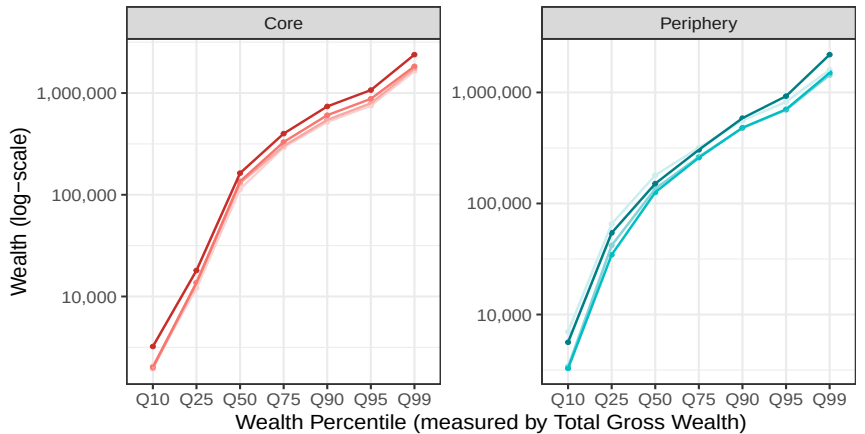


Wealth distributions x Years



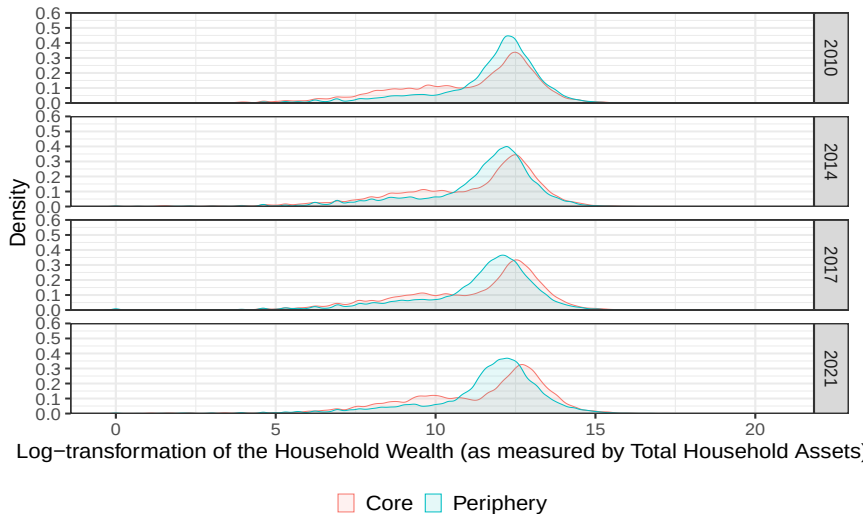
Core.2014 Core.2017 Core.2021
Periphery.2014 Periphery.2017 Periphery.2021

Values x Years

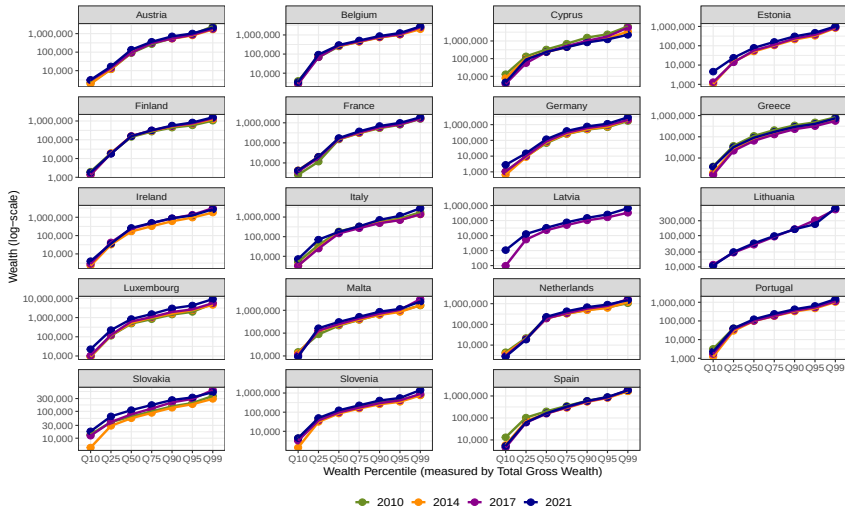


Core.2010 Core.2014 Core.2017 Core.2021
Periphery.2010 Periphery.2014 Periphery.2017 Periphery.2021

Full wealth distribution x Years

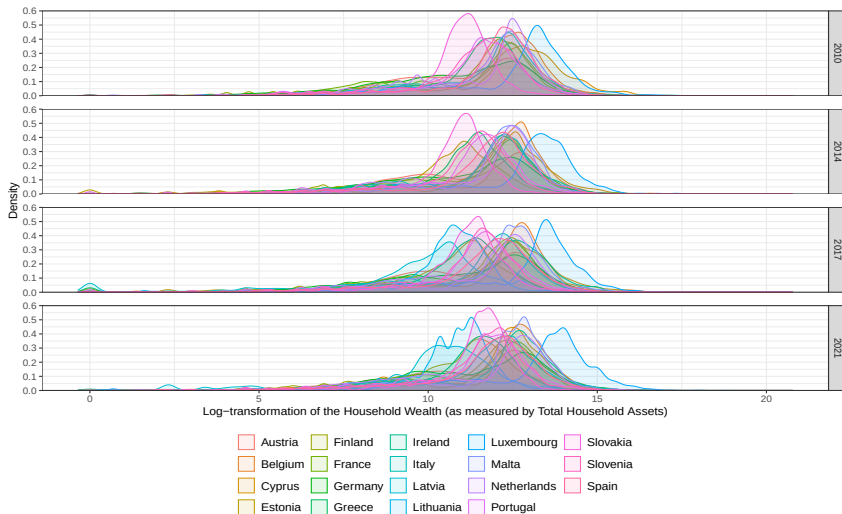


Countries x Wealth distrib. x Years



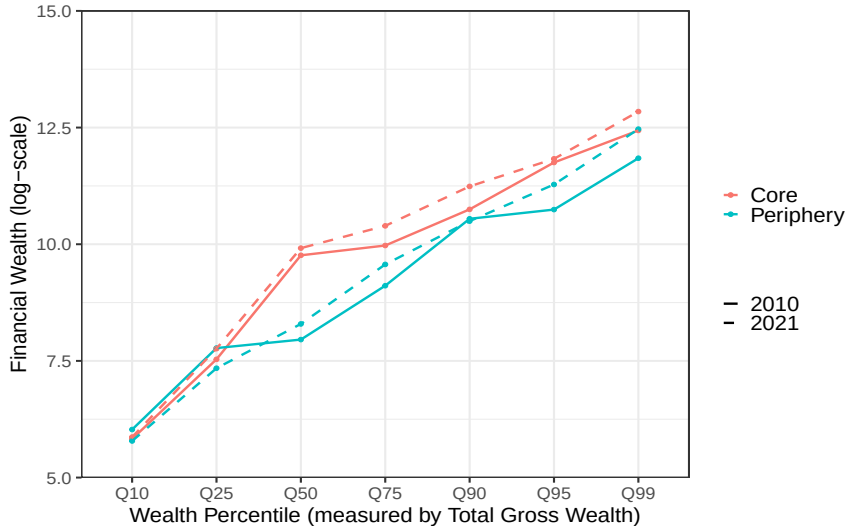
[Go back: Wealth distrib.](#)

Countries x Full wealth distrib. x Years



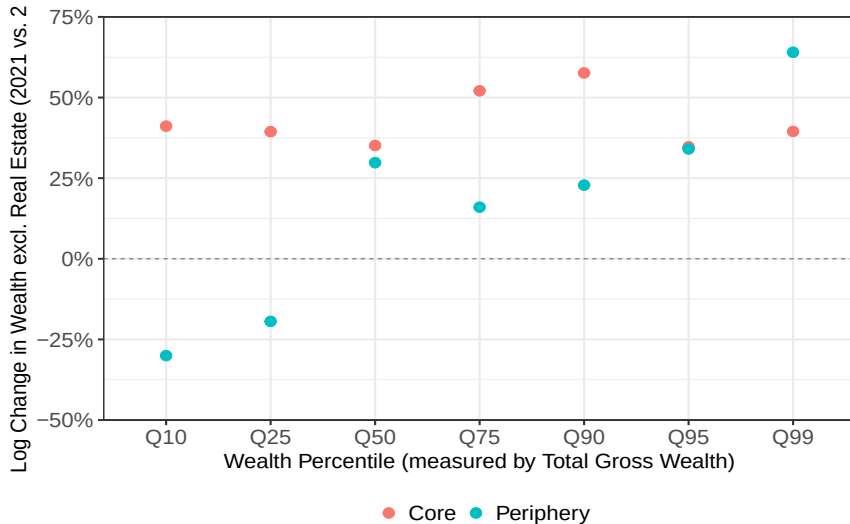
[Go back: Wealth distrib.](#)

Financial wealth

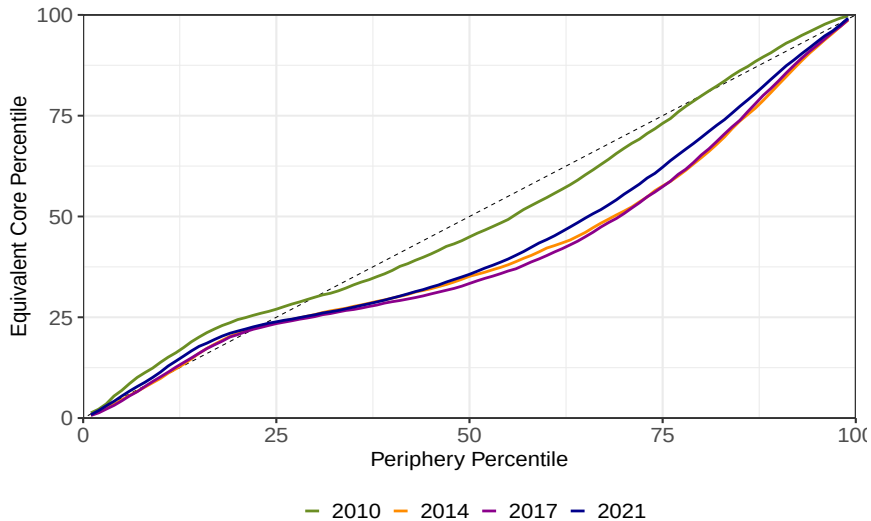


[Go back: Wealth distrib.](#)

Wealth excluding real estate

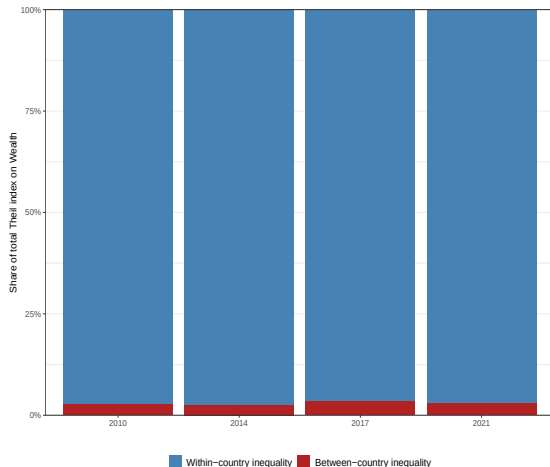
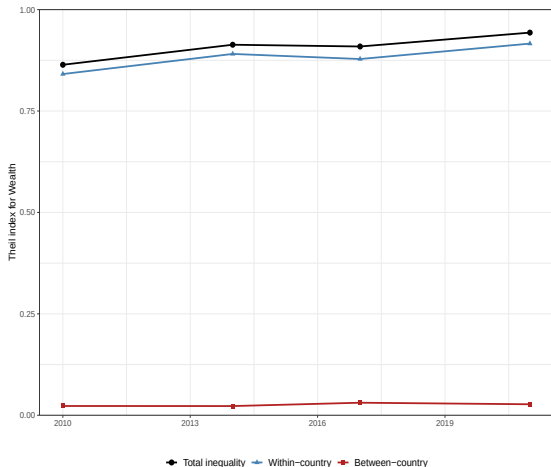


Equivalent percentiles of wealth



[Go back: Wealth distrib.](#)

Wealth inequality is (almost only) within countries



- In 2010 (resp. 2021), 97.4% (97.1%) of Euro area wealth inequality is due to within-country differences.

► Income

► Group x Wealth

► Group x Income

► $\text{Log(wealth)/Log(income)}$

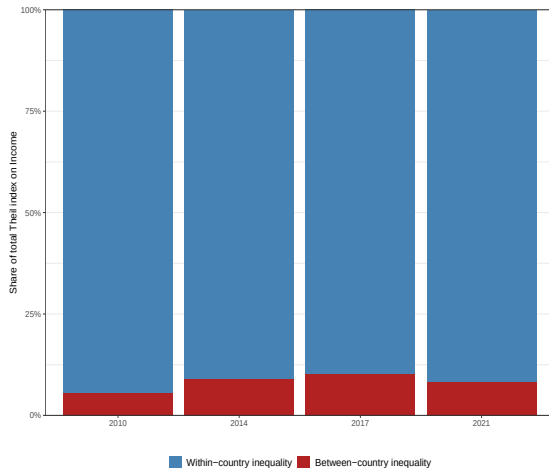
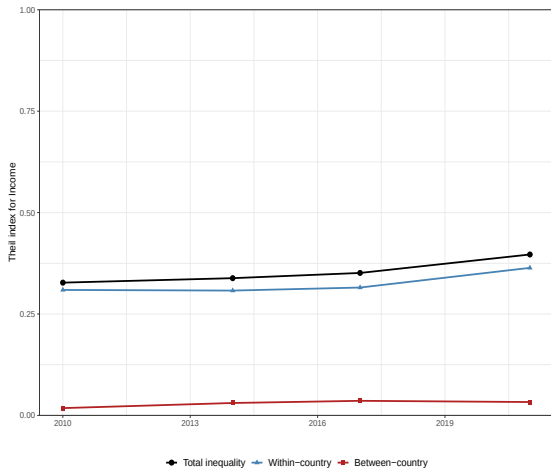
► $\text{Log(wealth)/Log(income)} \times \text{Years}$

► $\text{Countries} \times \text{Log(wealth)/Log(income)}$

► $\text{Countries} \times \text{Log(wealth)/Log(income)} \times \text{Years}$

Go back: Wealth distrib.

Theil Index x Income



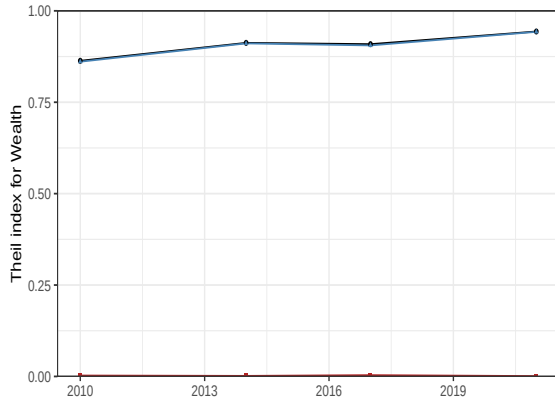
- Theil index: 91.7% of Euro area income inequality is due to within-country differences.

[Go back: Theil index wealth](#)

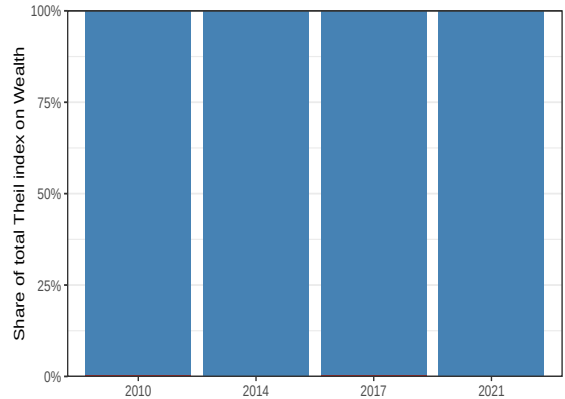
[Go back: Wealth distrib.](#)

[Go back: Stylized facts \(Summary\)](#)

Group x Theil Index x Wealth



◆ Total inequality ◆ Within-country ◆ Between-country



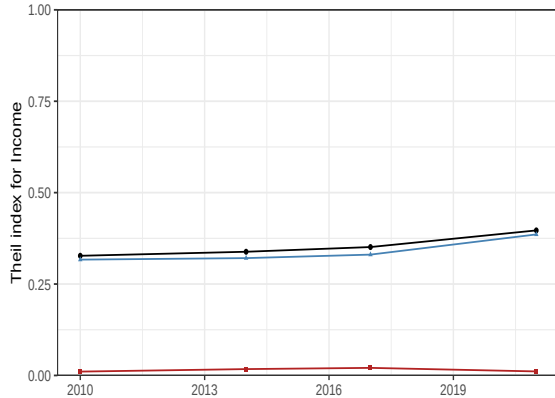
■ Within-country inequality ■ Between-country inequality

[Go back: Theil index wealth](#)

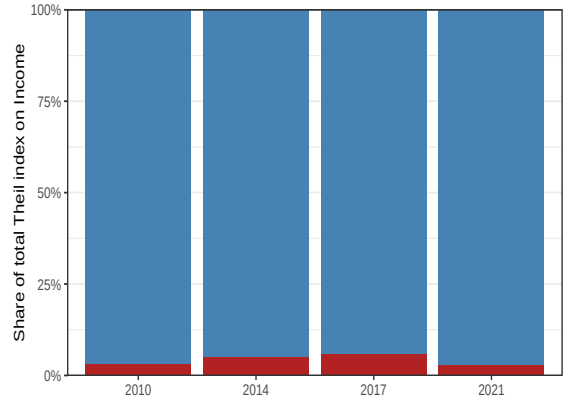
[Go back: Wealth distrib.](#)

[Go back: Stylized facts \(Summary\)](#)

Group x Theil Index x Income



◆ Total inequality ◆ Within-country ◆ Between-country



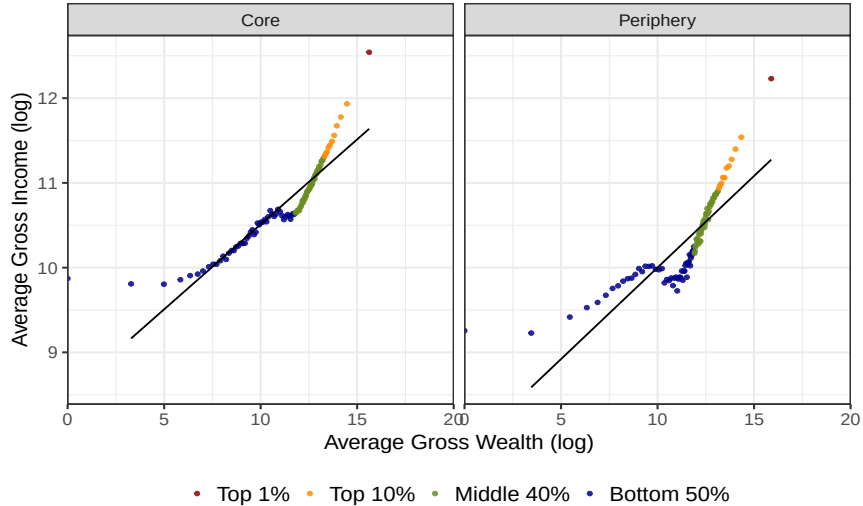
■ Within-country inequality ■ Between-country inequality

[Go back: Theil index wealth](#)

[Go back: Wealth distrib.](#)

[Go back: Stylized facts \(Summary\)](#)

$\text{Log(Wealth)}/\text{Log(Income)}$

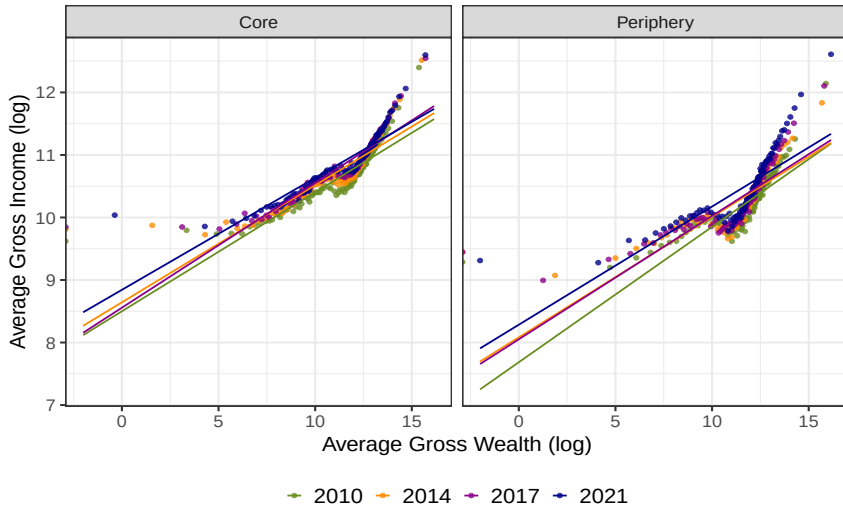


[Go back: Theil index wealth](#)

[Go back: Wealth distrib.](#)

[Go back: Stylized facts \(Summary\)](#)

$\text{Log(Wealth)}/\text{Log(Income)} \times \text{Years}$

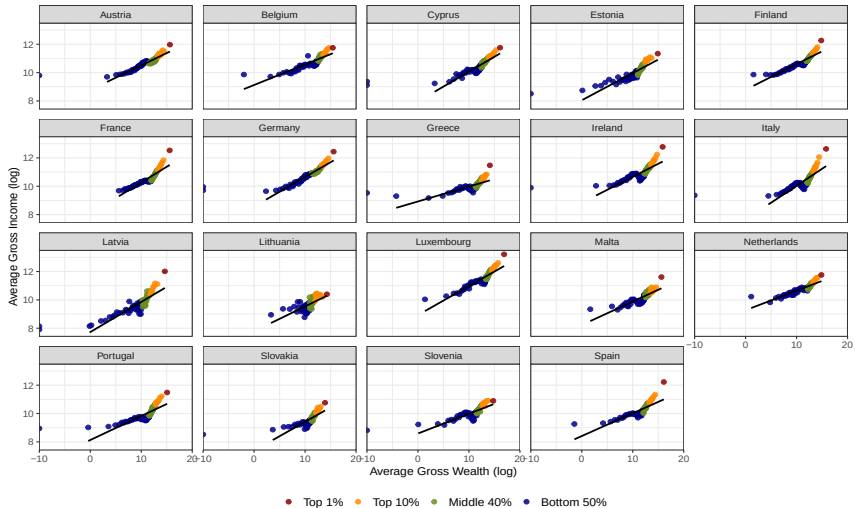


[Go back: Theil index wealth](#)

[Go back: Wealth distrib.](#)

[Go back: Stylized facts \(Summary\)](#)

Countries x Log(Wealth)/Log(Income)

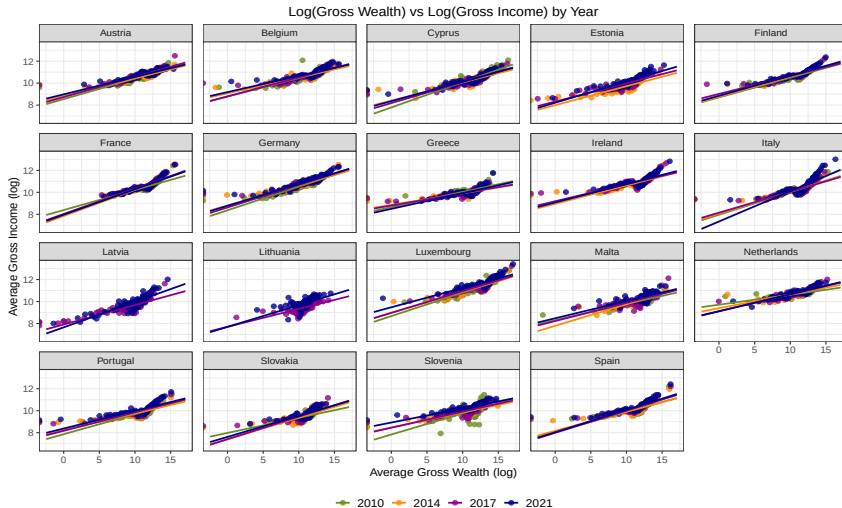


[Go back: Theil index wealth](#)

[Go back: Wealth distrib.](#)

[Go back: Stylized facts \(Summary\)](#)

Countries x Log(Wealth)/Log(Income) x Years



[Go back: Theil index wealth](#)

[Go back: Wealth distrib.](#)

[Go back: Stylized facts \(Summary\)](#)

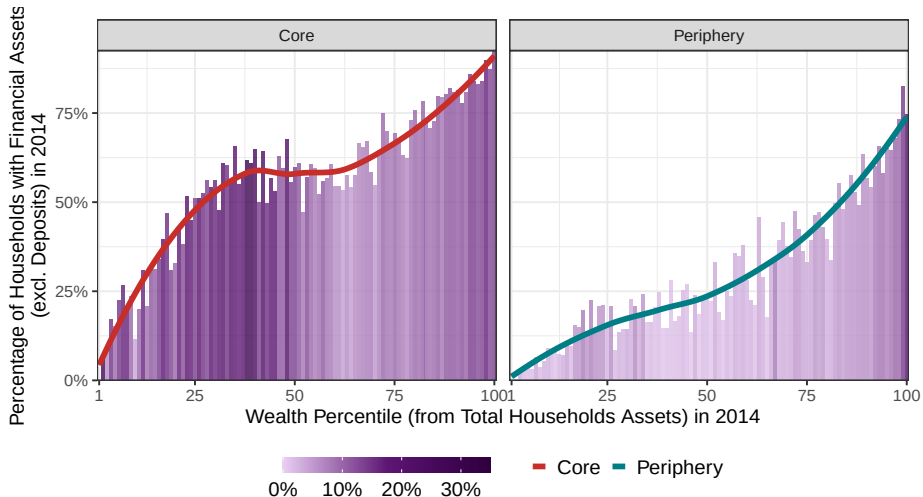
Wealth decomposition

- Financialization [▶ 2014](#) [▶ 2017](#) [▶ 2021](#)
- Wealth decomposition [▶ 2010](#) [▶ 2014](#) [▶ 2017](#) [▶ 2021](#)
- Wealth decomposition (detailed) [▶ More details \(2010\)](#) [▶ More details \(2014\)](#) [▶ More details \(2017\)](#) [▶ More details \(2021\)](#)
- Countries x Wealth decomposition [▶ By country \(2010\)](#) [▶ By country \(2014\)](#) [▶ By country \(2017\)](#) [▶ By country \(2021\)](#)
- Countries x Wealth decomposition (detailed)
[▶ By country \(detailed\) \(2010\)](#) [▶ By country \(detailed\) \(2014\)](#) [▶ By country \(detailed\) \(2017\)](#) [▶ By country \(detailed\) \(2021\)](#)

[Go back: Financialization](#)

[Go back: Stylized facts \(Summary\)](#)

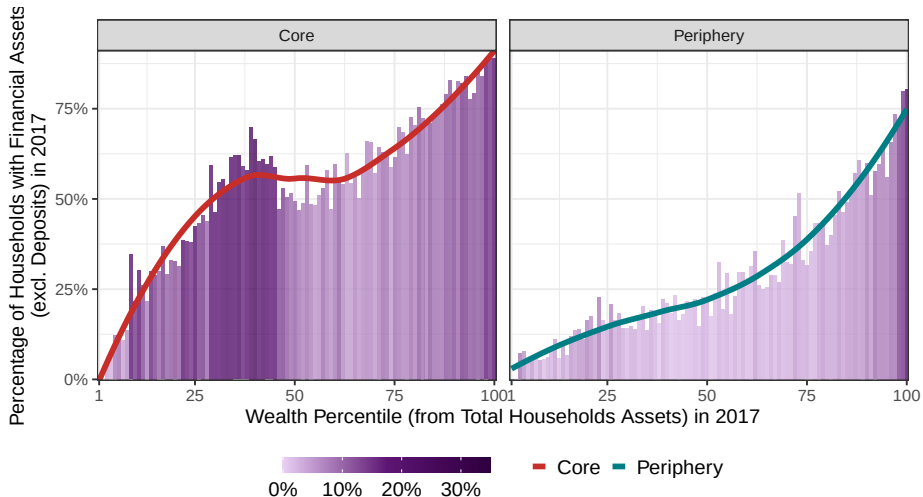
Financialization (2014)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

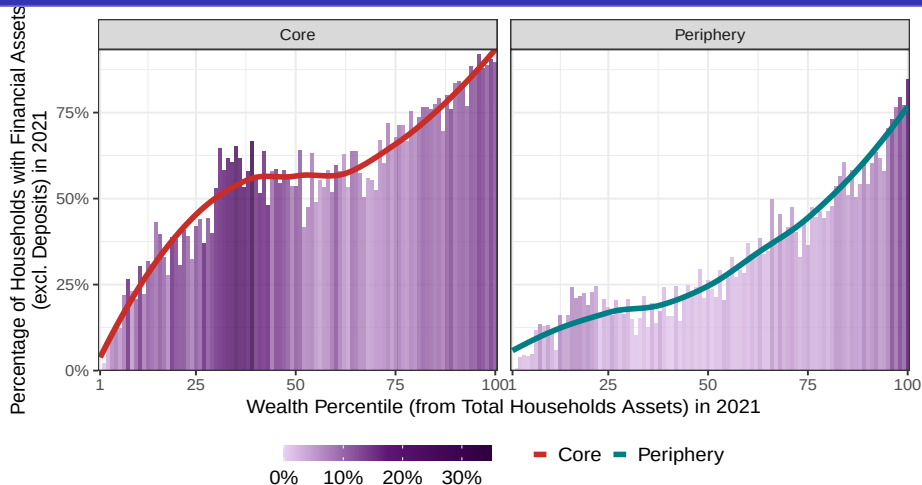
Financialization (2017)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

Financialization (2021)

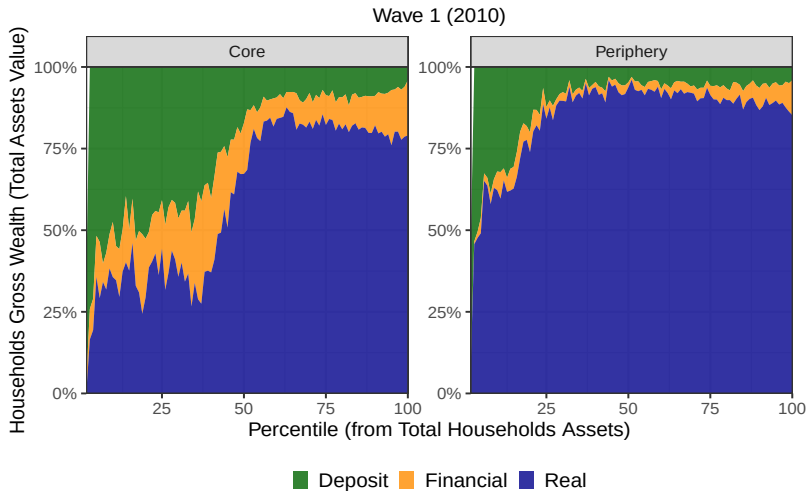


- Intensive (light to dark): in 2021, financial assets averaged 11.7% of wealth in Core vs. 4.5% in Periphery.
- Extensive (curve): in 2021, 45% of Core hhs. had no financial assets (excl. deposits) vs. 68% in Periphery.

[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

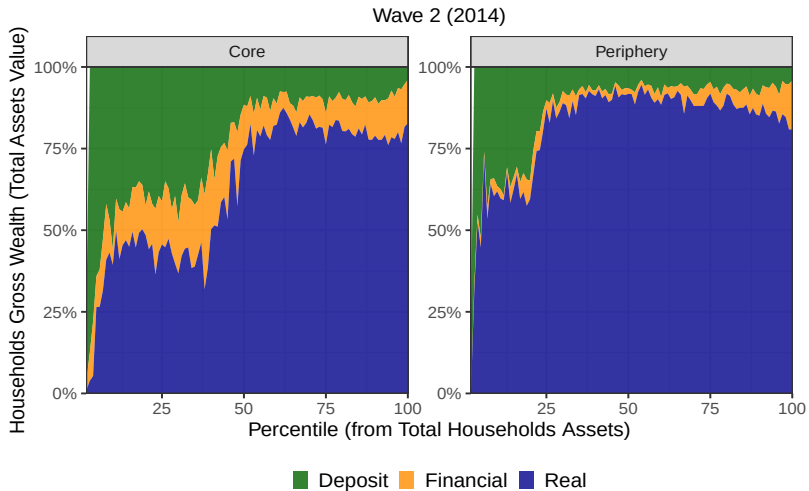
Wealth decomposition (2010)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

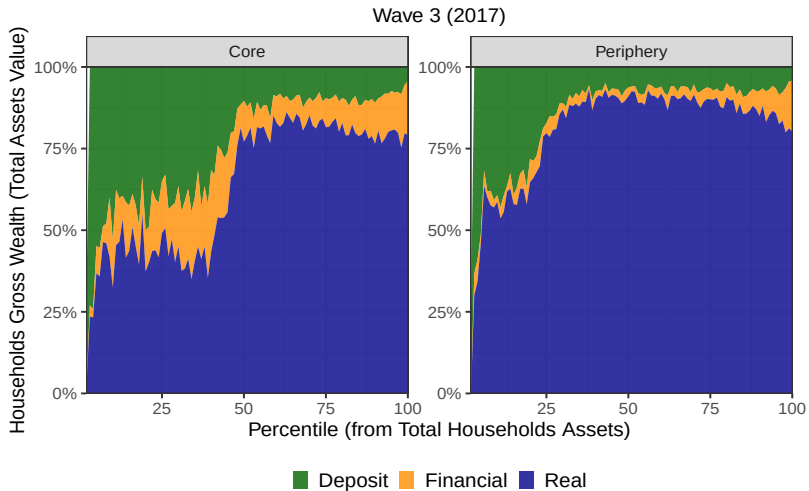
Wealth decomposition (2014)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

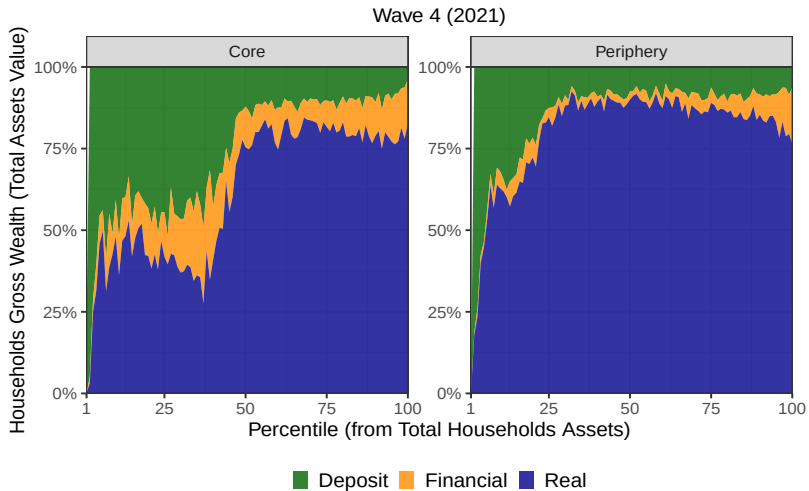
Wealth decomposition (2017)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

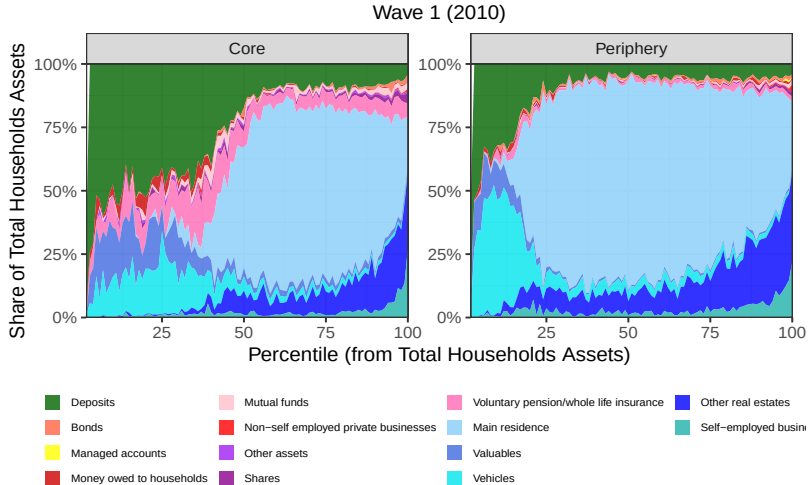
Wealth decomposition (2021)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

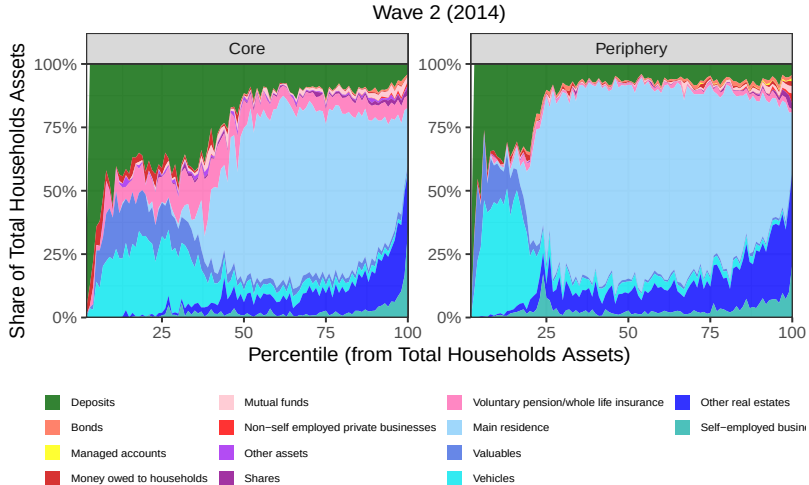
Wealth decomposition (detailed, 2010)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

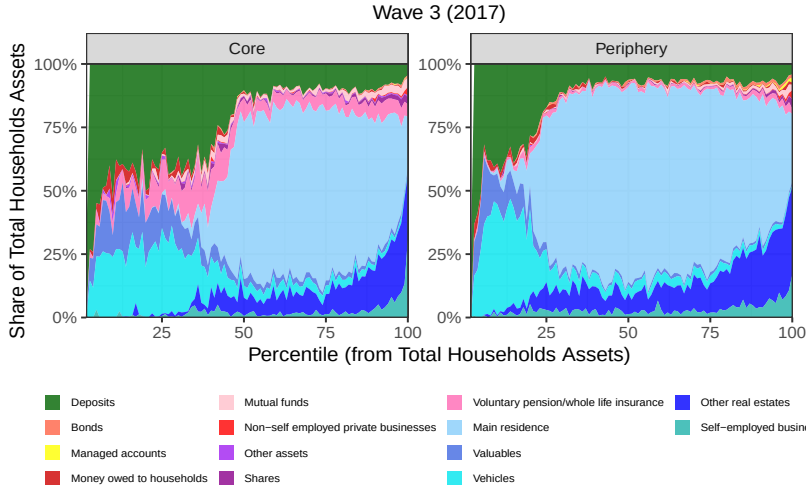
Wealth decomposition (detailed, 2014)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

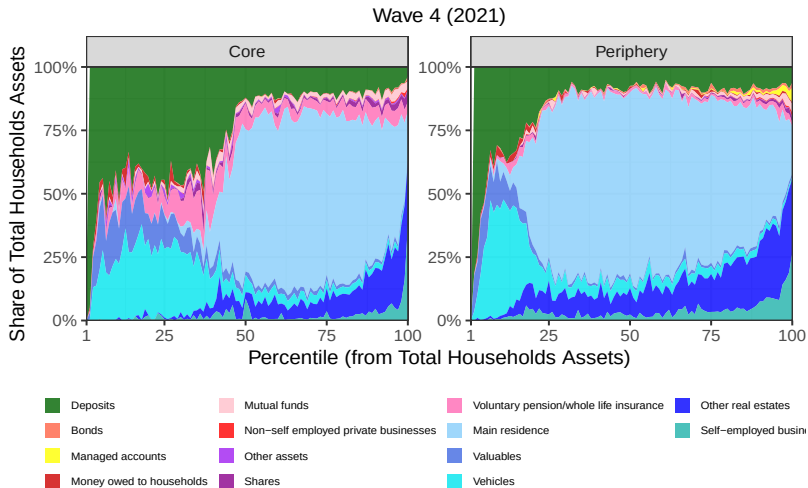
Wealth decomposition (detailed, 2017)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

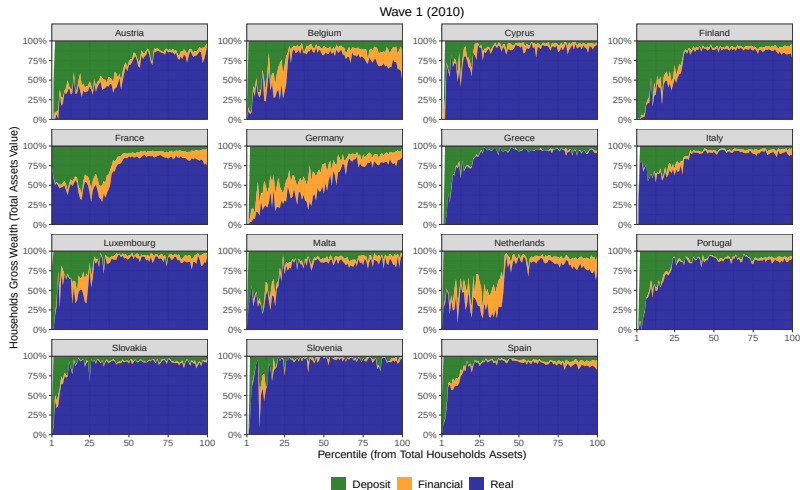
Wealth decomposition (detailed, 2021)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

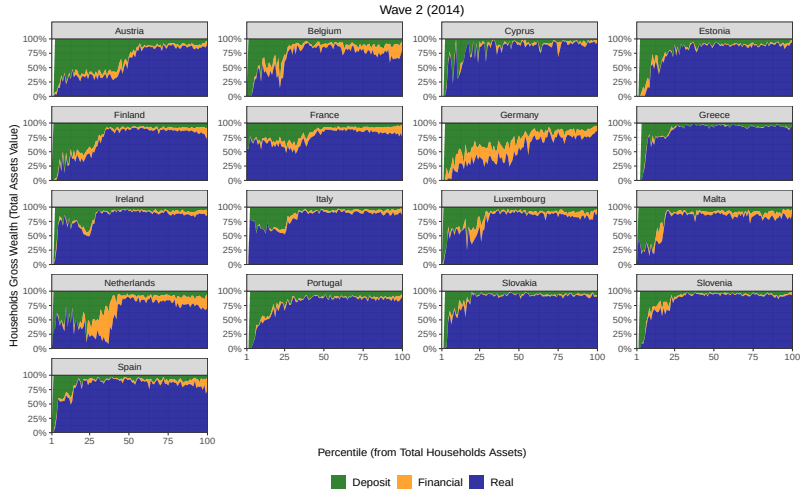
Countries x Wealth decomposition (2010)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

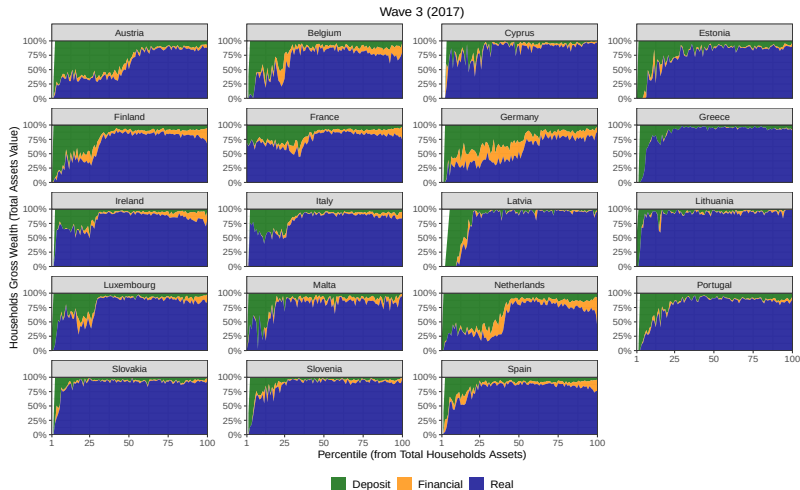
Countries x Wealth decomposition (2014)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

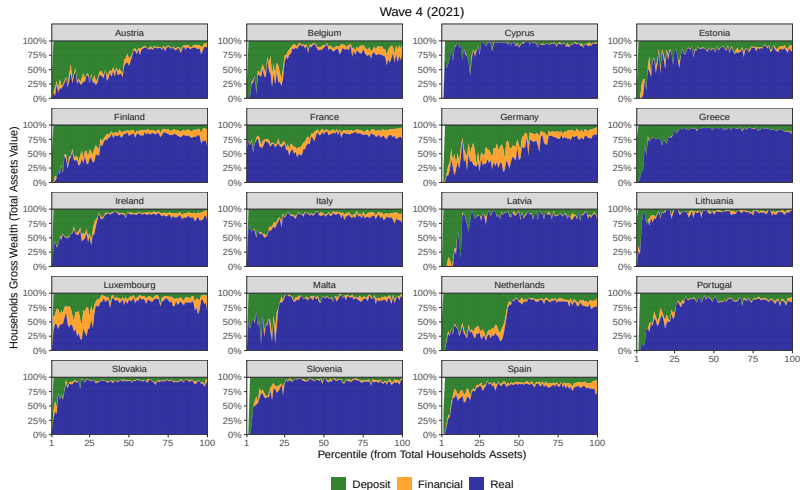
Countries x Wealth decomposition (2017)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

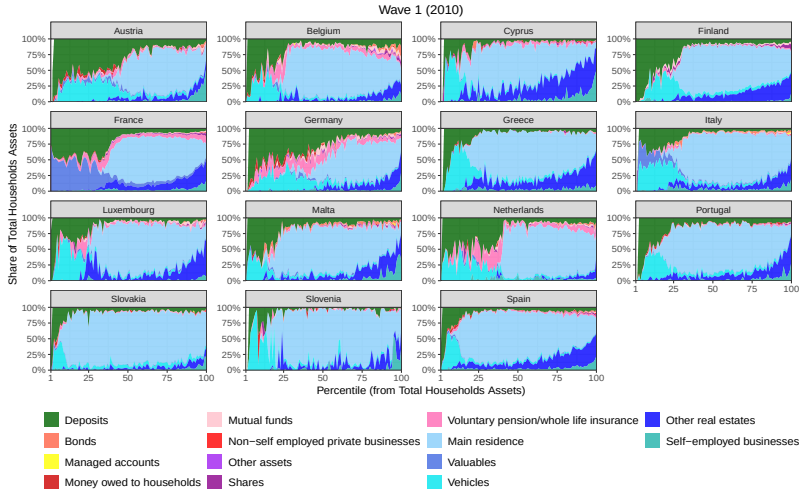
Countries x Wealth decomposition (2021)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

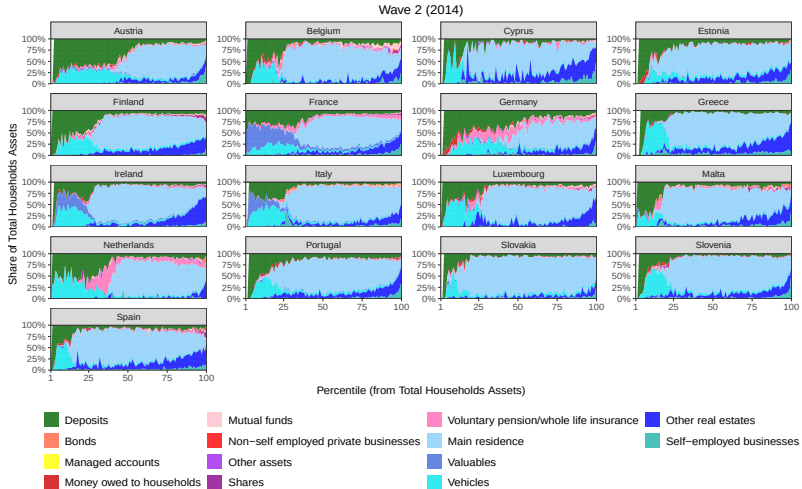
Countries x Wealth decomposition (detailed, 2010)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

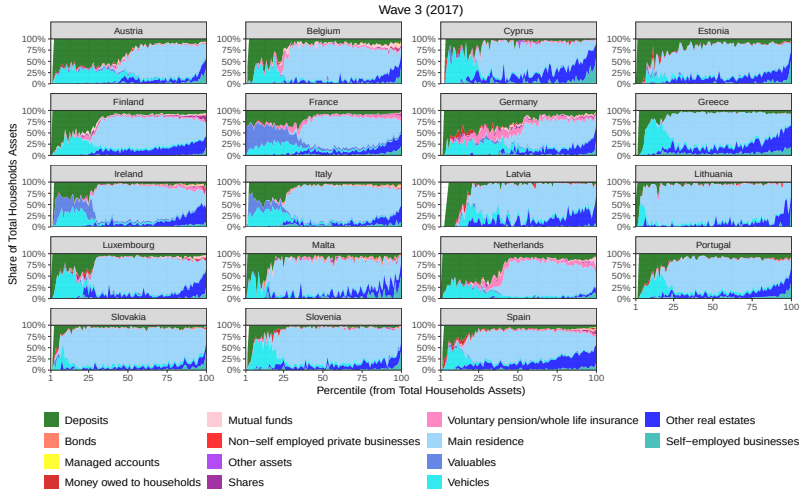
Countries x Wealth decomposition (detailed, 2014)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

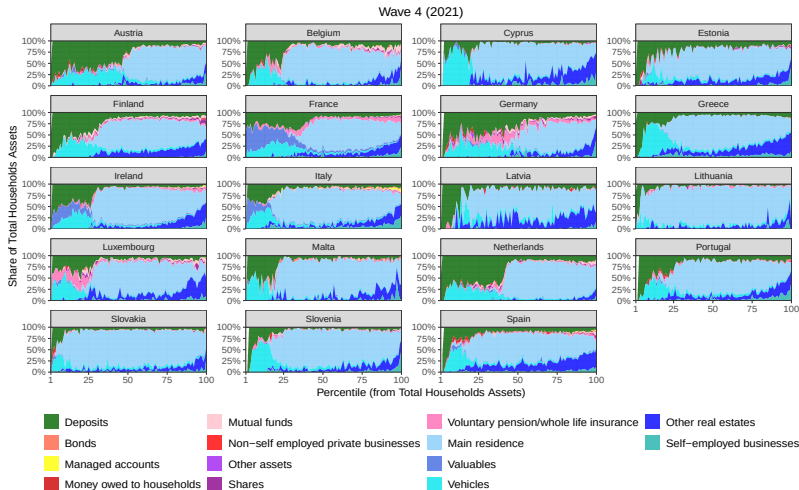
Countries x Wealth decomposition (detailed, 2017)



[Go back: Wealth decomposition](#)

[Go back: Stylized facts \(Summary\)](#)

Countries x Wealth decomposition (detailed, 2021)



[Go back: Wealth decomposition](#)

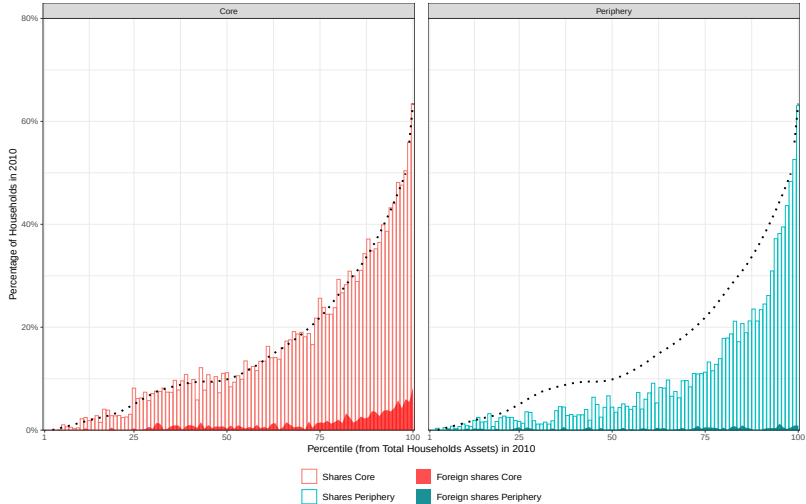
[Go back: Stylized facts \(Summary\)](#)

(Limited) Evidence of diversification

- Foreign shares [▶ 2010](#) [▶ 2014](#) [▶ 2017](#) [▶ 2021](#)
- Foreign shares (detailed) [▶ 2010](#) [▶ 2014](#) [▶ 2017](#)
- Country [▶ By country \(detailed\) \(2010\)](#) [▶ By country \(detailed\) \(2014\)](#) [▶ By country \(detailed\) \(2017\)](#) [▶ By country \(detailed\) \(2021\)](#)
- Portfolio value [▶ 2010](#) [▶ 2014](#) [▶ 2017](#) [▶ 2021](#)
- Country x Portfolio [▶ 2010](#) [▶ 2014](#) [▶ 2017](#) [▶ 2021](#)
- Income [▶ 2010](#) [▶ 2014](#) [▶ 2017](#) [▶ 2021](#)
- Country x Income [▶ 2010](#) [▶ 2014](#) [▶ 2017](#) [▶ 2021](#)
- Share HHs with foreign shares [▶ Share HHs with foreign shares](#)
- Countries x Foreign Shares x Years [▶ Countries x Foreign Shares x Years](#)

[Go back: Financialization](#)

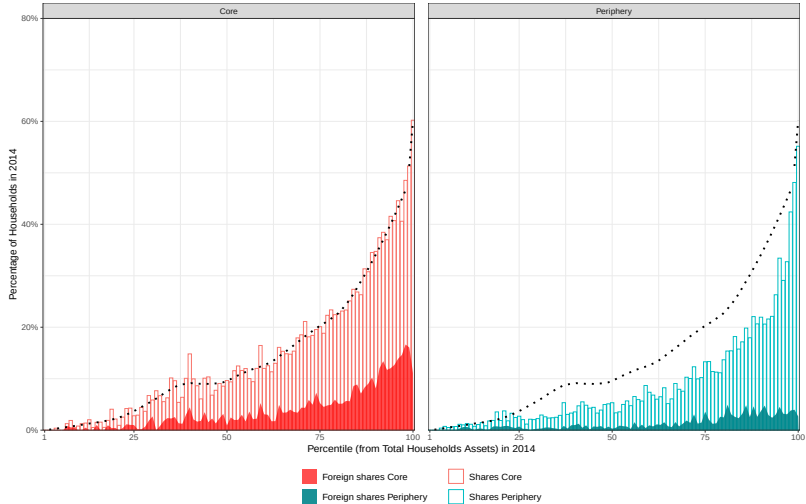
Foreign shares (2010)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

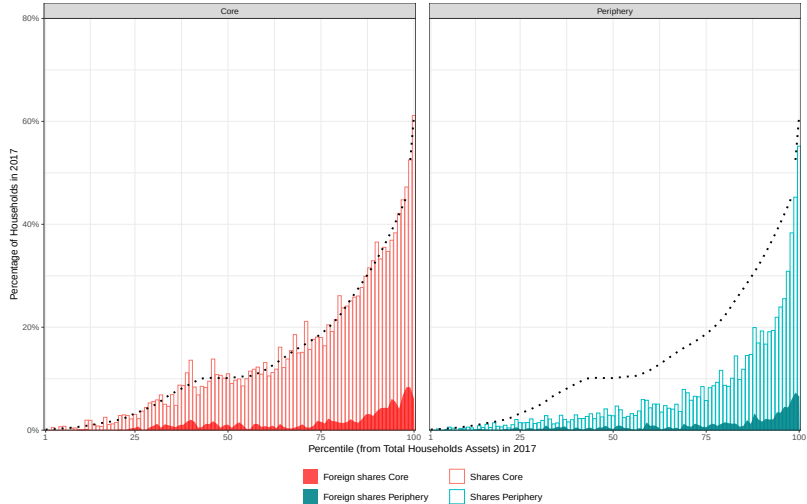
Foreign shares (2014)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

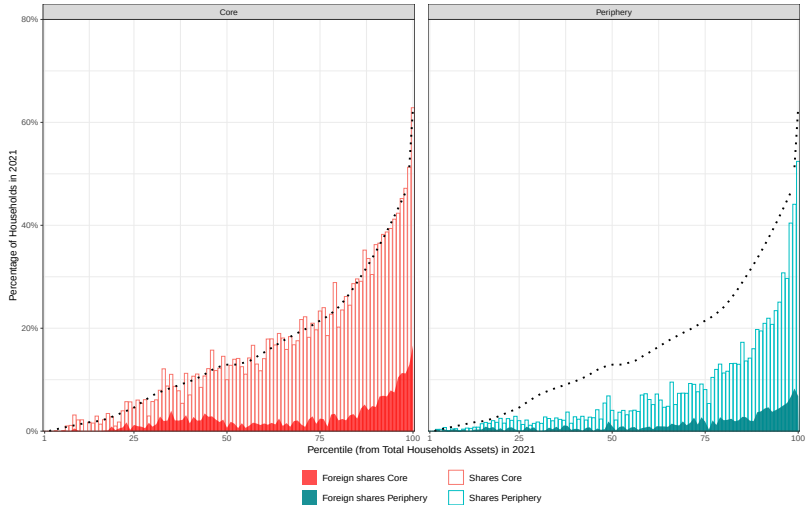
Foreign shares (2017)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

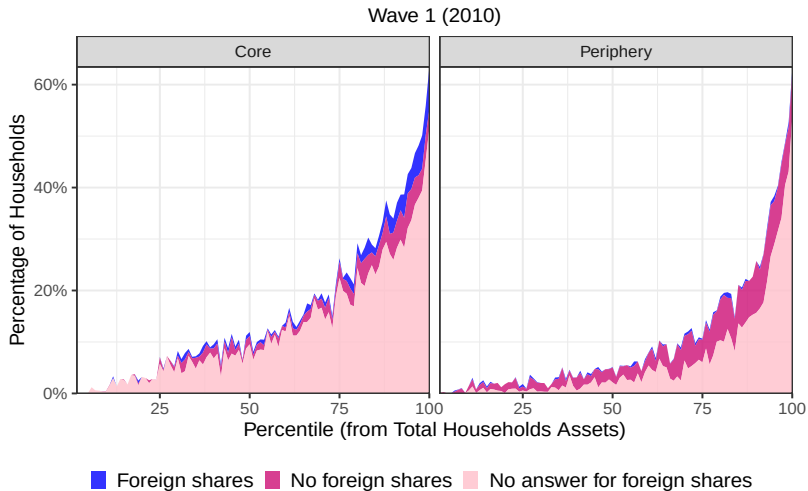
Foreign shares (2021)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

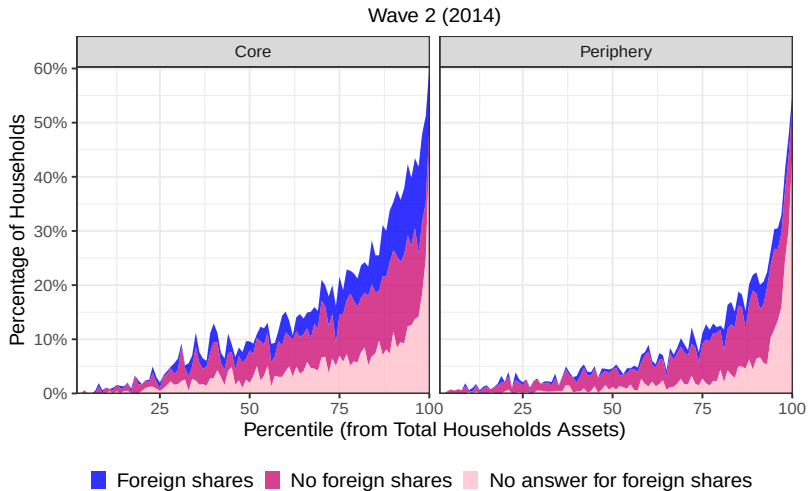
Foreign shares (detailed, 2010)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

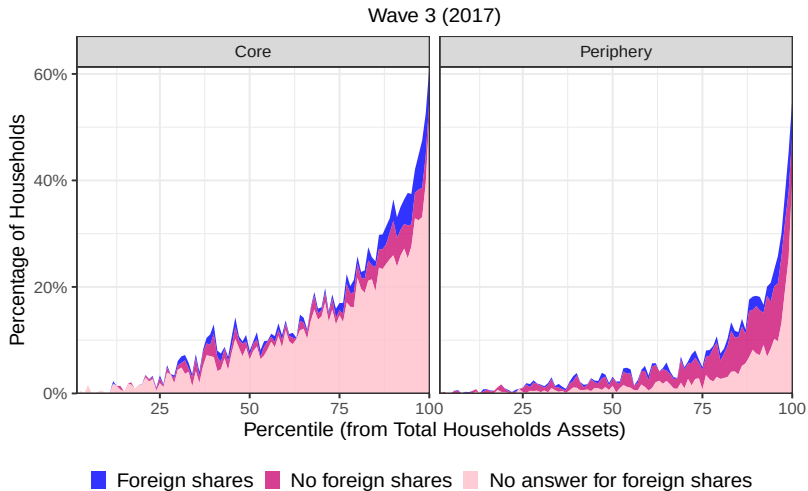
Foreign shares (detailed, 2014)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

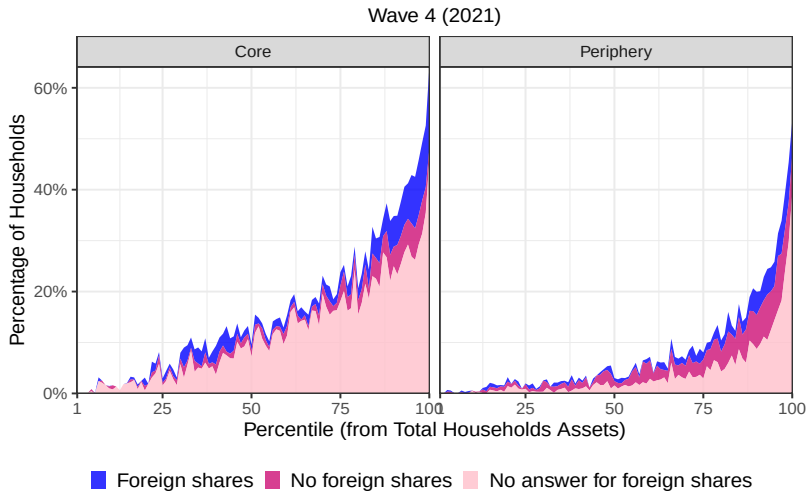
Foreign shares (detailed, 2017)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

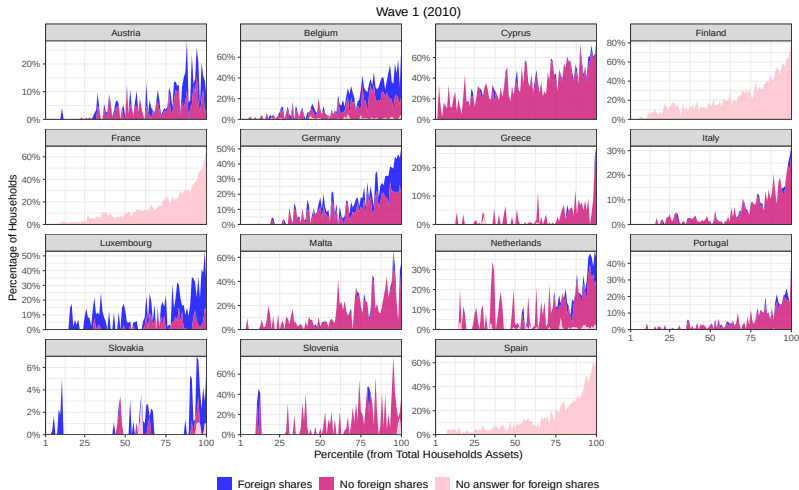
Foreign shares (detailed, 2021)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

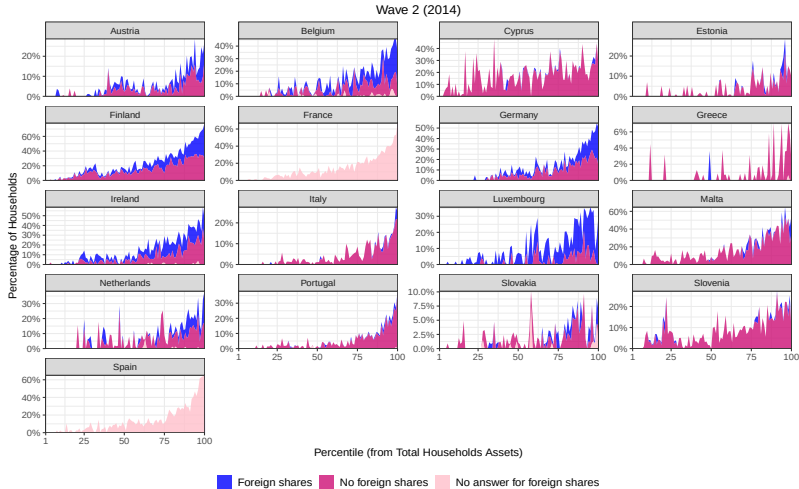
Countries x Foreign shares (detailed, 2010)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

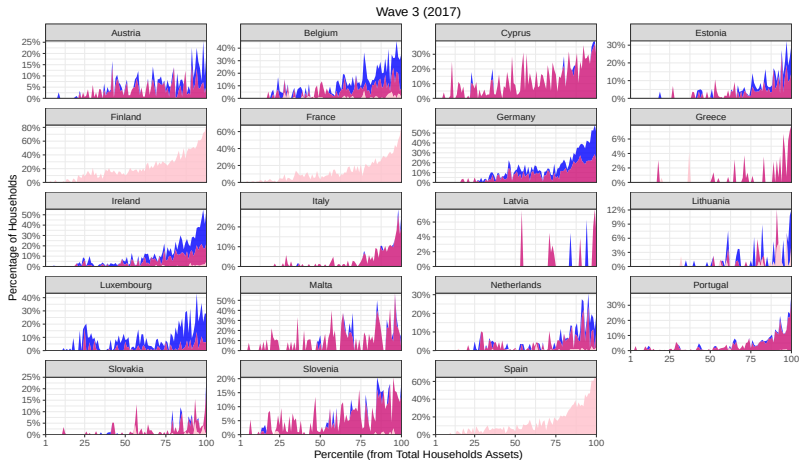
Countries x Foreign shares (detailed, 2014)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

Countries x Foreign shares (detailed, 2017)

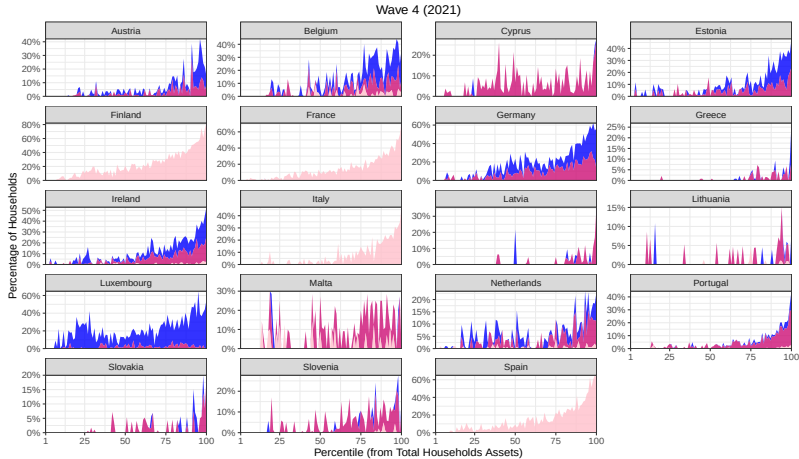


■ Foreign shares ■ No foreign shares ■ No answer for foreign shares

[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

Countries x Foreign shares (detailed, 2021)

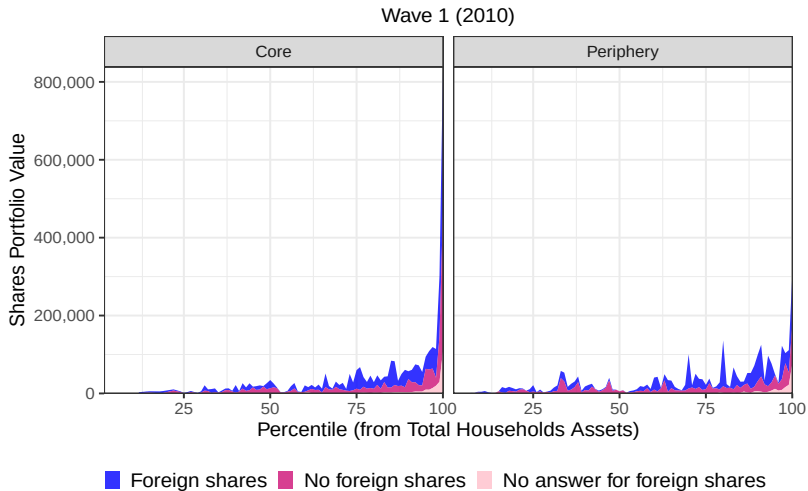


■ Foreign shares ■ No foreign shares ■ No answer for foreign shares

[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

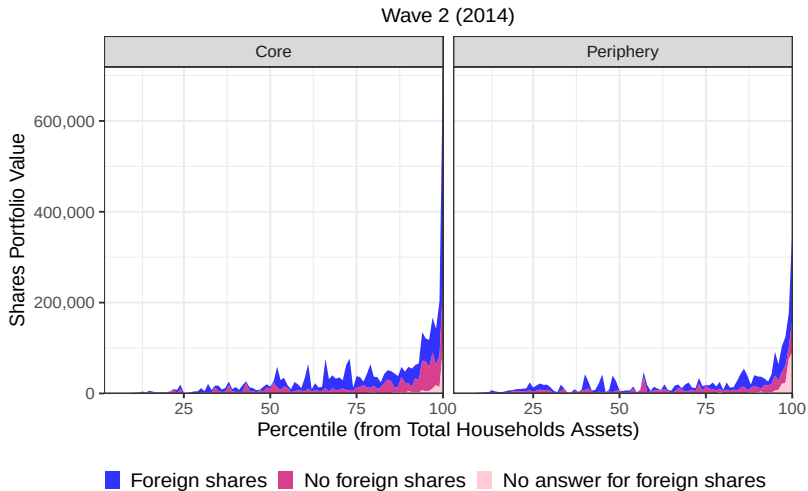
Shares Portfolio value (detailed, 2010)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

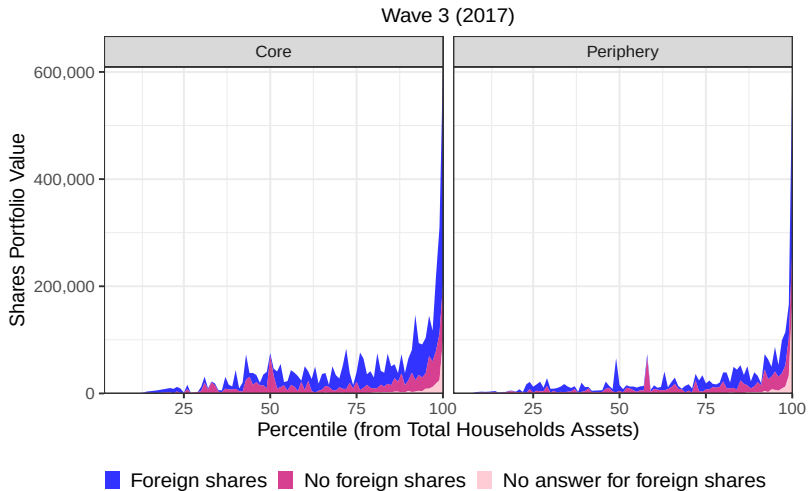
Shares Portfolio value (detailed, 2014)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

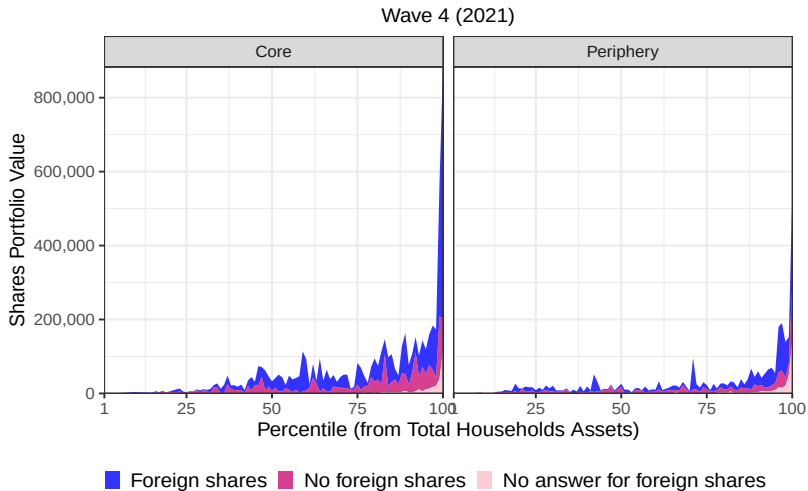
Shares Portfolio value (detailed, 2017)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

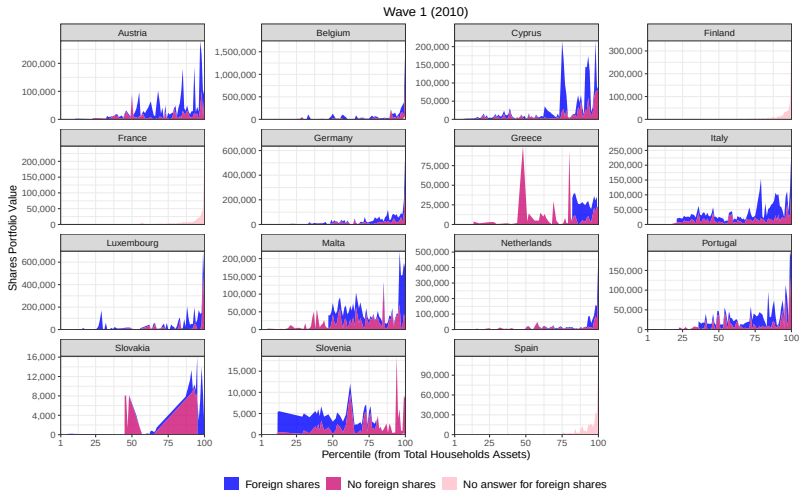
Shares Portfolio value (detailed, 2021)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

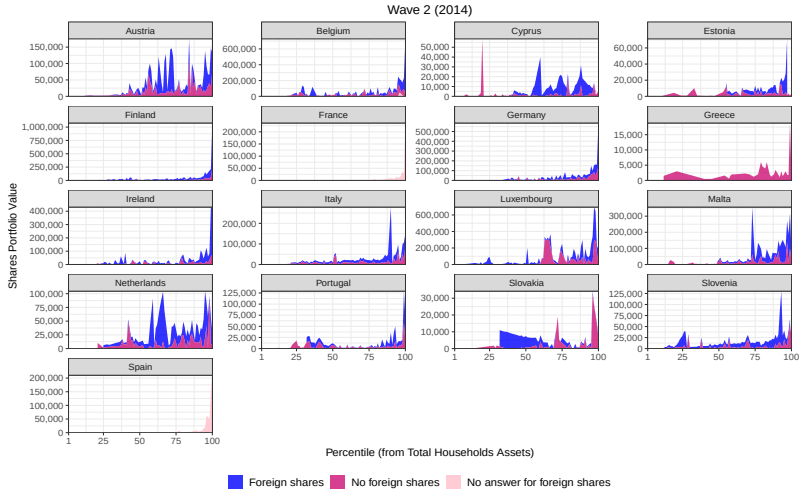
Countries x Shares Portfolio value (detailed, 2010)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

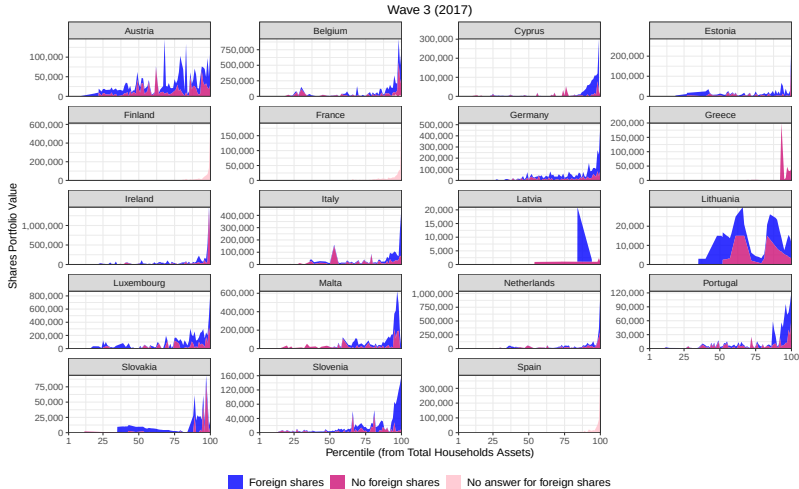
Countries x Shares Portfolio value (detailed, 2014)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

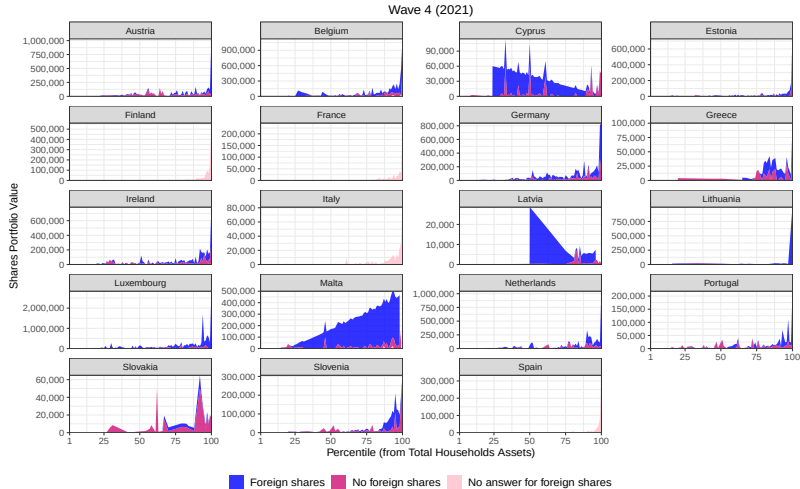
Countries x Shares Portfolio value (detailed, 2017)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

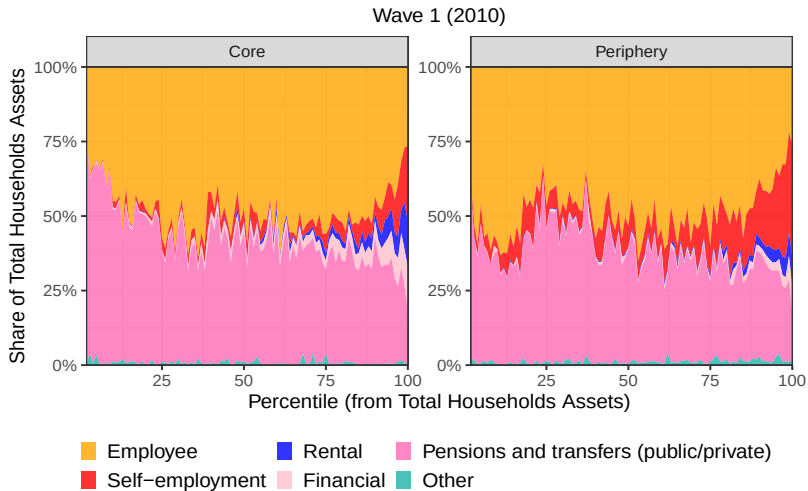
Countries x Shares Portfolio value (detailed, 2021)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

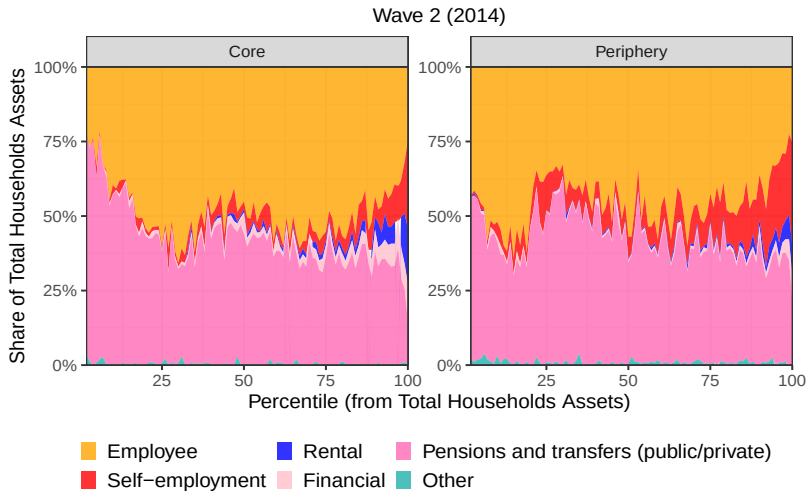
Income (2010)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

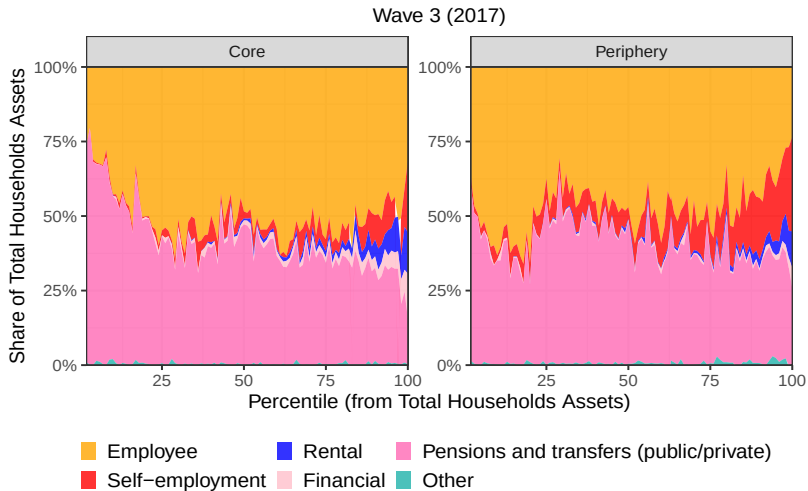
Income (2014)



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[Go back: Stylized facts \(Summary\)](#)

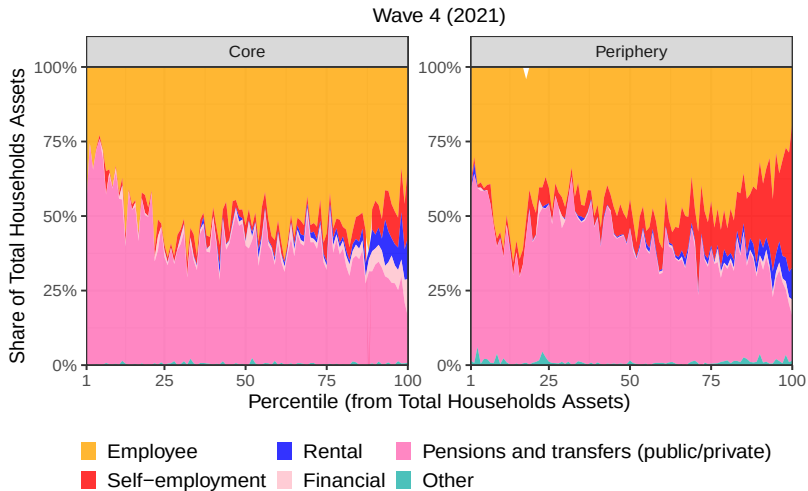
Income (2017)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

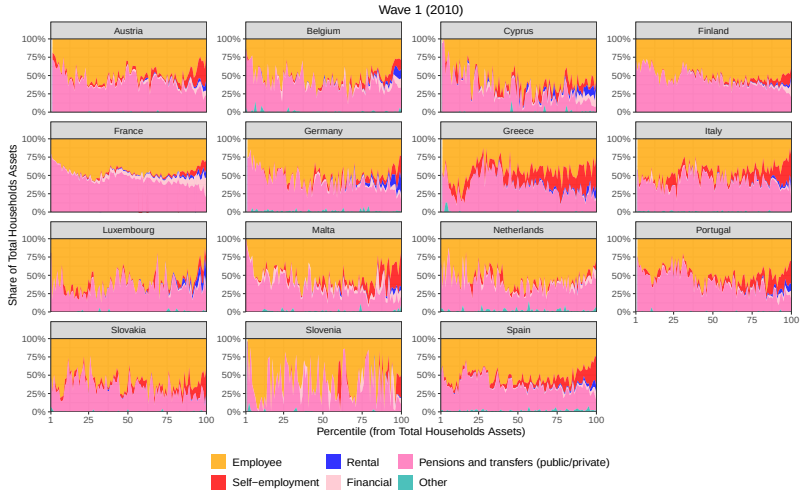
Income (2021)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

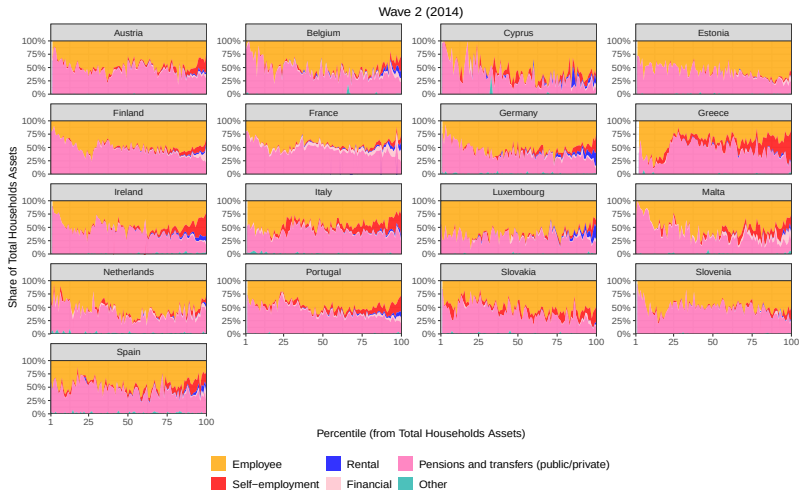
Countries x Income (2010)



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[Go back: Stylized facts \(Summary\)](#)

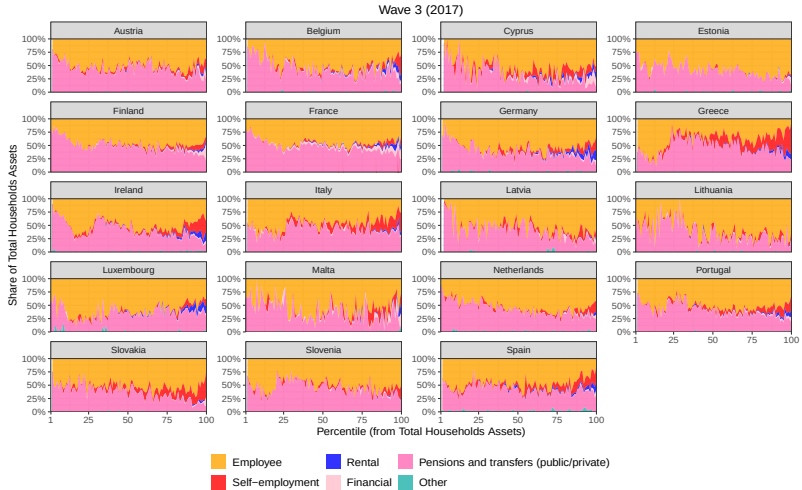
Countries x Income (2014)



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[Go back: Stylized facts \(Summary\)](#)

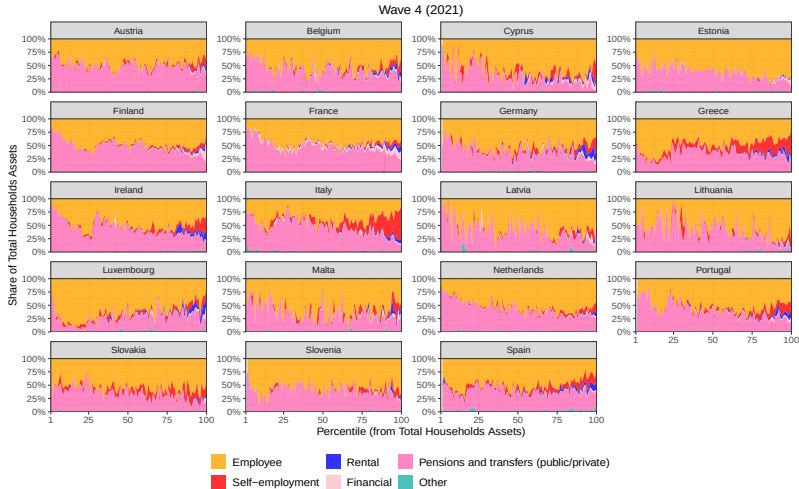
Countries x Income (2017)



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[Go back: Stylized facts \(Summary\)](#)

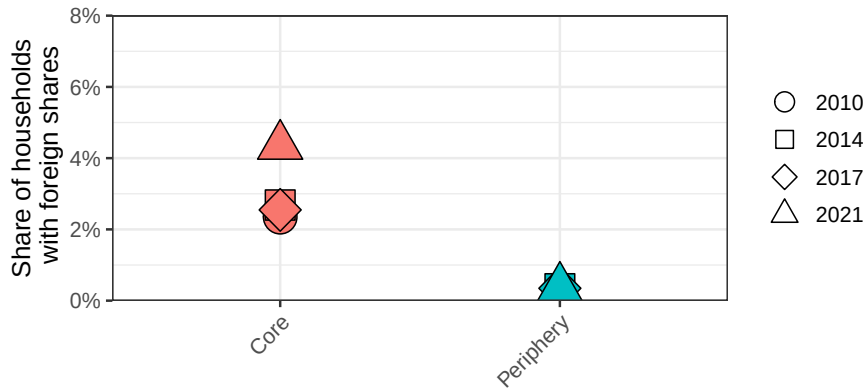
Countries x Income (2021)



[Go back: Diversification](#)

[Go back: Stylized facts \(Summary\)](#)

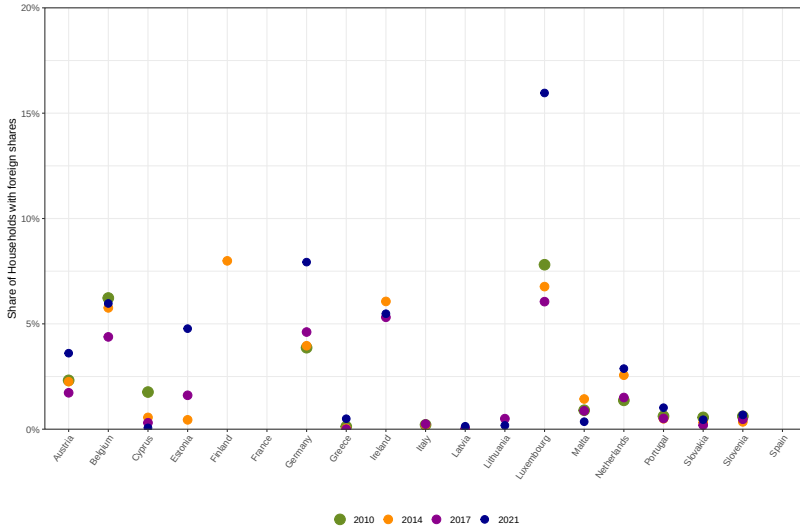
Share HHs with foreign shares



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[Go back: Stylized facts \(Summary\)](#)

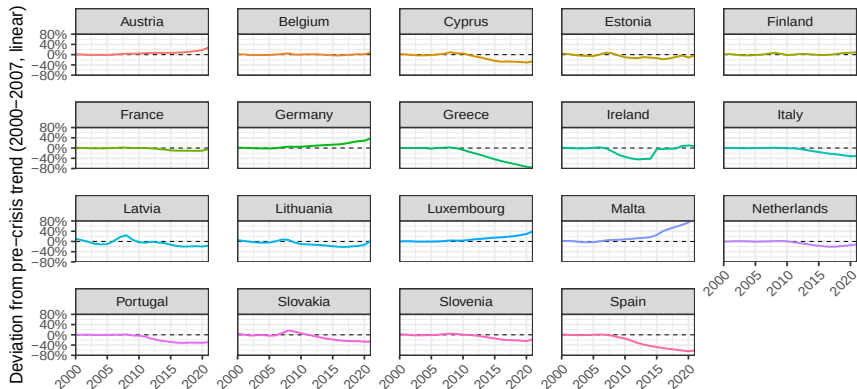
Countries x Foreign shares x Year



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Countries capital stock since 2000

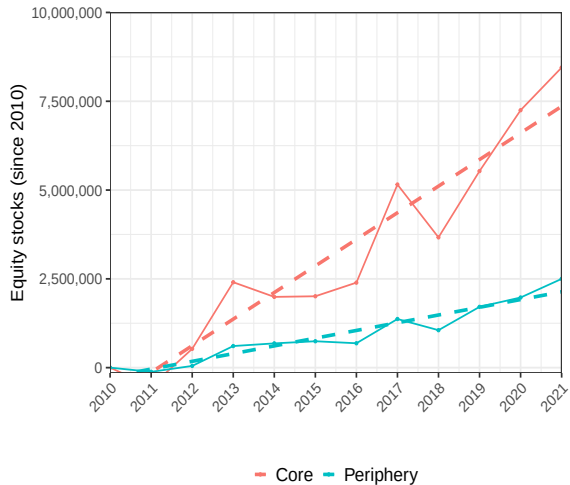
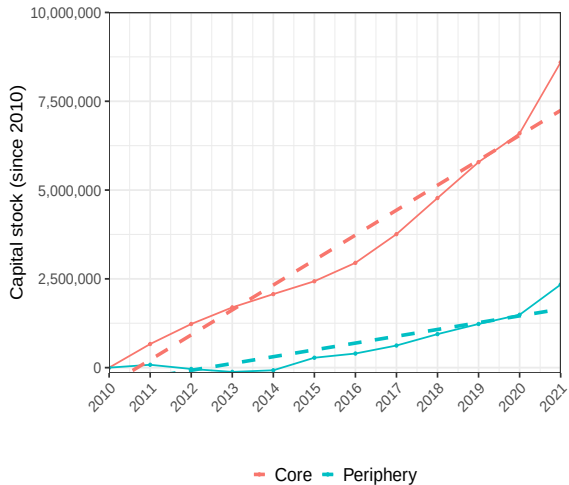


— Austria	— Finland	— Ireland	— Luxembourg	— Slovakia
— Belgium	— France	— Italy	— Malta	— Slovenia
— Cyprus	— Germany	— Latvia	— Netherlands	— Spain
— Estonia	— Greece	— Lithuania	— Portugal	

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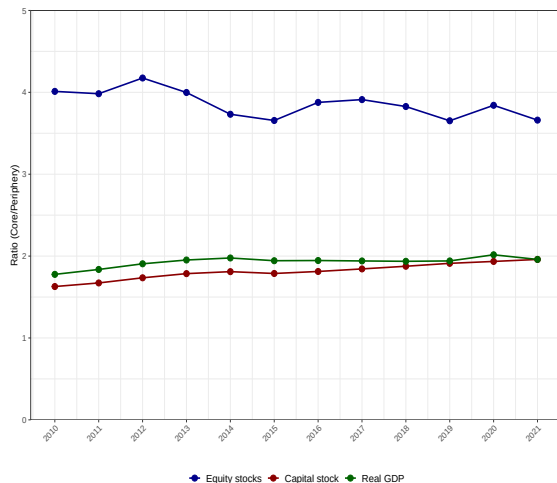
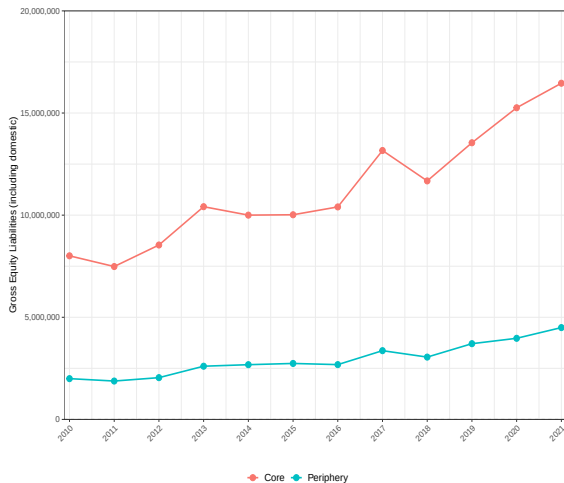
Capital stock vs. Equity stock



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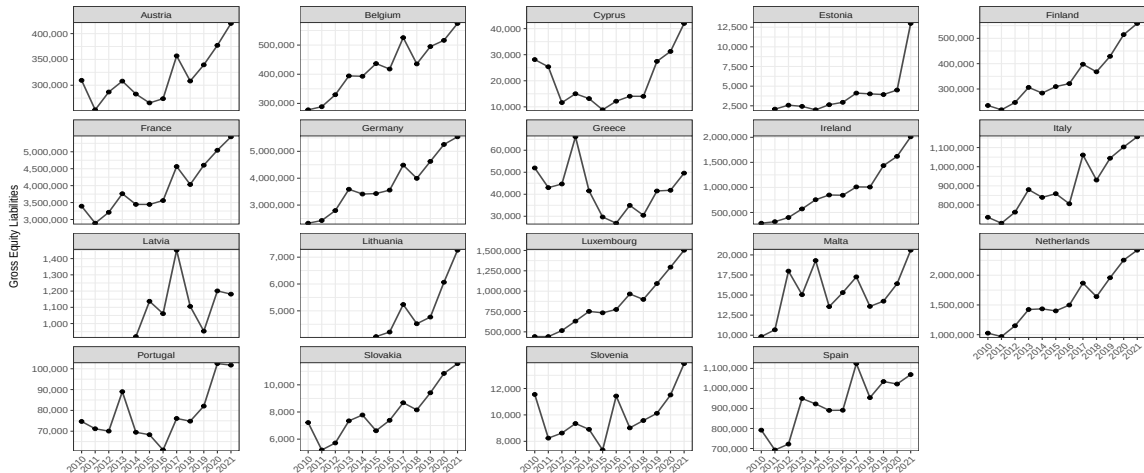
Equity stock is disproportionately large in the Core



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[Go back: Stylized facts \(Summary\)](#)

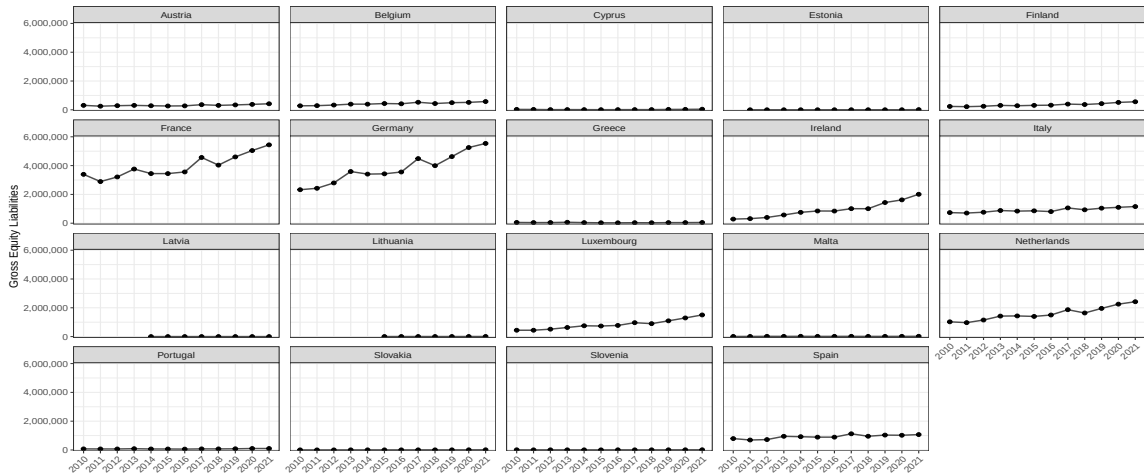
Countries x Gross Equity Liabilities



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[Go back: Stylized facts \(Summary\)](#)

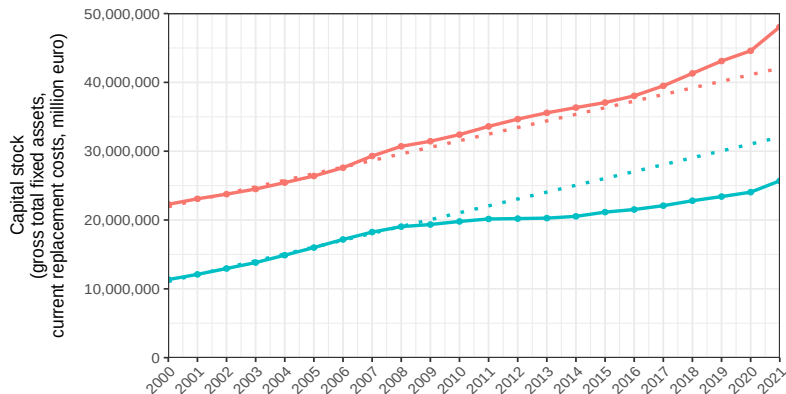
Countries x Gross Equity Liabilities (Fixed scale)



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Capital stock (Gross)

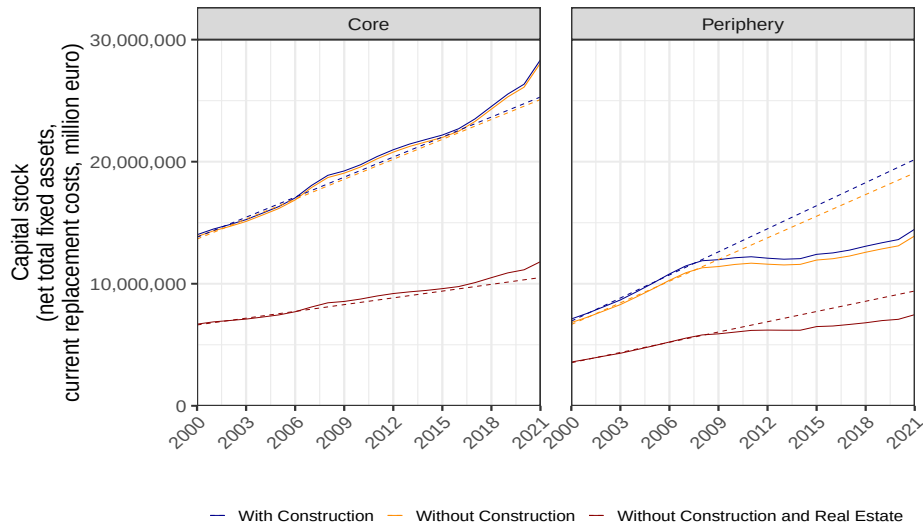


- Group pre-crisis (2000–2007, linear) trend
- Core
- Periphery

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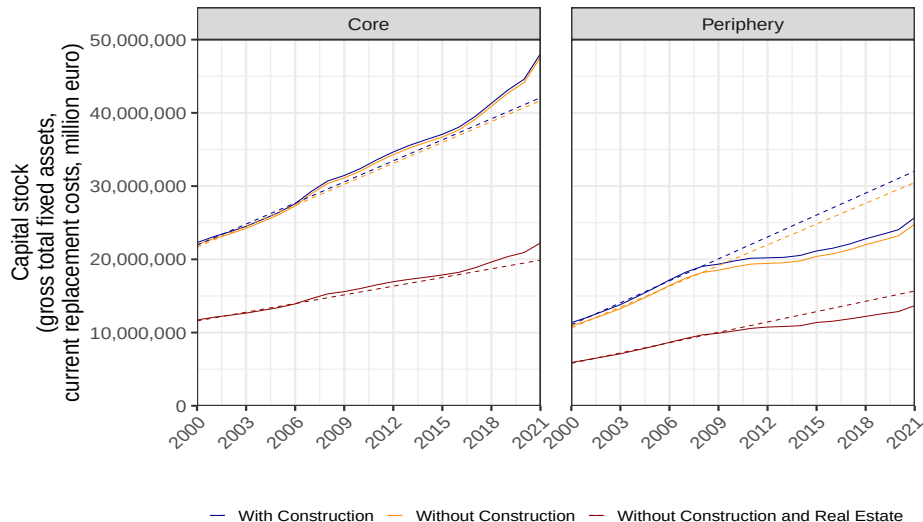
Capital stock without Housing (Net)



[Go back: Capital stocks](#)

[Go back: Stylized facts \(Summary\)](#)

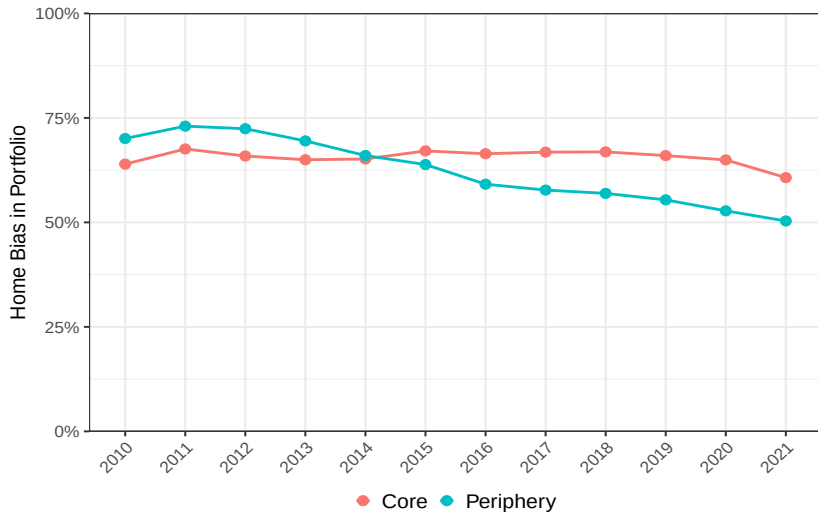
Capital stock without Housing (Gross)



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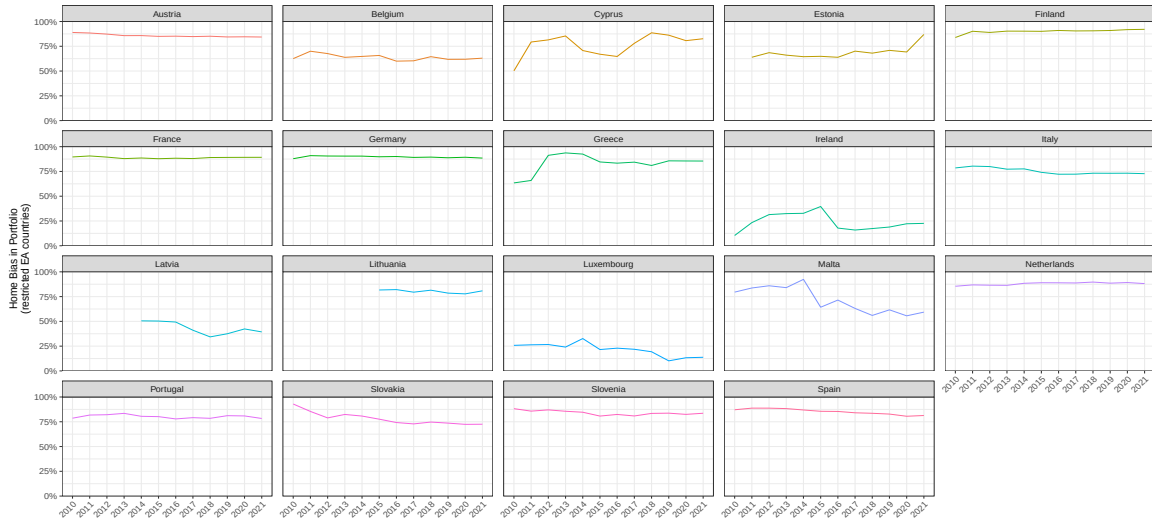
Home Bias including RoW



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[Go back: Stylized facts \(Summary\)](#)

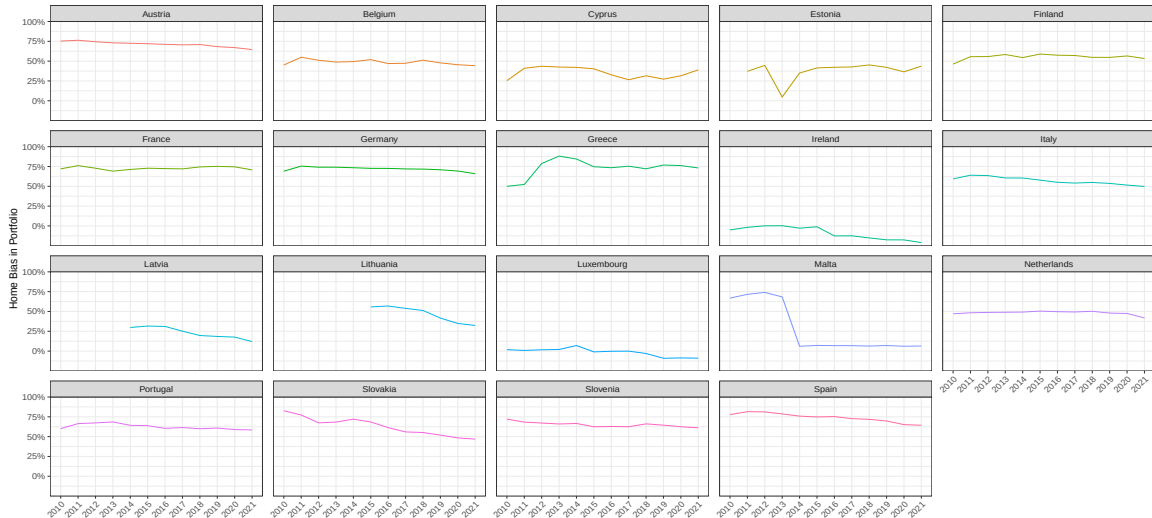
Home Bias x Country



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[Go back: Stylized facts \(Summary\)](#)

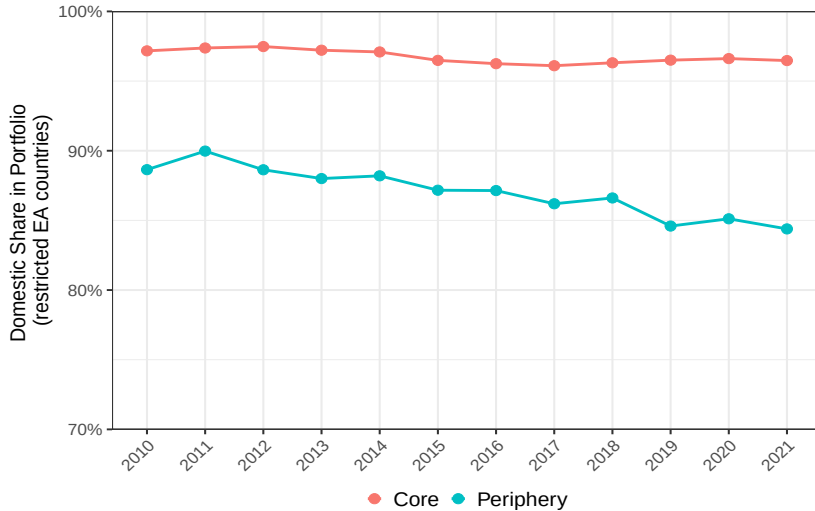
Home Bias x Country



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[Go back: Stylized facts \(Summary\)](#)

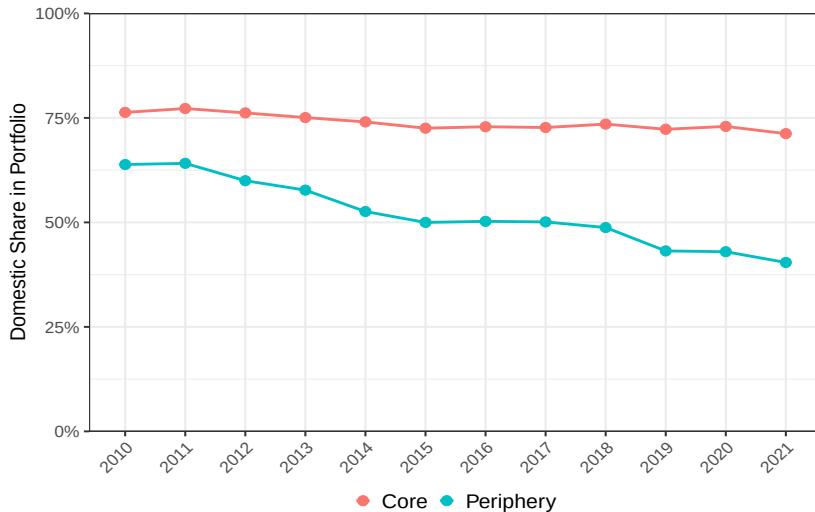
Domestic share



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[Go back: Stylized facts \(Summary\)](#)

Domestic share with RoW



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[Go back: Stylized facts \(Summary\)](#)

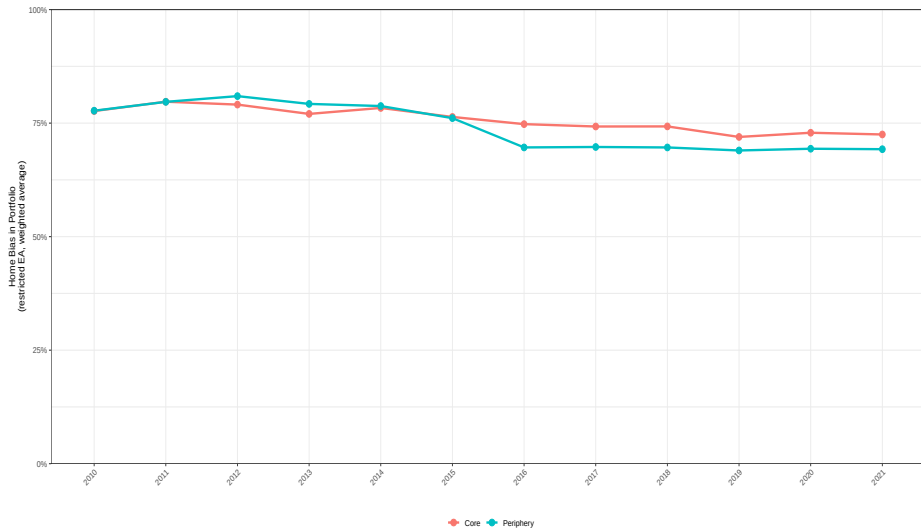
Portfolios & Liabilities

- Home Bias
 - ▶ As country weighted average per group
 - ▶ As country weighted average per group with RoW
- Average relative to Market Weight
 - ▶ Restricted EA (G)
 - ▶ With RoW (G)
- Portfolio share
 - ▶ Portfolio share (G)
 - ▶ Portfolio share (C)
 - ▶ Portfolio share (C) x RoW
 - ▶ Portfolio share (C) x RoW (detailed)
- Portfolio value
 - ▶ Portfolio (G)
 - ▶ Portfolio (G)
 - ▶ Portfolio (C) x RoW
 - ▶ Portfolio (C) x RoW (detailed)
- Liabilities share
 - ▶ Liabilities share (G)
 - ▶ Liabilities share (G)
 - ▶ Liabilities share (C) x RoW
- Liabilities value
 - ▶ Liabilities (G)
 - ▶ Liabilities (G)
 - ▶ Liabilities (C) x RoW
- Country x Domestic share
 - ▶ Country x Domestic share
 - ▶ Country x Domestic share with RoW
- Country x Portfolio share
 - ▶ Country x Portfolio share (G)
 - ▶ Country x Portfolio share (G)
 - ▶ Country x Portfolio share (C) x RoW
 - ▶ Country x Portfolio share (C) x RoW (detailed)
- Country x Portfolio value
 - ▶ Country x Portfolio (G)
 - ▶ Country x Portfolio (C)
 - ▶ Country x Portfolio (C) x RoW
 - ▶ Country x Portfolio (C) x RoW (detailed)
- Country x Liabilities share
 - ▶ Country x Liabilities share (G)
 - ▶ Country x Liabilities share (C)
 - ▶ Country x Liabilities share (C) x RoW
- Country x Liabilities value
 - ▶ Country x Liabilities (G)
 - ▶ Country x Liabilities (C)
 - ▶ Country x Liabilities (C) x RoW

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[Go back: Stylized facts \(Summary\)](#)

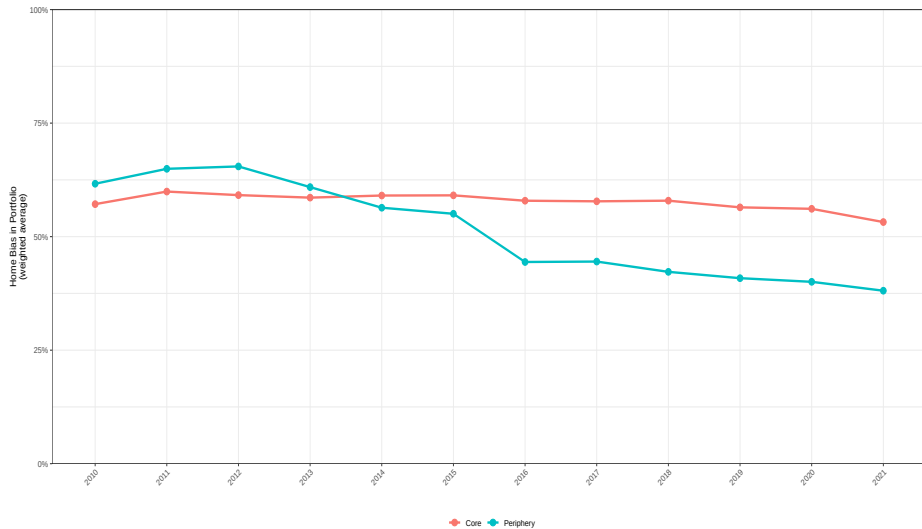
Home Bias as country weighted average per group



[Go back: Portfolios & Liabilities](#)

[Go back: Stylized facts \(Summary\)](#)

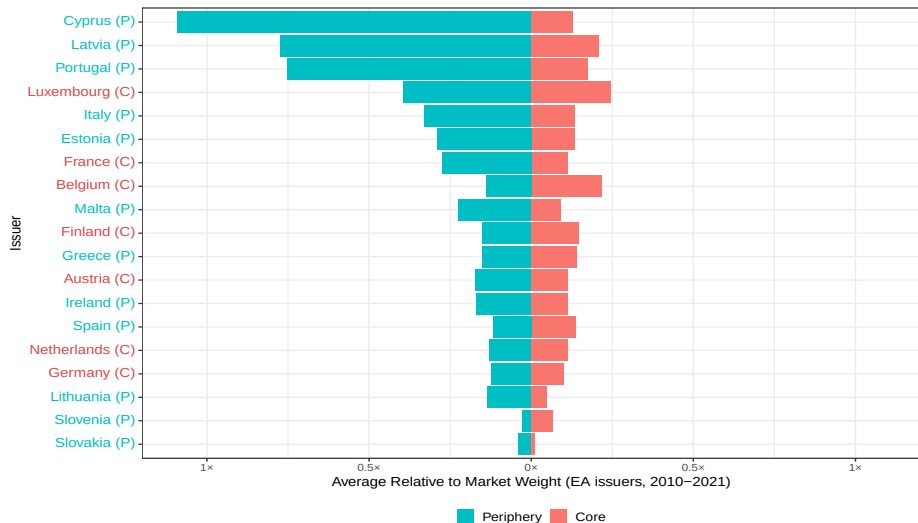
Home Bias as country weighted average per group with RoW



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[Go back: Stylized facts \(Summary\)](#)

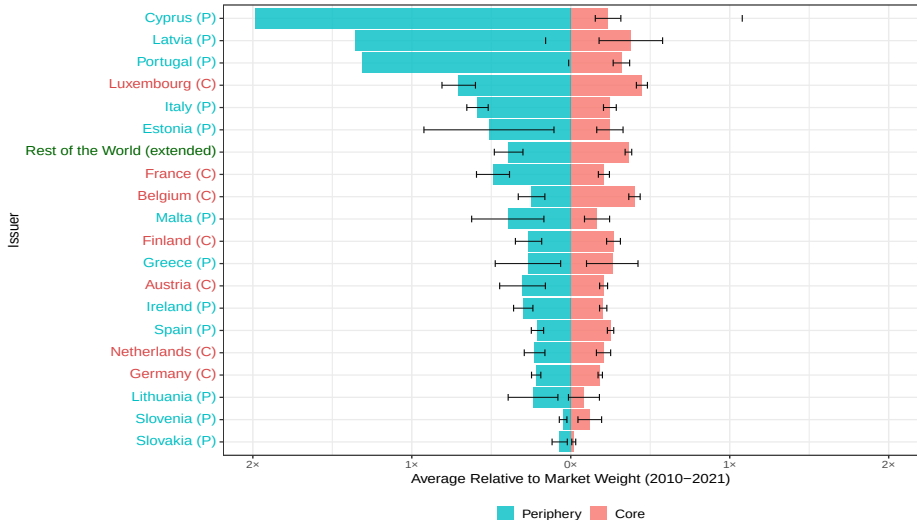
Average relative to Market Weight (Restricted)



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[Go back: Stylized facts \(Summary\)](#)

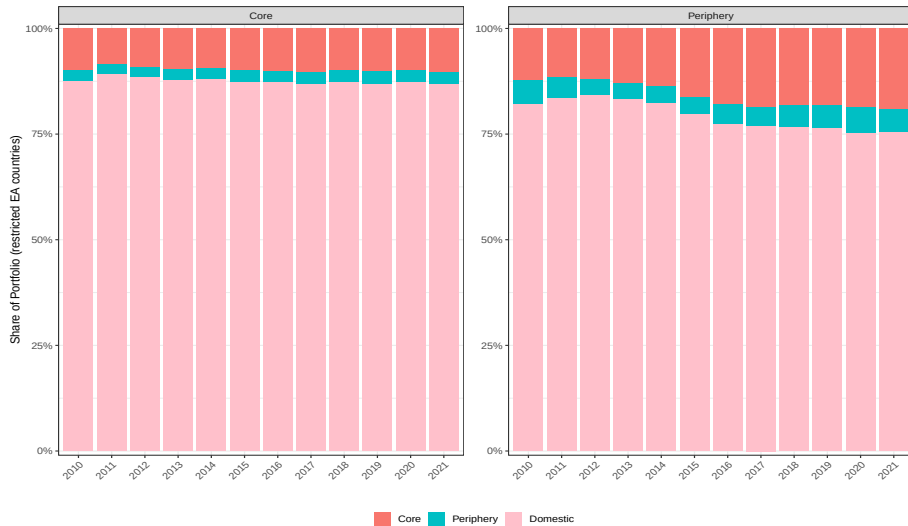
Average relative to Market Weight (with RoW)



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[Go back: Stylized facts \(Summary\)](#)

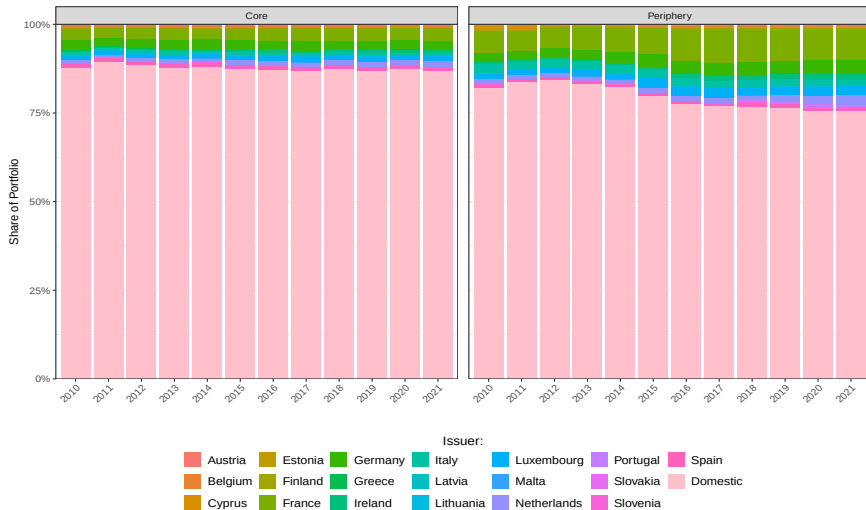
Portfolio share (G)



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[Go back: Stylized facts \(Summary\)](#)

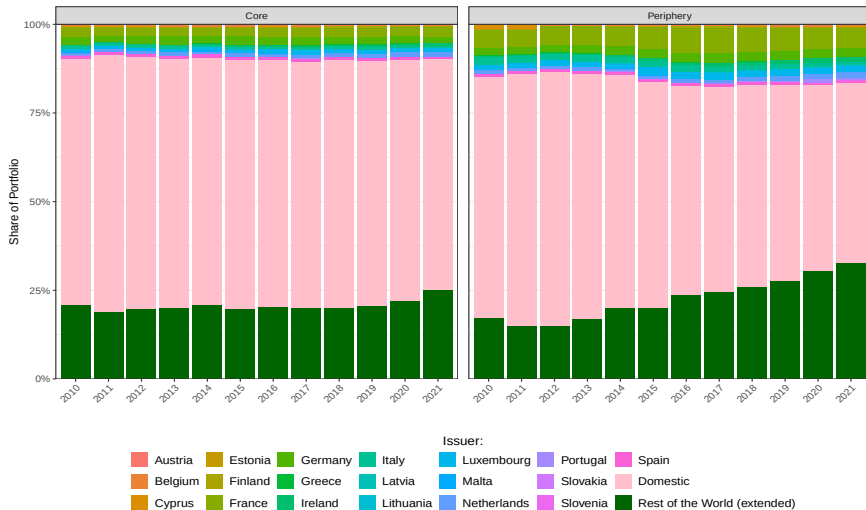
Portfolio share (C)



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[Go back: Stylized facts \(Summary\)](#)

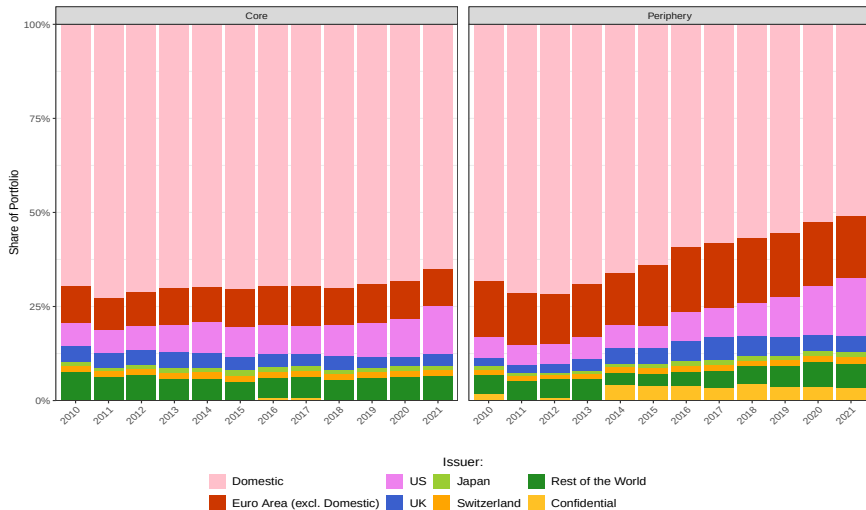
Portfolio share (C) x RoW



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[Go back: Stylized facts \(Summary\)](#)

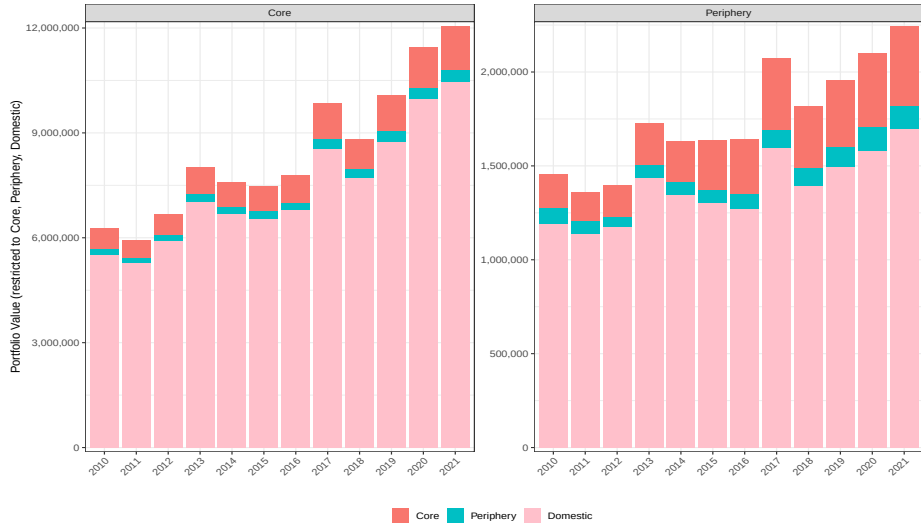
Portfolio share (C) x RoW (detailed)



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[Go back: Stylized facts \(Summary\)](#)

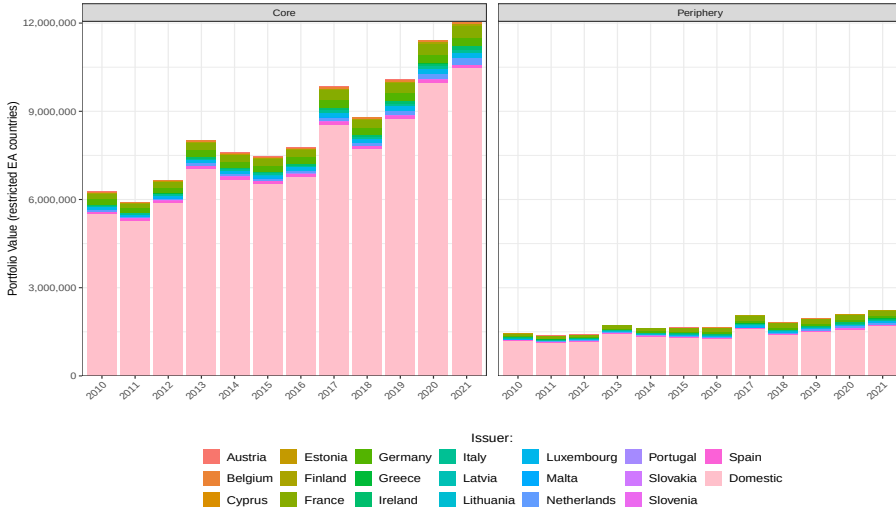
Portfolio (G)



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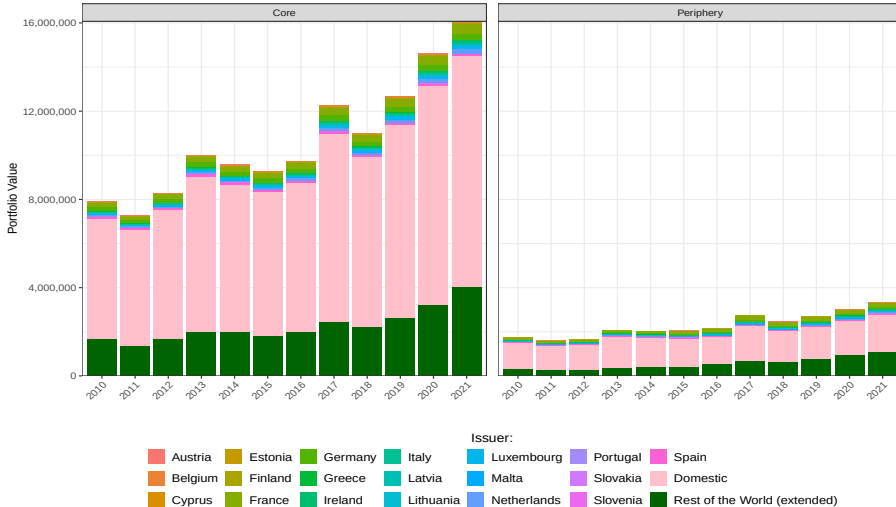
Portfolio (C)



[Go back: Portfolios & Liabilities](#)

[Go back: Stylized facts \(Summary\)](#)

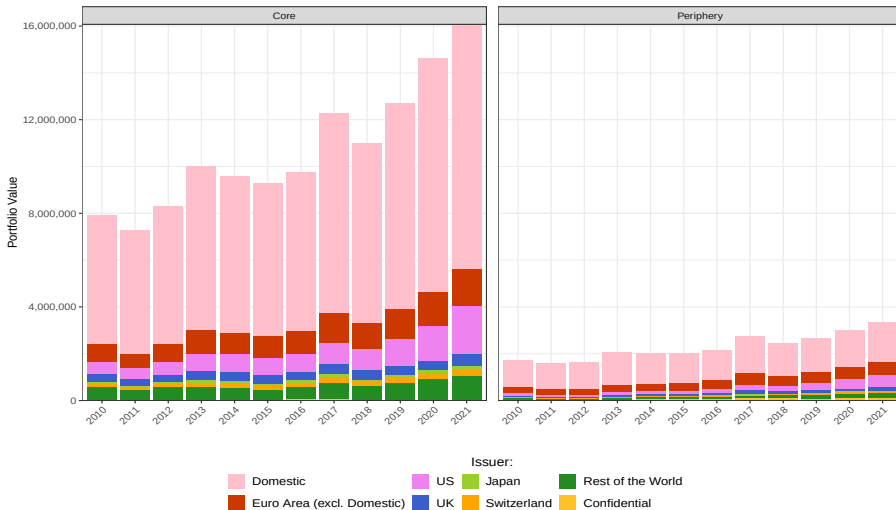
Portfolio (C) x RoW



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[Go back: Stylized facts \(Summary\)](#)

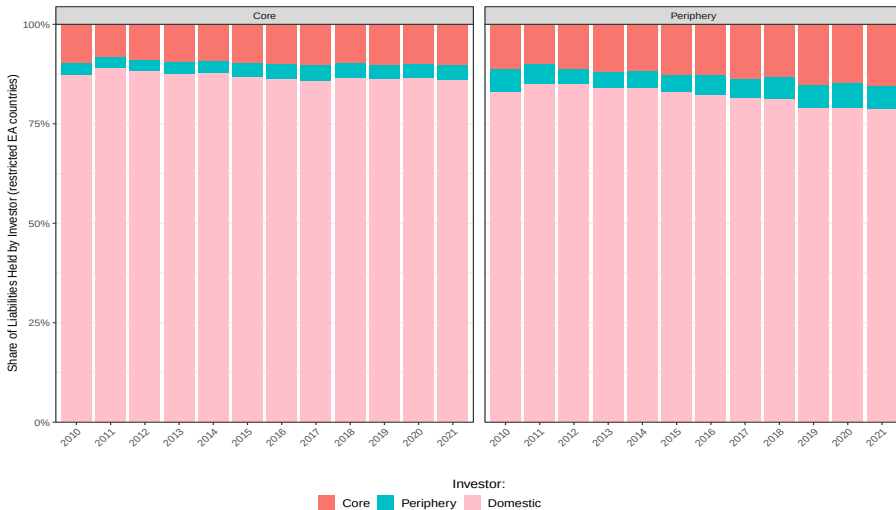
Portfolio (C) x RoW (detailed)



[Go back: Portfolios & Liabilities](#)

[Go back: Stylized facts \(Summary\)](#)

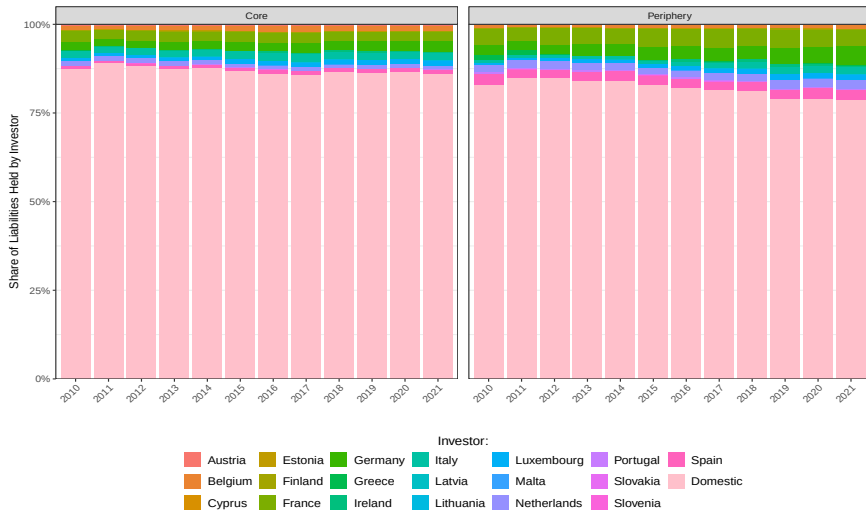
Liabilities share (G)



[Go back: Portfolios & Liabilities](#)

[Go back: Stylized facts \(Summary\)](#)

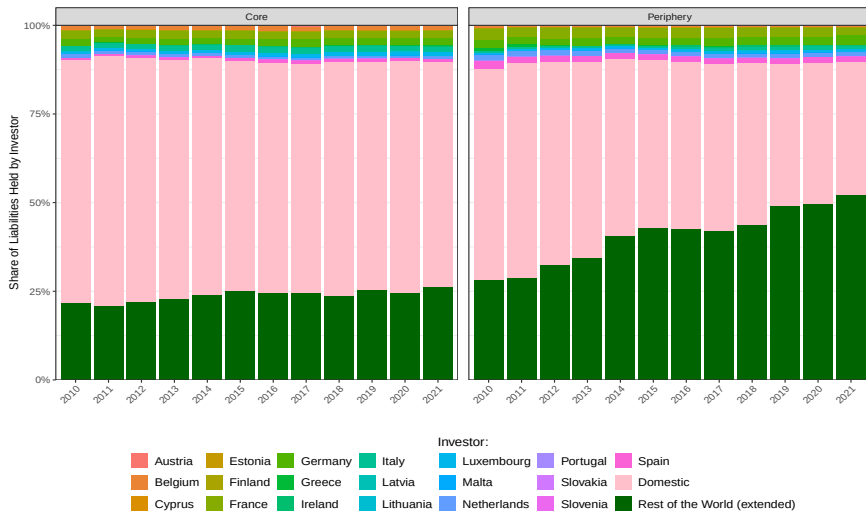
Liabilities share (C)



[Go back: Portfolios & Liabilities](#)

[Go back: Stylized facts \(Summary\)](#)

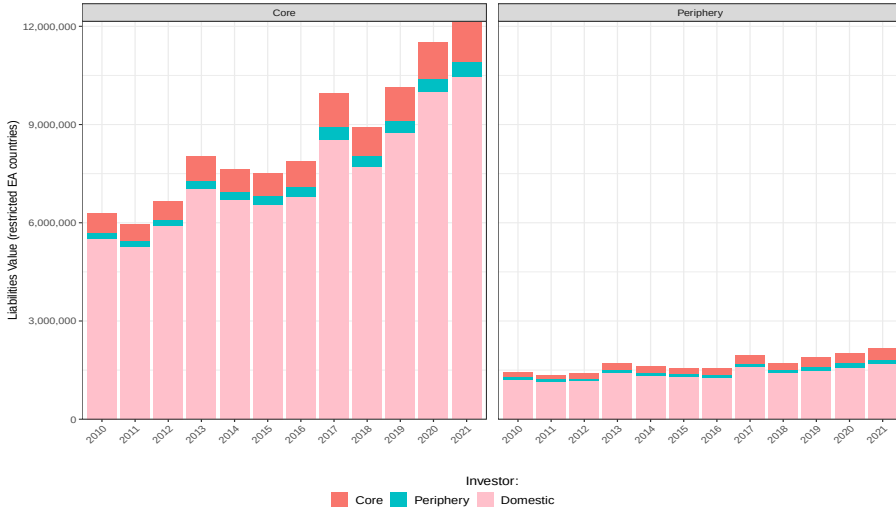
Liabilities share (C) x RoW



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[Go back: Stylized facts \(Summary\)](#)

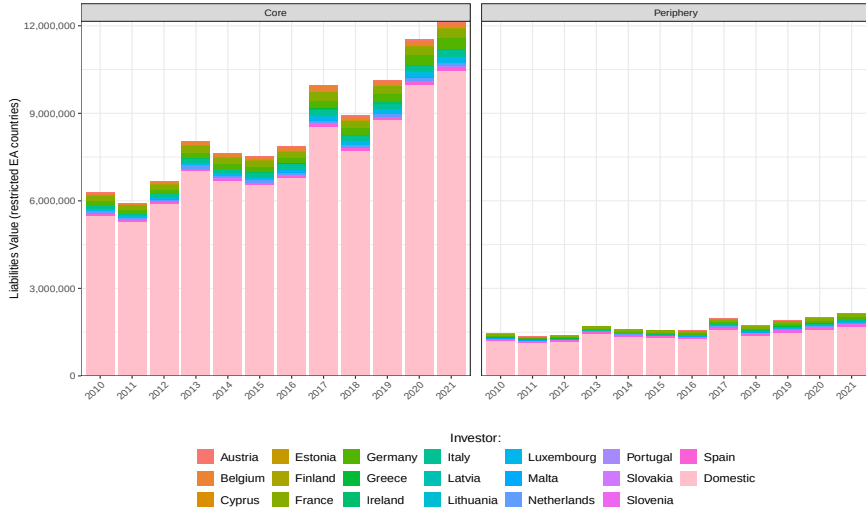
Liabilities (G)



[Go back: Portfolios & Liabilities](#)

[Go back: Stylized facts \(Summary\)](#)

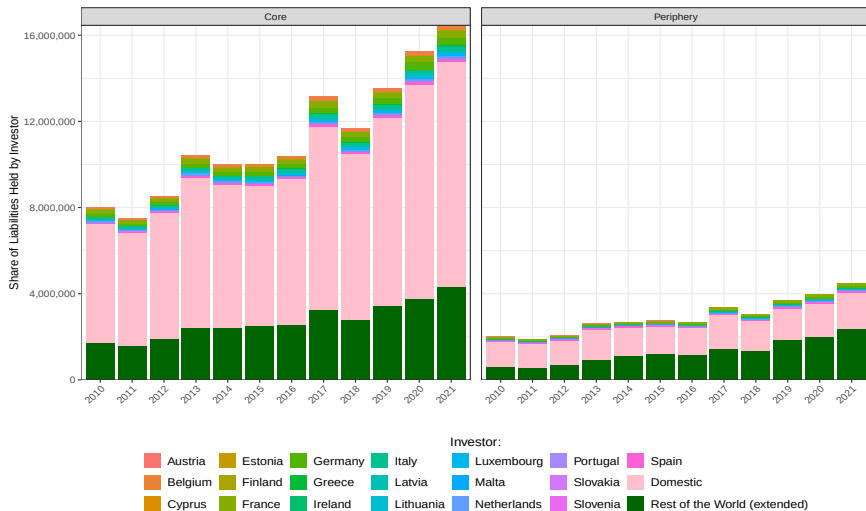
Liabilities (C)



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Liabilities (C) x RoW



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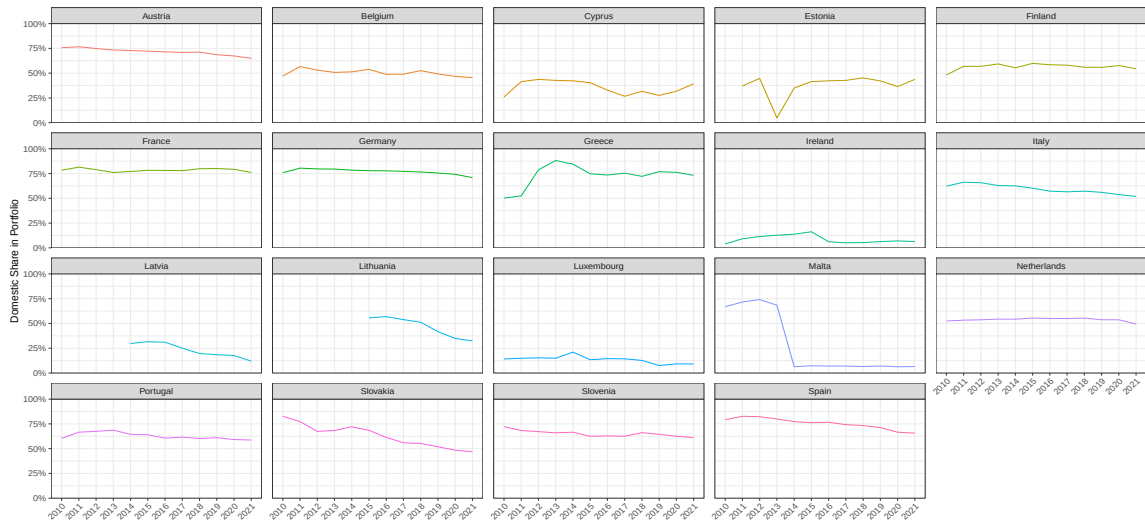
Country x Domestic share



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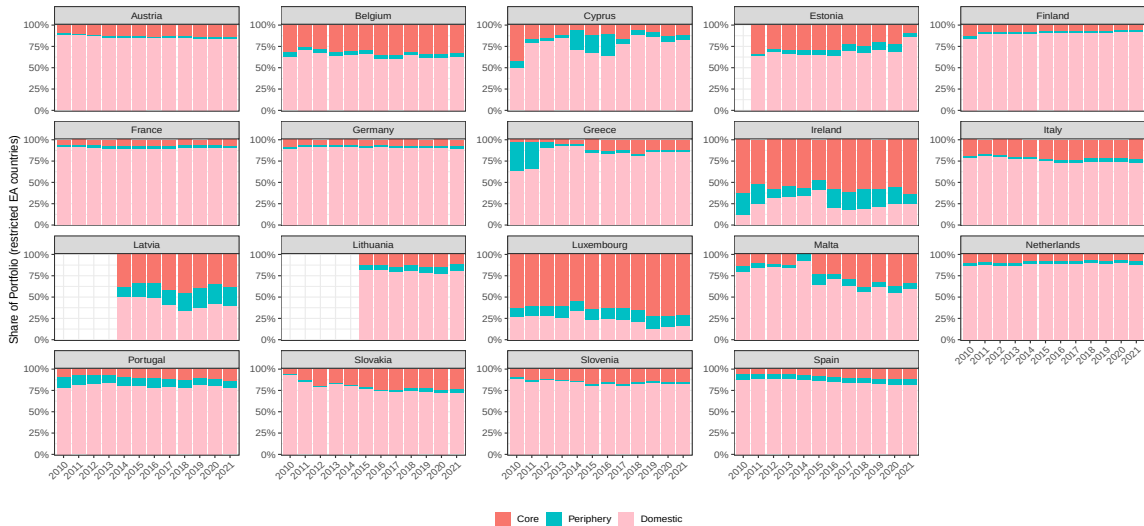
Country x Domestic share with RoW



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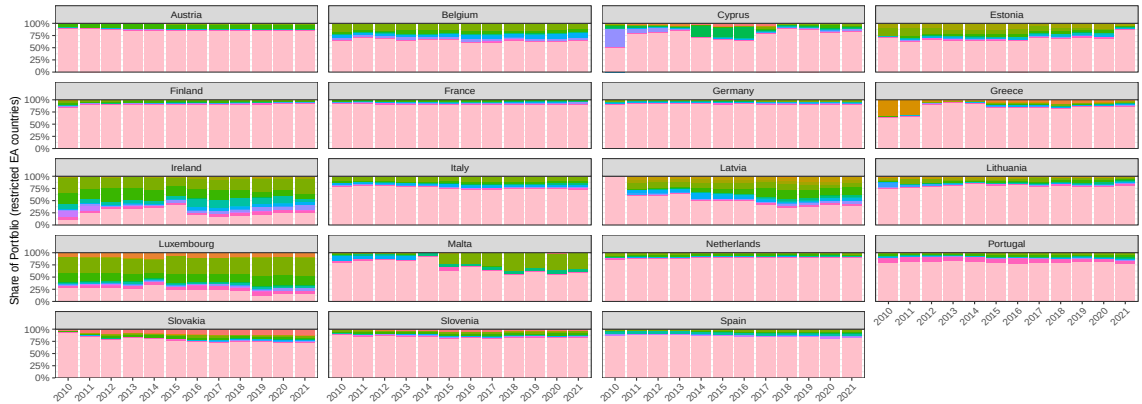
Country x Portfolio share (G)



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Country x Portfolio share (C)



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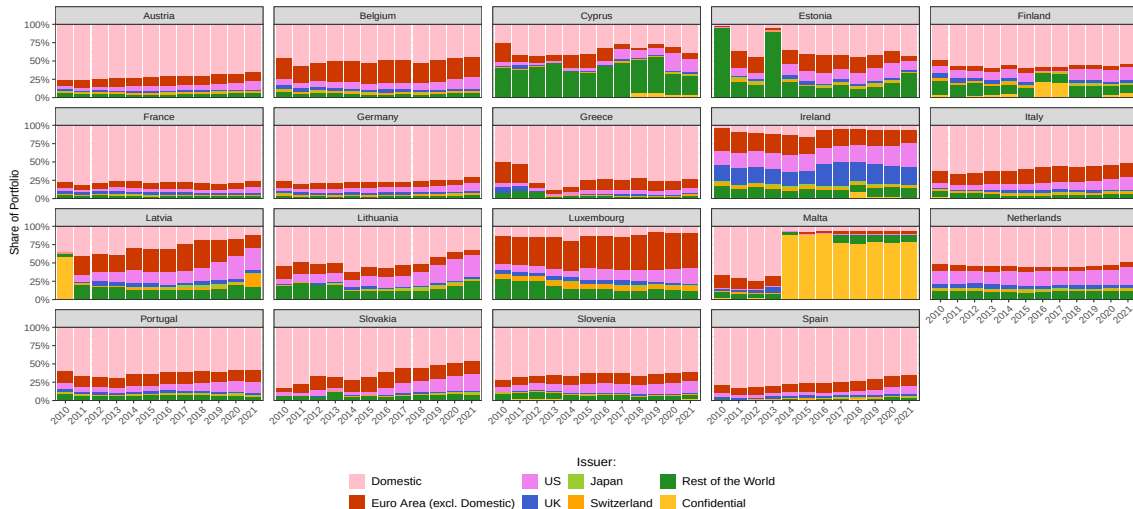
Country x Portfolio share (C) x RoW



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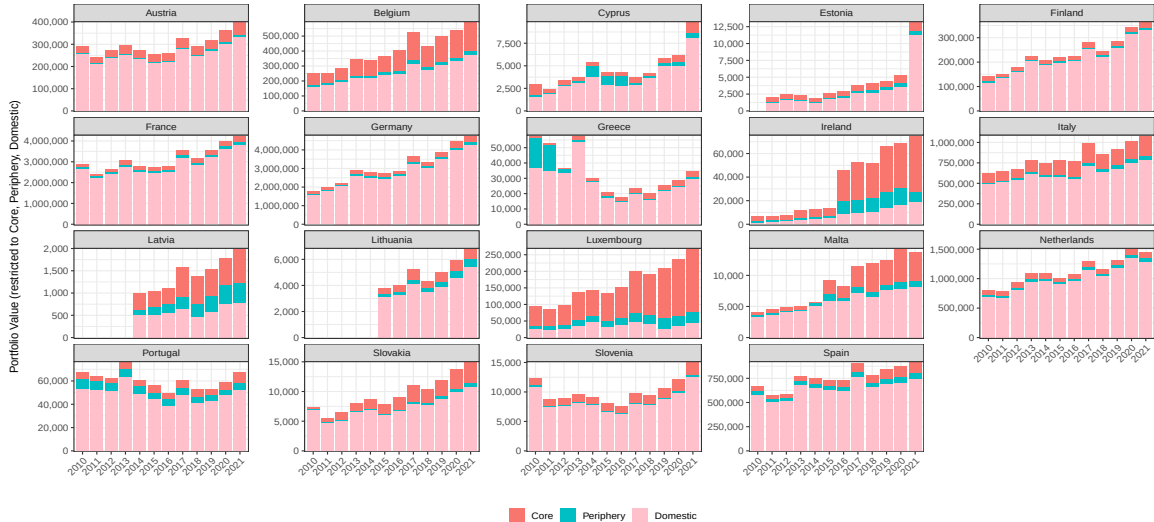
Country x Portfolio share (C) x RoW (detailed)



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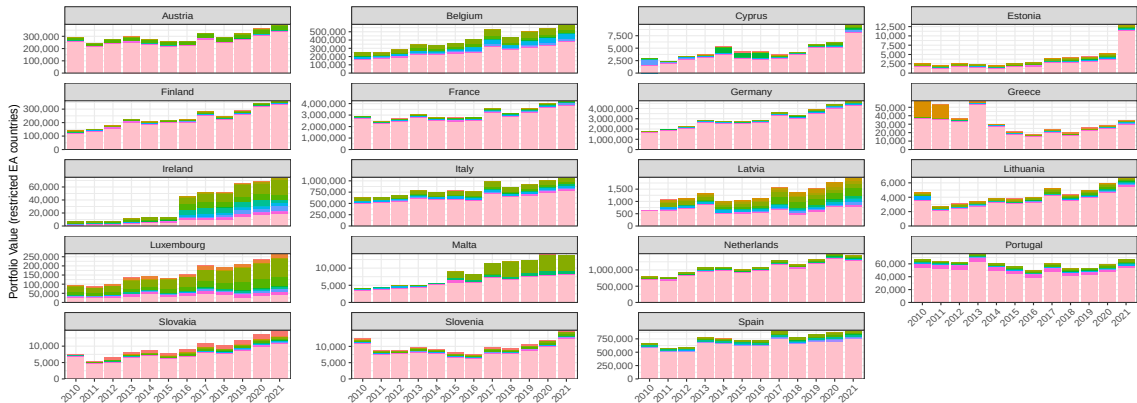
Country x Portfolio (G)



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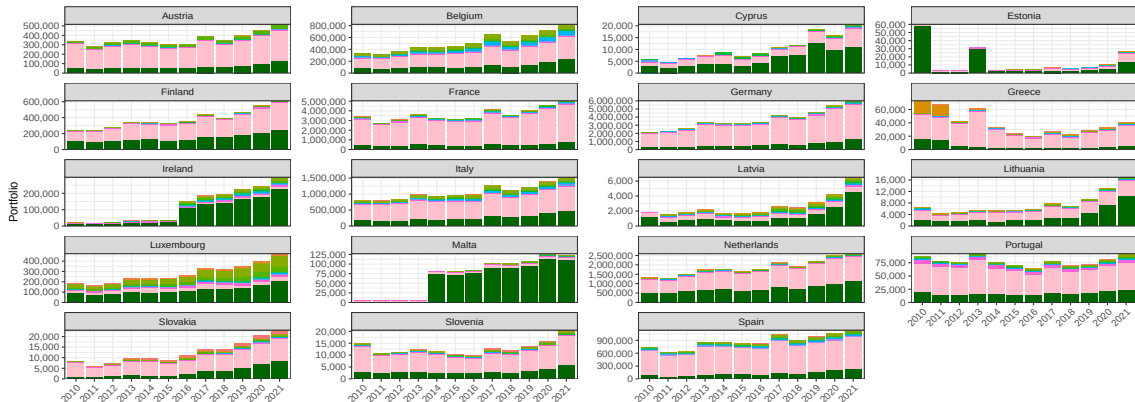
Country x Portfolio (C)



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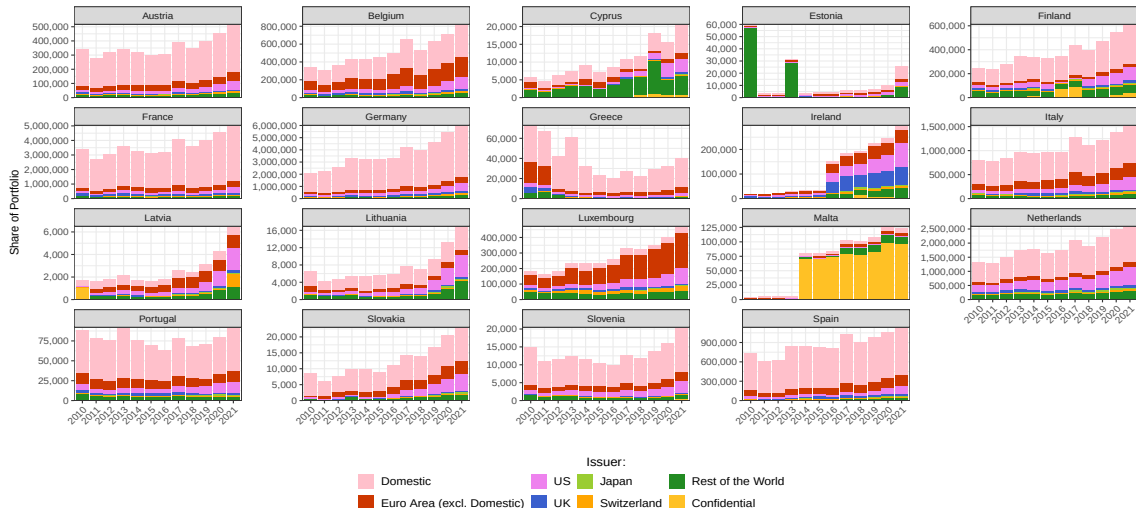
Country x Portfolio (C) x RoW



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Country x Portfolio (C) x RoW (detailed)



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Country x Liabilities share (G)



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Country x Liabilities share (C)



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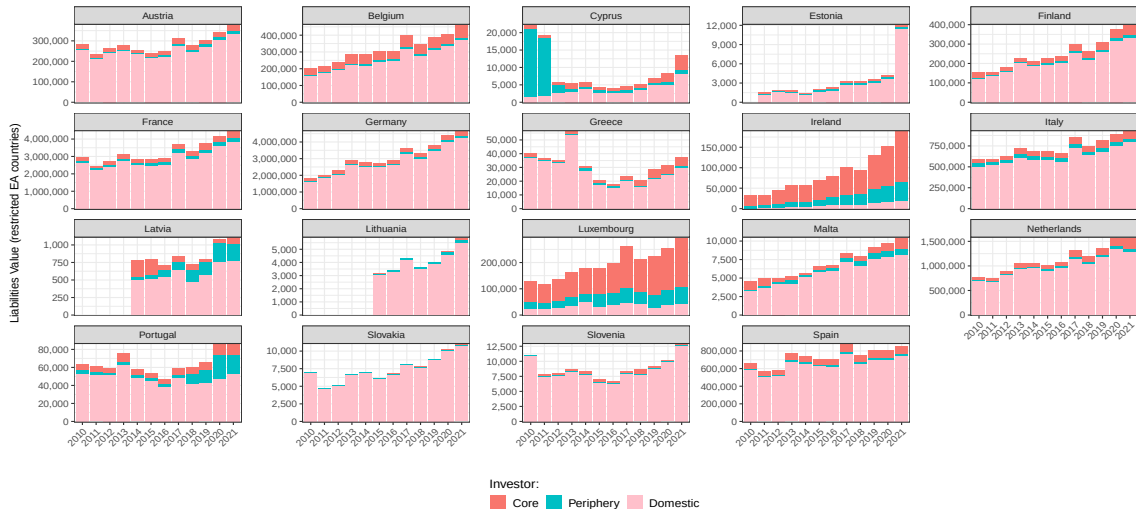
Country x Liabilities share (C) x RoW



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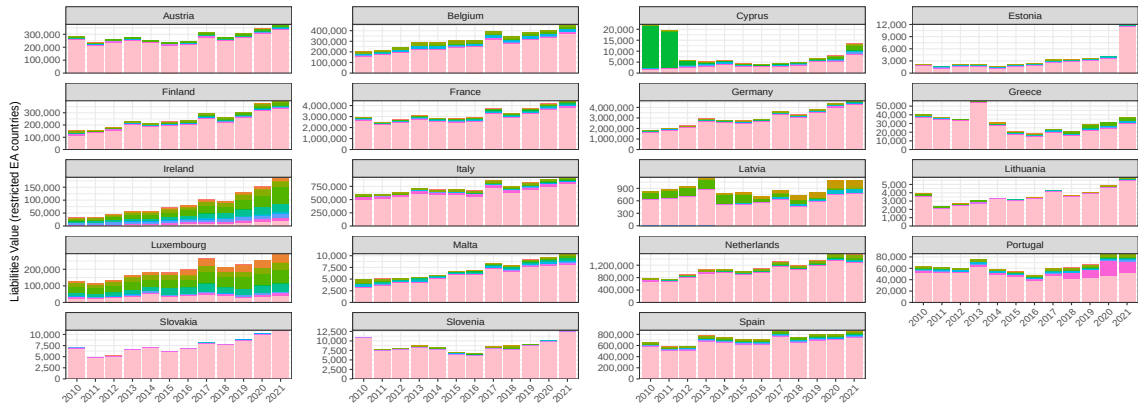
Country x Liabilities (G)



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Country x Liabilities (C)



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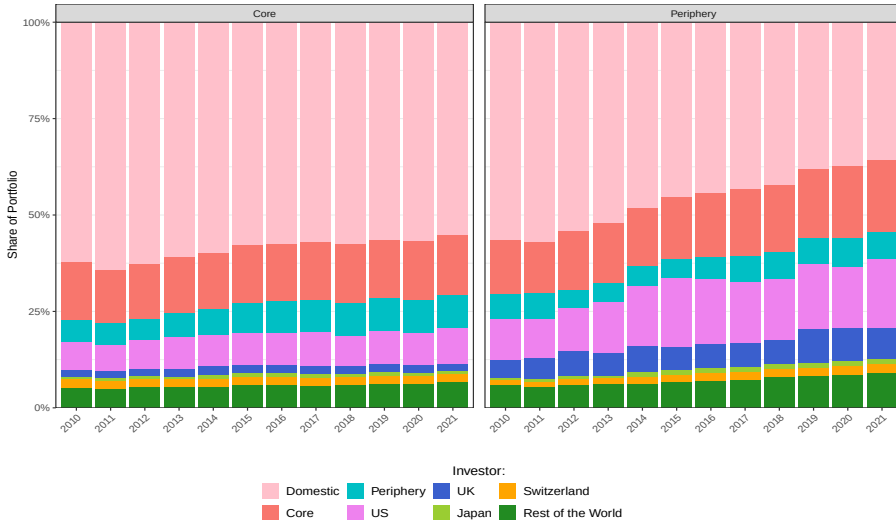
Country x Liabilities (C) x RoW



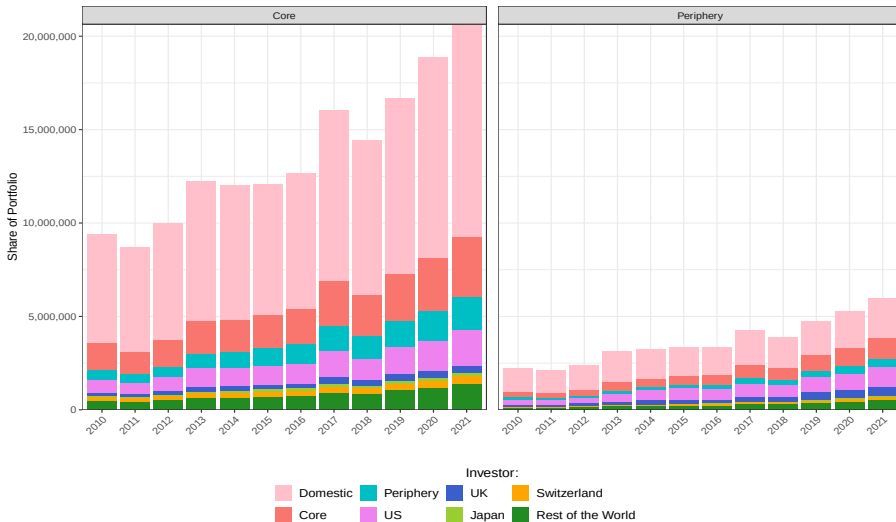
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Role of US? Share of Liabilities x RoW (No correction)



Role of US? Liabilities Value x RoW (No correction)



Preferences

- Consumption bundle, common to all agents in country i : [Dom. Share Good/Asset](#) [HB. Good/Asset](#)

$$C_t^i \equiv \left((1 - \omega_i)^{\frac{1}{\phi}} C_{i,t}^{\frac{\phi-1}{\phi}} + (\underbrace{\omega_i}_{\text{Import share}})^{\frac{1}{\phi}} C_{j,t}^{\frac{\phi-1}{\phi}} \right)^{\frac{\phi}{\phi-1}}$$

- Normalization as relative to domestic CPI:

$$p_t^i \equiv \frac{P_t^i}{CPI_t^i} \text{ and } p_t^j \equiv \frac{P_t^j}{CPI_t^j} \implies 1 = \left[(1 - \omega_i) (p_t^i)^{1-\phi} + \omega_i (p_t^j S_t)^{1-\phi} \right]^{\frac{1}{1-\phi}}$$

- Optimal allocation in country i :

$$C_{i,t}^i = (1 - \omega_i) (p_t^i)^{-\phi} C_t^i \text{ and } C_{j,t}^i = \omega_i \left(\frac{p_t^j}{S_t} \right)^{-\phi} C_t^i$$

- Real exchange rate:

$$S_t = \frac{CPI_t^j}{CPI_t^i}$$

Agents maximisation

- Share λ^i of Non-Savers: excluded from asset markets. Consume everything out of labor income:

$$C_{H,t}^i = w_t^i L_t^{U,i}$$

- Maximisation problem of the Saver:

$$\max_{\{C_{S,t}^i, E_{S,t}^i, b_{S,t}^i\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_{S,t}^i{}^{1-\sigma}}{1-\sigma} - \chi \frac{L_t^{U,i^{1+\eta}}}{1+\eta} \right)$$

$$\text{s.t. } C_{S,t}^i + E_{S,t}^i + \underbrace{b_{S,t}^i}_{\substack{\text{Union debt in net zero supply} \\ \text{(net lender/borrower)}}} = w_t^i L_t^{U,i} + r_t^i E_{S,t-1}^i + b_{S,t-1}^i \underbrace{\frac{r_{t-1}^U}{\pi_t^{CPI,i}}}_{\substack{\text{Real gross interest rate} \\ \text{given central bank decision}}} - \frac{K_E}{2} p_t^i (E_{S,t}^i - \bar{E}_S^i)^2 + \frac{K_D}{2} p_t^i b_{S,t}^i{}^2$$

- FOCs:

$$C_{S,t}^i{}^{-\sigma} \left(1 + \kappa^{E,i} p_t^i (E_{S,t}^i - \bar{E}_S^i) \right) = \beta E_t \left(C_{S,t+1}^i{}^{-\sigma} r_{t+1}^i \right)$$

$$C_{S,t}^i{}^{-\sigma} \left(1 + \kappa^{D,i} p_t^i b_{S,t}^i \right) = \beta E_t \left(\frac{C_{S,t+1}^i{}^{-\sigma} r_t^U}{\pi_{t+1}^{CPI,i}} \right)$$

► HANK equivalent

Go back: Model

Production

- Final-good firm that aggregates varieties across intermediate firms via CES in country i .
- Intermediate-good firm j :

$$Y_t^i(j) = Z_t^i K_t^{i,j\alpha} L_t^{i,j1-\alpha} \text{ at price } P_{i,t}(j)$$

- Real marginal cost:

$$\xi_t^i = \left(\frac{1}{Z_t^i} \right) \left(\frac{r_t^{K,i}}{\alpha} \right)^\alpha \left(\frac{w_t^i}{1-\alpha} \right)^{1-\alpha}$$

- Optimal allocation:

$$\frac{K_{t-1}^i}{L_t^i} = \left(\frac{\alpha}{1-\alpha} \right) \left(\frac{w_t^i}{r_t^{K,i}} \right)$$

- Flexible prices (tax/subsidy to compensate for steady-state distortion):

$$p_t^i = \xi_t^i, \Omega_t^i = 0$$

- Domestic price inflation:

$$\pi_t^i = \frac{p_t^i}{p_{t-1}^i} \pi_t^{CPI,i}$$

- Technology shock:

$$Z_t^i = Z_0^i e^{-u_t^i}, u_t^i = \rho^i u_{t-1}^i + \epsilon_t^i$$

Unions

- Competitive technology combines union-specific labor supplies in each country i .
- Quadratic adjustment costs (Rotemberg type):

$$UC_t^i(k) = \frac{\kappa_W^i}{2} \left(\frac{W_t^i(k)}{W_{t-1}^i(k)} - \bar{\pi}^W \right)^2 dk$$

- Each union k sets wages to maximize members' welfare subject to relative labor demand.
- New-Keynesian Wage Phillips curve:

$$\begin{aligned} \pi_t^{W,i} \left(\pi_t^{W,i} - \bar{\pi}^W \right) &= \mathbb{E}_t \left[\left(\pi_{t+1}^{W,i} - \bar{\pi}^W \right) \pi_{t+1}^{W,i} \right] \\ &+ \underbrace{\frac{\theta_W^i}{\kappa_W^i} \left(v'(L_t^{S,i}) - \frac{(\theta_W^i - 1)}{\theta_W^i} w_t^i \int_h y_{h,t}^i u'(c_{h,t}^i) l(dh) \right) L_t^{S,i}}_{\text{in TANK}} \\ \text{in TANK} &= \left(\chi L_t^{S,i 1+\eta} - \frac{(\theta_W^i - 1)}{\theta_W^i} w_t^i L_t^{S,i} \left(\lambda^i C_{H,t}^{i -\sigma} + (1-\lambda^i) C_{S,t}^{i -\sigma} \right) \right) \end{aligned}$$

- Domestic wage inflation:

$$\pi_t^{W,i} = \frac{p_t^{W,i}}{p_{t-1}^{W,i}} \pi_t^{CPI,i}$$

Monetary policy

- Central bank sets union-wide nominal rate r_t^U at each period t .
- Rate applies between t and $t + 1$ to the entire union (= both countries).
- Taylor rule:

$$r_t^U = \underbrace{\bar{r}}_{\text{Steady-state nominal interest rate}} + \Psi(\pi_t^{HICP} - 1)$$

- Harmonized Index of Consumer Prices (HICP):

$$\pi_t^{HICP} = \underbrace{\left(\pi_t^{CPI,C}\right)^\gamma}_{\gamma = \text{central bank weight on Core inflation}} \left(\pi_t^{CPI,P}\right)^{1-\gamma}$$

Market clearing conditions (TANK)

- Capital in country i : $K_t^i = K_{i,t}^i + K_{j,t}^i$
- Consumption in country i : $C_t^i = \lambda^i C_{H,t}^i + (1 - \lambda^i) C_{S,t}^i$
- Labor in country i : $L_t^i = \lambda^i L_t^{U,i} + (1 - \lambda^i) L_t^{U,i}$
- Equity in country i : $E_t^i = (1 - \lambda^i) E_{S,t}^i$
- Bond in country i : $b_t^i = (1 - \lambda^i) b_{S,t}^i$
- Goods market in country i :

$$Y_t^i = C_{i,t}^i + I_{i,t}^i + C_{i,t}^j + I_{i,t}^j + \frac{K_E}{2(1 - \lambda^i)} (E_t^i - \bar{E}^i)^2 + \frac{K_D}{2(1 - \lambda^i)} b_t^{i,2}$$

- Resource constraint of the economy in country i :

$$C_t^i + I_t^i + TB_t^i = p_t^i Y_t^i - \frac{\kappa^{E,i}}{2(1 - \lambda^i)} p_t^i (E_t^i - \bar{E}^i)^2 - \frac{\kappa^{D,i}}{2(1 - \lambda^i)} p_t^i b_t^{i,2}$$

- Trade balance in country i :

$$TB_t^i = b_t^i - b_{t-1}^i \frac{r_{t-1}^i}{\pi_{t,i}^{CPI,i}} + r_t^{K,i} K_{j,t-1}^i - r_t^{K,j} K_{i,t-1}^j S_t + S_t I_{j,t}^{F,i} - I_{i,t}^{F,j} + \frac{\kappa^i}{2} \left(\frac{K_{i,t-1}^i}{E_{t-1}^i} - \frac{\bar{K}_i^i}{\bar{E}^i} \right)^2 E_{t-1}^i$$

- Bond market at union level:

$$b_t^i + S_t b_t^j = 0$$

Market clearing conditions (HANK)

- Capital in country i : $K_t^i = K_{i,t}^i + K_{j,t}^i$
- Consumption in country i : $C_t^i = \int_h c_{h,t}^i l(dh)$
- Equity in country i : $A_t^i = \int_h a_{h,t}^i = E_t^i + b_t^i$.
- Goods market in country i :

$$Y_t^i = C_{i,t}^i + I_{i,t}^i + C_{i,t}^j + I_{i,t}^j + \frac{K_E}{2(1-\lambda^i)} (E_t^i - \bar{E}^i)^2 + \frac{K_D}{2(1-\lambda^i)} b_t^{i2}$$

- Trade balance in country i :

$$TB_t^i = b_t^i - b_{t-1}^i \frac{r_{t-1}^i}{\pi_t^{CPI,i}} + r_t^{K,i} K_{j,t-1}^i - r_t^{K,j} K_{i,t-1}^j S_t + S_t I_{j,t}^{F,i} - I_{i,t}^{F,j} + \frac{\kappa^i}{2} \left(\frac{K_{i,t-1}^i}{E_{t-1}^i} - \frac{\bar{K}_i^i}{\bar{E}^i} \right)^2 E_{t-1}^i$$

- Bond market at union level:

$$b_t^i + S_t b_t^j = 0$$

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[Go back: HANK](#)

Idiosyncratic income risk

- Each household faces an **idiosyncratic, uninsurable productivity shock**

$$y_t \in \mathcal{Y} = \{y_1, \dots, y_n\}.$$

- Idiosyncratic productivity follows a **time-homogeneous Markov chain** with transition probabilities $\pi_{yy'}$.
- Risk generates **persistent heterogeneity in earnings and wealth** even in absence of aggregate shocks.
- Let S_y denote the invariant distribution over productivity states, satisfying:

$$S_y = \sum_{\tilde{y} \in \mathcal{Y}} \pi_{\tilde{y}y} S_{\tilde{y}}, \quad \forall y \in \mathcal{Y}.$$

- Identical calibration of individual shock in **Core and Periphery**.
- Steady-state mass at borrowing constraint: **Core = 31.1%**, **Periphery = 58.2%**.

One-asset equivalent

- Household now buys only the mutual fund claim A_t^i .
- Fund reallocates internally btw. equity E_t^i and bonds b_t^i , such that $A_t^i = E_t^i + b_t^i$ (and $E_t^i = K_{i,t}^i + K_{i,t}^j S_t$).
- Household FOC for A_t^i :

$$C_{S,t}^i^{-\sigma} \left(1 + p_t^i \left(\frac{E_t^i}{A_t^i} \frac{\kappa_E}{(1-\lambda^i)} (E_t^i - \bar{E}^i) + \frac{b_t^i}{A_t^i} \frac{\kappa_D}{(1-\lambda^i)} b_t^i \right) \right) = \beta \mathbb{E}_t [C_{S,t+1}^i^{-\sigma} r_{t+1}^A]$$

- Fund return:

$$r_t^A A_{t-1}^i = r_t^i E_{t-1}^i + \frac{r_{t-1}^U}{\pi_{CPI,i}^i} b_{t-1}^i$$

- Fund overall no-arbitrage condition:

$$\mathbb{E}_t(r_{t+1}^i) + \frac{\kappa_D}{(1-\lambda^i)} p_t^i b_t^i = \frac{r_t^U}{\pi_{CPI,i}^i} + \frac{\kappa_E}{(1-\lambda^i)} p_t^i (E_t^i - \bar{E}^i)$$

- Equity arbitrage remains as before:

$$r_t^i E_{t-1}^i = (r_t^{K,i} + 1 - \delta^i) K_{i,t-1}^i + (r_t^{K,j} + 1 - \delta^j) K_{i,t-1}^j S_t - \frac{\kappa^i}{2} \left(\frac{K_{i,t-1}^i}{E_{t-1}^i} - \frac{\bar{K}_i^i}{\bar{E}^i} \right)^2 E_{t-1}^i$$

$$\mathbb{E}_t(r_{t+1}^{K,i} + 1 - \delta^i) = \mathbb{E}_t \left((r_{t+1}^{K,j} + 1 - \delta^j) \frac{S_{t+1}}{S_t} \right) + \kappa^i \left(\frac{K_{i,t}^i}{E_t^i} - \frac{\bar{K}_i^i}{\bar{E}^i} \right)$$

- **Preferences and Risk Attitudes:**

- CRRA vs. habit formation, recursive preferences: can rationalize skew toward domestic assets (Merton, 1969; Campbell & Cochrane, 1999; Epstein & Zin, 1989; Coeurdacier & Rey, 2013).

- **Background Risks (non-tradable income):**

- Labor income, entrepreneurial/business wealth, and housing risks reduce incentives to diversify internationally (Heaton & Lucas, 1997, 2000; Curcuru, Heaton, Lucas & Moore, 2010; Baxter & Jermann, 1997; Guiso, Sapienza & Zingales, 2018).

- **Market Frictions:**

- Fixed participation costs, transaction costs, taxes, and borrowing constraints hinder diversification (Constantinides, 1986; Vissing-Jorgensen, 2002; Martin & Rey, 2004; Du, Koch & Schreger, 2023).

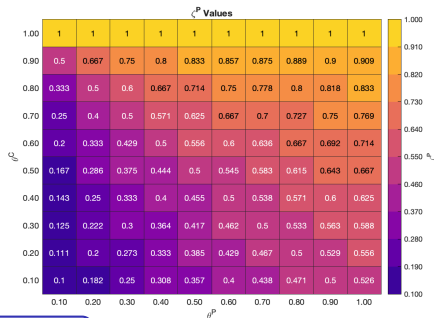
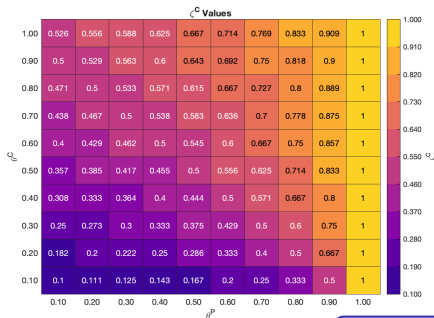
- **Institutional Features:**

- Restricted pension investments, employer stock in retirement plans, informational frictions (Curcuru et al., 2010; Sialm, Sun & Zheng, 2015; Lambert, Molestina Vivar & Wedow, 2023).

Portfolio determination

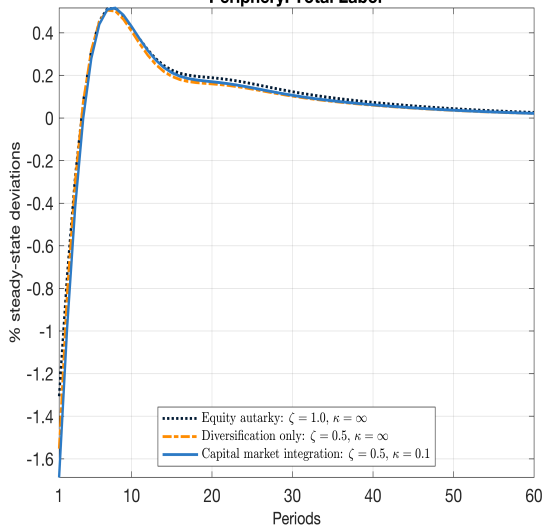
- Not all combinations of (ζ^i, ζ^j) are simulable $\rightarrow$ corner solutions.
- Define for each country θ^i = share of capital that is domestically owned $\rightarrow K_i^i = \theta^i K^i$.
- Total equity: $E^i = K_i^i + K_i^j S = \theta^i K^i + (1 - \theta^j) K^j S$
- Steady-state portfolios: exposure to domestic shock $\rightarrow$ enable to simulate any combination of (θ^i, θ^j) .

$$\zeta^i = \frac{\bar{K}_i^i}{\bar{E}^i} = \frac{\theta^i \bar{K}^i}{\bar{E}^i}$$

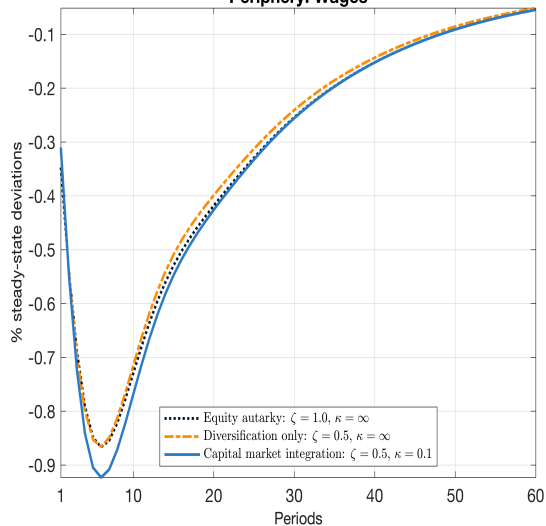


Parameter	Value	Description	Source
β	0.99	Discount factor	Smets and Wouters (2003)
α	0.36	Capital share	Krueger et al. (2017)
σ	2.0	Relative risk aversion	CRRA
ϕ	2.0	Elasticity of substitution (home vs. foreign)	Pasch and Tervala (2024)
δ	0.025	Depreciation rate (quarterly)	Smets and Wouters (2003)
η	2.0	Inverse Frisch elasticity of labor supply	Chetty et al. (2011)
Ψ	1.5	Taylor rule coefficient on inflation	Darvas and Merler (2013)
κ_D	0.10	Debt adjustment cost	Schmitt-Grohe and Uribe (2003)
κ_E	0.10	Equity adjustment cost	Schmitt-Grohe and Uribe (2003)
ρ_z	0.95	TFP autocorrelation	Den Haan (2010)
Λ	1.0	Saver wage premium	Normalization
θ_W	21.0	Wage markup elasticity	Bilbiie and Ragot (2021)
κ_W	2100	Wage adjustment cost	Bilbiie and Ragot (2021)
Steady-State Normalization			
GDP^C	1.0	Gross nominal product in Core	Normalization
L^C	1/3	Hours worked in Core	Normalization

Periphery: Total Labor

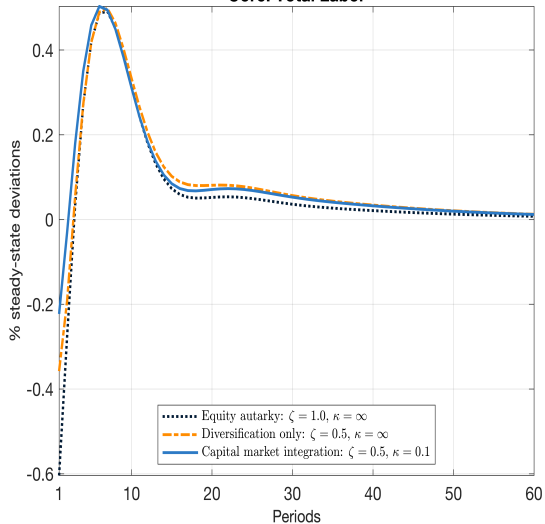


Periphery: Wages

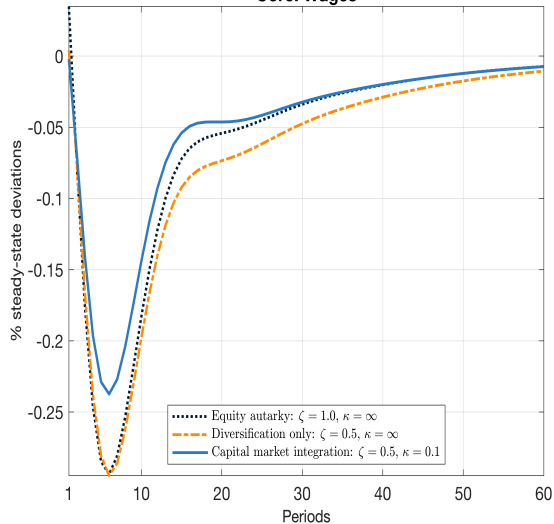


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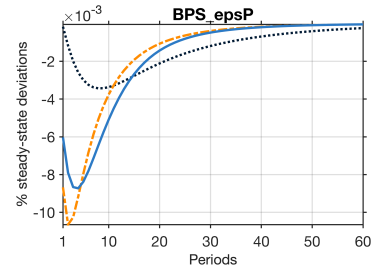
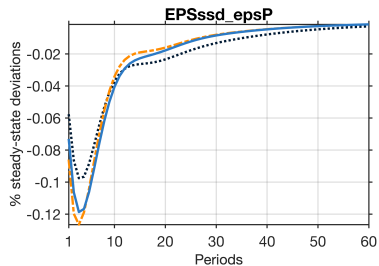
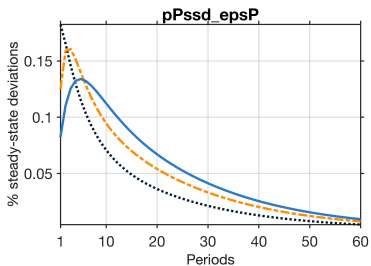
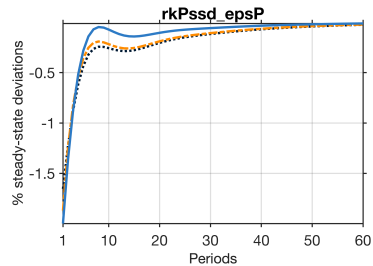
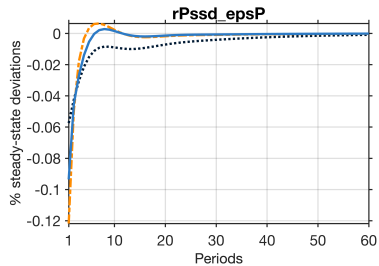
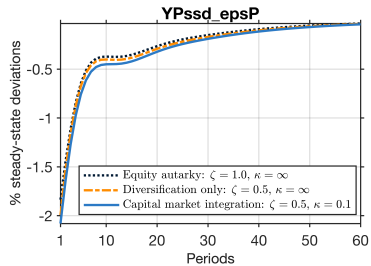
Core: Total Labor



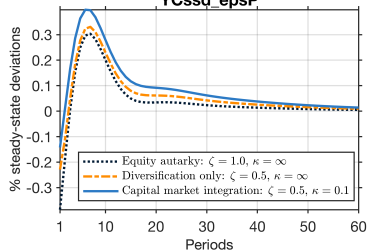
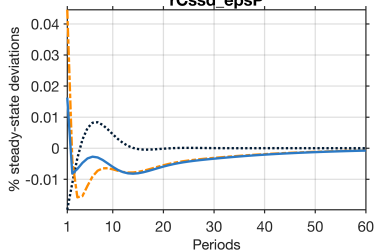
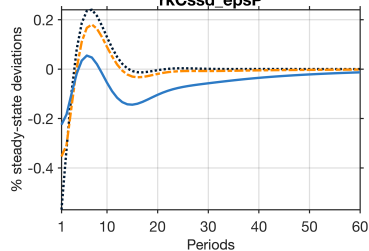
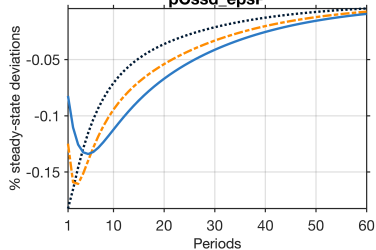
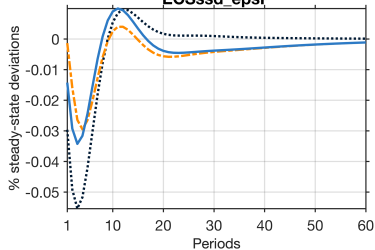
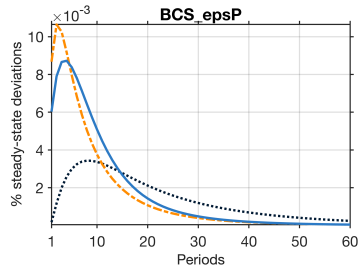
Core: Wages



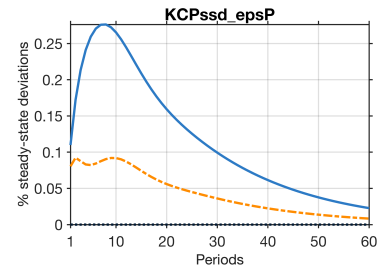
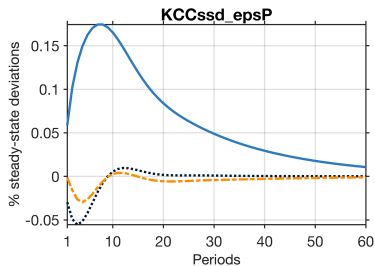
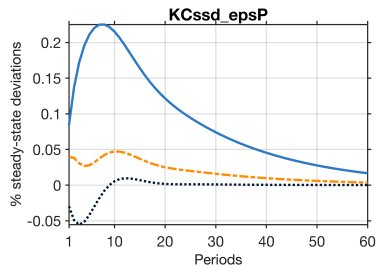
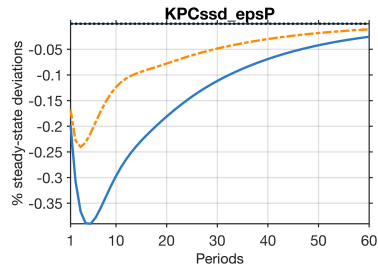
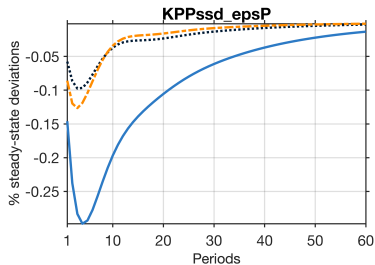
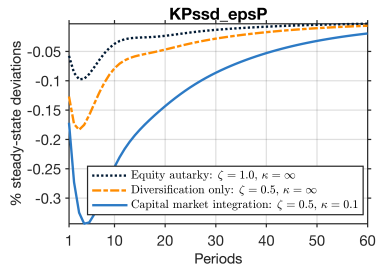
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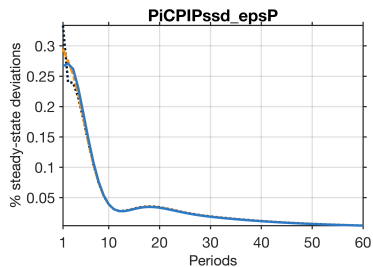
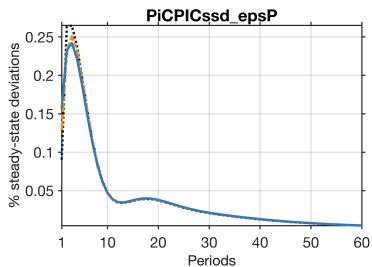
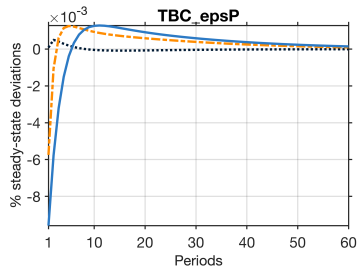
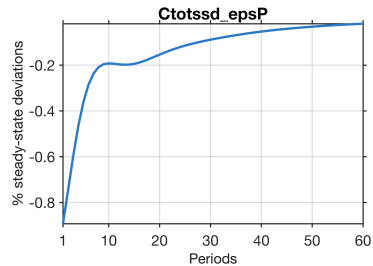
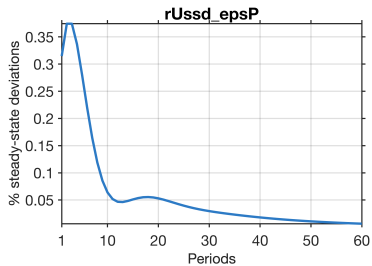
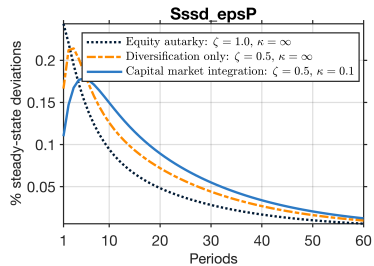
[Go back: Symmetric case](#)

YCssd_epsP**rCssd_epsP****rkCssd_epsP****pCssd_epsP****ECSsd_epsP****BCS_epsP**

[Go back: Symmetric case](#)



[Go back: Symmetric case](#)



[Go back: Symmetric case](#)

TANK: euro-area calibration

- Calibration for Core and Periphery in 2010.

Parameter	Core	Periphery	Source
Domestic portfolio share	$\zeta^C = 0.97$	$\zeta^P = 0.89$	CPIS (IMF), corrected with SHS, Beck et al. (2024)
Share of Non-Savers	$\lambda^C = 0.43$	$\lambda^P = 0.67$	HFCS (ECB, 2010 wave)
Import share	$\omega^C = 0.33$	$\omega^P = 0.39$	Eurostat, national accounts (imports/GDP)
Portfolio adjustment cost	$\kappa^C = 0.10$	$\kappa^P = 0.10$	Calibrated (see general calibration)
Inflation weight in union	$\gamma = 0.60$	$1 - \gamma = 0.40$	ECB (HICP weights, 2010)
TFP shock	$\sigma_z^C = 0.0423$	$\sigma_z^P = 0.2905$	Q4 deviation from pre-crisis trend (2011)
GDP ratio $\frac{GDP^P}{GDP^C}$	$\psi = 0.23$		Equity ratios $\frac{E^P}{E^C}$ from CPIS (IMF)

- Higher financial participation and home bias in the **Core**.
- Larger mass of constrained households and diversification in the **Periphery**.

What is the impact of omitting calibrated capital market integration?

- **Hold inequality fixed:** same shares of Savers and Non-Savers in both cases.
- **Vary integration only:** compare calibrated euro-area portfolios to **equity autarky**.

Case	ζ (= domestic share)		κ (= portfolio adj. cost)	
	Core	Periphery	Core	Periphery
Equity autarky	1.0	1.0	∞	∞
Calibrated (2010)	0.97	0.89	0.1	0.1

[Go back: Additional results](#)

HANK: euro-area calibration

- Calibration for Core and Periphery in 2010.

Parameter	Core	Periphery	Source
Domestic portfolio share	$\zeta^C = 0.97$	$\zeta^P = 0.89$	CPIS (IMF), corrected with SHS, Beck et al. (2024)
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Portfolio adjustment cost	$\kappa^C = 0.10$	$\kappa^P = 0.10$	
Inflation weight in union	$\gamma = 0.60$	$1 - \gamma = 0.40$	ECB (HICP weights, 2010)
TFP shock	$\sigma_z^C = 0.00$	$\sigma_z^P = -0.19$	
GDP ratio $\frac{GDP^P}{GDP^C}$			Equity ratios $\frac{E^P}{E^C}$ from CPIS (IMF)
$\psi = 0.23$			

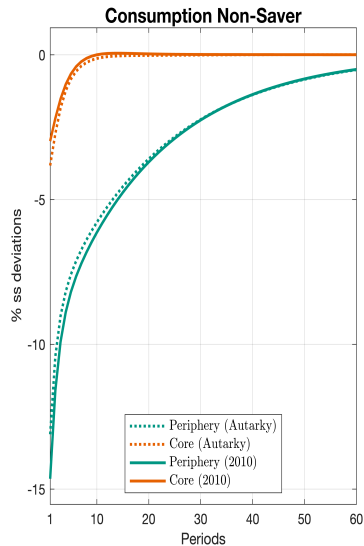
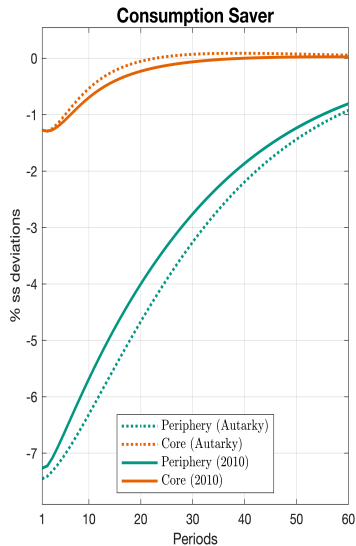
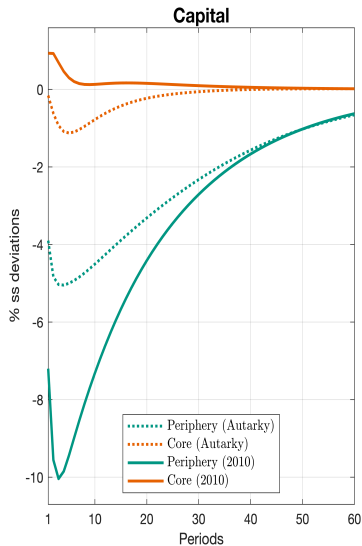
- Higher financial participation and home bias in the **Core**.
- Larger mass of constrained households and diversification in the **Periphery**.

► Calib. HANK parameters

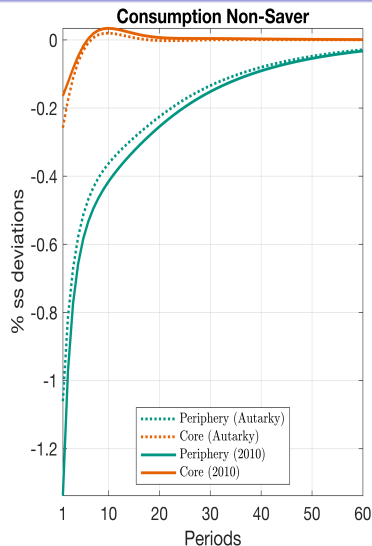
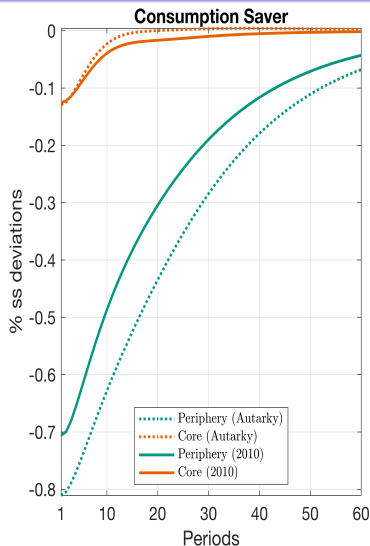
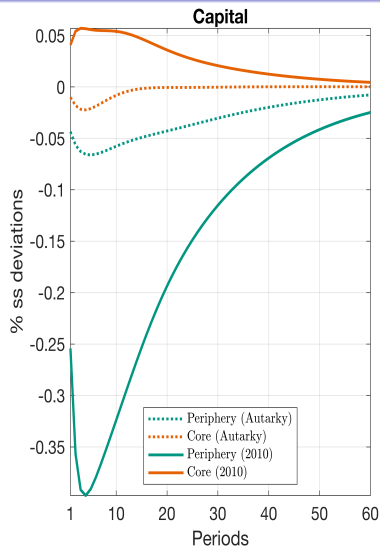
► HANK solution method

Go back: Quantification

Same mechanisms, but different magnitudes



1% decline in productivity in the Periphery only (TANK)



[Go back: Main results](#)

[Go back: Additional results](#)

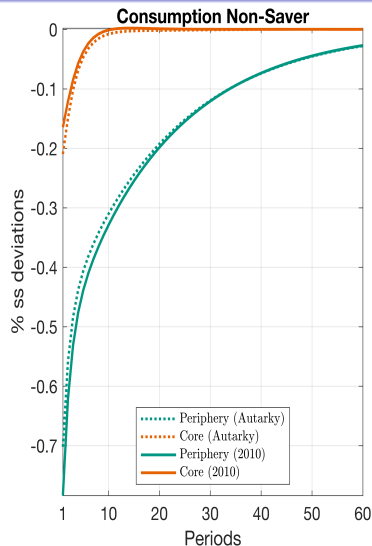
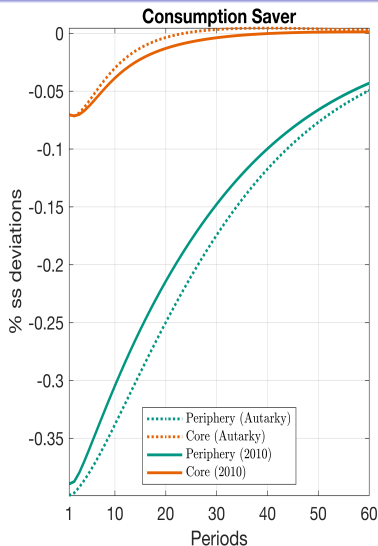
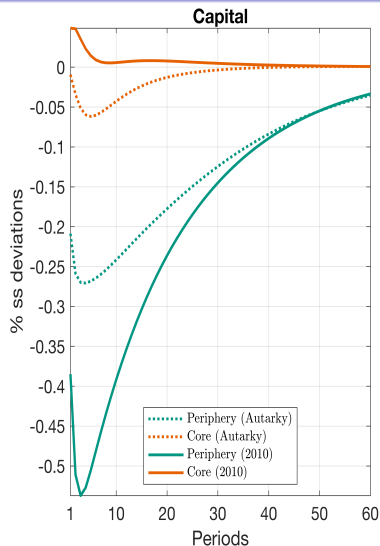
HANK calibration: general parameters

Parameter	Value	Description	Source
β	0.93	Discount factor	Smets & Wouters (2003)
α	0.36	Capital share	Krueger et al. (2017)
σ	2.0	Risk aversion (CRRA)	Standard
ϕ	2.0	Home-foreign elasticity	Pasch et al. (2024)
δ	0.025	Capital depreciation (q)	Smets & Wouters (2003)
η	2.0	Inverse Frisch elasticity	Chetty et al. (2011)
Ψ	1.5	Taylor-rule inflation coeff.	Darvas (2013)
κ_D	0.10	Debt adjustment cost	Schmitt-Grohé & Uribe (2003)
κ_E	0.10	Equity adjustment cost	Schmitt-Grohé & Uribe (2003)
ρ_Z	0.95	TFP persistence	Den Haan (2010)
ρ_y	0.96	Idiosyncratic income persistence	Author
σ_y	0.11	Idiosyncratic income risk (ann.)	Author
N_a	300	Asset grid points	Discretization
N_y	2	Income states	Rouwenhorst
$\bar{a}$	0.0	Borrowing limit	Mass at constraint
θ_W	21	Wage markup elasticity	Bilbiie et al. (2021)
κ_W	2100	Wage adjustment cost	Bilbiie et al. (2021)
Steady-state normalization			
r^U	1.065	Gross nominal interest rate	Asset market clearing

HANK solution method

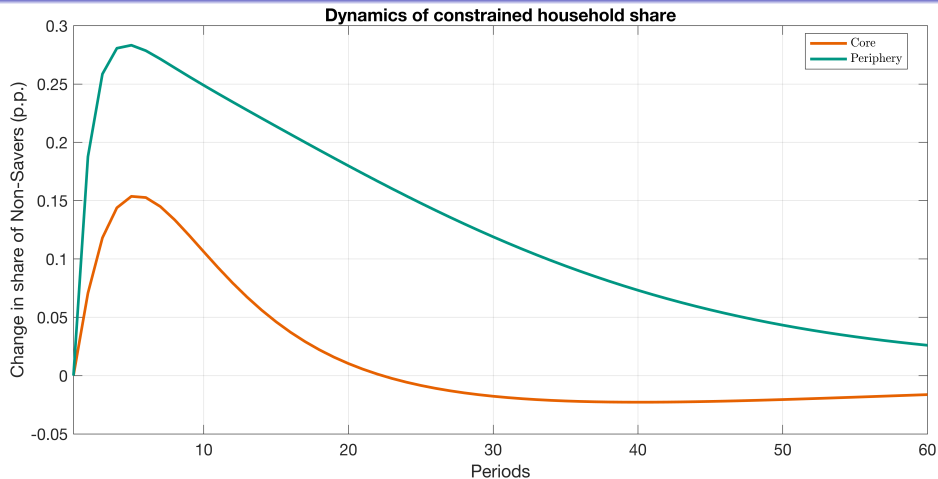
- Solving a HANK model with aggregate shocks is challenging because:
 - the state space includes the full household distribution,
 - policy functions depend on both aggregate states and the distribution itself.
- I solve the model using a **hybrid projection–perturbation approach**:
 - stationary equilibrium with idiosyncratic risk, no aggregate uncertainty,
 - discretized household state space (endogenous grid method),
 - linearization around the stationary distribution.
- The distribution is treated as an additional aggregate state, summarized by a finite set of moments.
- This approach follows [Reiter \(2009\)](#), combined with the simulation strategy of [Young \(2010\)](#).

1% decline in productivity in the Periphery only (HANK)



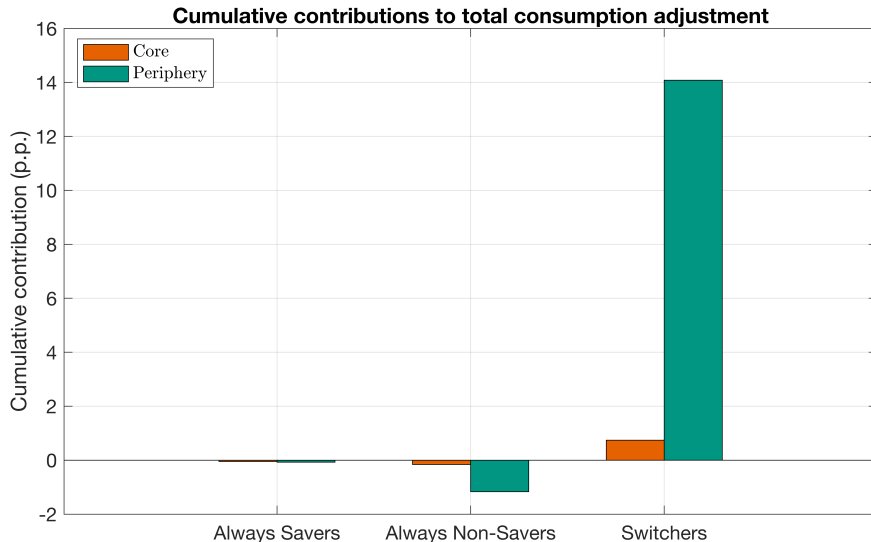
[Go back: HANK results](#)

Endogenous tightening of financial constraints



- Negative shock raises the share of constrained households endogenously.
- Increase is larger and more persistent in the **Periphery**: weaker buffers and stronger income losses.

Who adjusts? Switchers from Savers to Non-Savers



- Aggregate adjustment is driven by households switching into constraint: **Switchers**.



Paper discussion

“Stablecoins under Stress in a National Economy” by Saggese, Sigmund, Raunig, Segalla, Haslhofer and Makridis (2026)

Giulio Bagattini (ESMA)

The paper at a glance

- **Topic:** How crypto/stablecoin users react to major stress episodes – with attention to user type, asset and direction of flow.
- **Data:** Transaction-level deposits and withdrawals to/from all wallet addresses controlled by 12 Austrian regulated crypto-asset service providers (CASPs).
 - NB: No visibility on customers' off-chain ledger balances, trades executed on a CASP's platform, or the ultimate disposition of withdrawn funds.
- **Research questions:**
 - Do crypto/stablecoin flows respond to stress episodes?
 - How do retail-like and institutionally-mediated users react?
 - Do aggregate flows conceal markedly different behaviors across users, assets and destinations?

- **Registry-based data:** Measures precisely the entire CASP-intermediated segment in a specific jurisdiction
 - Overcomes data limitations of other recent studies, e.g. Auer et al. (2025) “DeFying gravity? An empirical analysis of cross-border Bitcoin, Ether and stablecoin flows”: *“external data providers [...] link pseudonymous blockchain addresses and their transactions to entities such as crypto exchanges using proprietary attribution data. In addition, they rely on clustering heuristics to support attribution by grouping addresses that belong to the same entity. [...] The entity-to-entity data are complemented by the geographic distribution of app usage of the respective exchange or the web traffic of a crypto exchange’s website.”*
- **Flow decomposition:** Separates external flows from CASP-CASP and within-CASP movements, uncovering how much on-chain volume is internal or intermediary-driven, and shows that raw transaction counts can mislead
- **User heterogeneity:** Improves the identification of retail-like versus institutional activity at a large scale (3.2m transactions, EUR 50bn)
- **Empirical insights:** Leverages flow decomposition to uncover otherwise confounded investor reactions to market distress
 - Post-SVB dynamics explained by stablecoin two-tier redemption model: institutions redeem at par; retail sells on secondary markets

- The authors do a great job at leveraging this unique granular dataset to obtain a well-grounded **inference of retail vs institutional activity**
- However, the subsequent empirical design focuses on the **aggregate flows** (retail vs institutional, by asset) around key events
- This is useful to study the macro dynamics, but it **leaves on the table a lot of heterogeneity** that could improve identification and yield further insights into the channels at play!
- **Exploit the panel structure** (address × CASP × asset × time) to:
 - relate flows to prior holdings (% change), stablecoin share, account size and exposures
 - study CASP heterogeneity
 - control for prior wallet activity, market returns, off-chain trading volumes
 - ...
- The identification of abnormal flows could be strengthened by **directly comparing activity in distressed and non-distressed assets** (control group)

Extensions/improvements: Identification of economic activity

- The paper uses blockchain movements to/from CASP wallets to infer economic behaviour consistent with the data:
 - Retail withdrawal → Self-custody
 - Institutional stablecoin withdrawal → Redemption at par
 - Flow change → Portfolio rebalancing or risk reduction
- Can this powerful dataset be used for **stronger identification of economic activity** – when complemented with other sources that allow connecting CASPs' deposits and withdrawals to investors' decisions?
- Potential measures: stablecoin primary redemptions, off-chain trading volumes, market prices, peg deviations, DeFi activity...
- Example: identify the *CASP* → *Circle* redemption chain after SVB shock by looking at actual redemption volumes?
 - Ma, Zeng and Zhang (RFS 2026) collect transaction-level minting and redemption events for the six largest stablecoins from the Ethereum, Avalanche, and Tron blockchains
 - Du, Sonawane and Watsky (2025) track USDC transaction-level minting and redemptions on Avalanche, Ethereum, Solana, and TRON to identify SVB contagion to DeFi (Dai stablecoin)

Policy takeaways

- CASP registry data look like a **promising platform for financial-stability analysis and developing supervisory indicators**, especially when combined with on-chain and off-chain data
- If crypto keeps growing more interconnected with traditional finance, **understanding these linkages through effective analytical tools** that link the different layers will become increasingly relevant
- **Stablecoins are a prime example**: a growing adoption could have implications for financial stability, monetary policy transmission, international capital flows and banks' funding costs
- **Hopefully, we will see more of these win-win arrangements** where skilled researchers get access to rich regulatory data, regulators get new analytical tools, and we build the capacity to keep a fast-evolving sector well understood and monitored



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 [European Securities and Markets Authority \(ESMA\)](https://www.linkedin.com/company/european-securities-and-markets-authority/)

Stablecoins under Stress in a National Economy

Transaction-Level Evidence from Austrian Crypto-Asset Service Providers

Pietro Saggese^{1,2} Michael Sigmund³ Burkhard Raunig³
Esther Segalla³ Bernhard Haslhofer² Christos A. Makridis^{2,4}

¹IMT Scuola Alti Studi Lucca ²Complexity Science Hub

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ESMA Research Conference 2026

Paris, September 22nd, 2026

Motivation



A major asset class
~\$2.2 trillion market cap



Entangled with TradFi
stablecoin reserves,
custodians, institutions



Matters for stability
monetary transmission,
public digital money

Open questions

1

How large and how structured is crypto activity *within* a national economy?

2

How do retail and institutional actors react to systemic shocks?

3

Do stablecoins act as a within-crypto **safe haven**?

The measurement problem: on-chain activity has no location

Blockchains are

- **pseudonymous:**
addresses, not names
- **cheap to fragment:**
fresh addresses by design
- **borderless:**
no geographic identifier

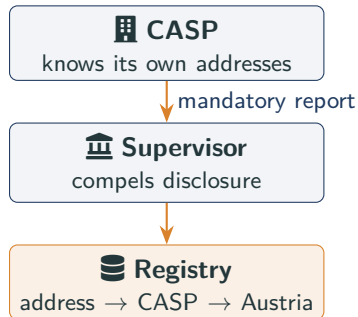
So existing work has to guess

- **Geography by proxy:** web traffic, exchange location, IP relay data, surveys
(Chainalysis Geography of Crypto Report 2025; BIS Project Atlas 2023)
- **Ownership by heuristics:** address clustering misses and misattributes addresses at entity level
(Müller et al. 2026)

💡 Proxies are **noisy and partial**, heuristics **misattribute**: jurisdiction-level flows cannot be measured reliably by inferring *who* owns an address and *where* they are.

Our approach: a regulatory entity-to-address mapping

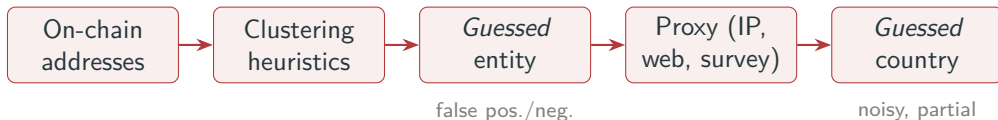
- Austrian CASPs must **report all blockchain addresses they control** to the competent financial authority
- Result: a pseudonymized **address-to-entity registry** covering **all 12 CASPs** registered at end-2024
- Ownership is **disclosed, not inferred**:
 - no clustering, no proxies
 - no false positives from heuristics
- Retroactive: includes past addresses



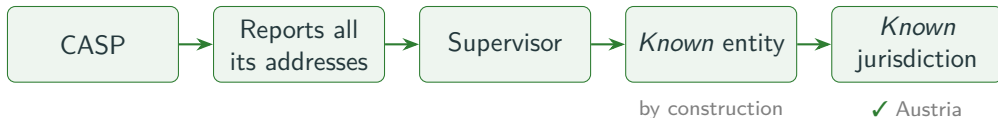
💡 Only CASPs know their addresses, and only supervisors can compel disclosure: the only way to bind on-chain flows to a jurisdiction without guessing.

Inferred vs. reported attribution

Heuristics & proxies (state of the art)



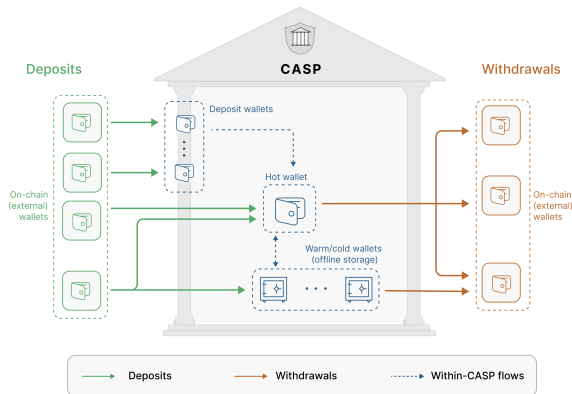
Regulatory registry (this paper)



Only external *counterparties* remain pseudonymous; we classify them from on-chain behavior (later).

💡 To our knowledge, the first study that observes *all* licensed CASPs of a jurisdiction at transaction level.

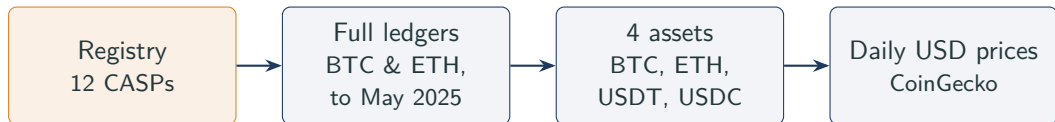
What the registry reveals: CASP wallet architecture



- **Hot wallets:** customer deposits & withdrawals
- **Warm / cold wallets:** secure storage, large-value transfers
- Customer balances live in an off-chain ledger; only on-chain movements are public

💡 Knowing every address *and its tier* lets us separate bookkeeping from market activity, and large counterparties from small ones.

From registry to flows



11.98M

asset transfers
(3.21M transactions)

\$50.4B

total volume through
Austrian CASP wallets

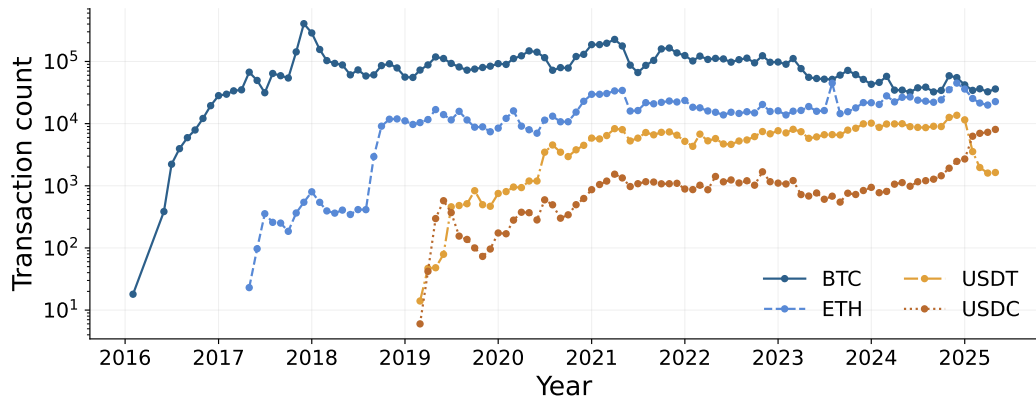
3

shocks selected
from 19 large events
via Google Trends

Volume by asset: BTC 65.5 % ETH 15.9 % USDT 15.5 % USDC 3.1 %

We observe changes in on-chain custodial exposure, not off-chain trades or final custody.

CASP activity over time



💡 Bitcoin dominates since 2016; Ether from 2017, stablecoins from 2019. Activity peaks around 2021, while stablecoin activity keeps growing.

Decomposing flows by counterparty

\$30B

CASP-to-market
activity with
external actors

\$5.8M

CASP-to-CASP
3,040 transfers between
Austrian CASPs

\$20.7B

Within-CASP
41.1 % of volume,
6.7 % of transfers

- Austrian CASPs are integrated **globally, not domestically**
- Internal bookkeeping would be **misread as economic activity** in aggregate on-chain data

💡 This decomposition requires knowing which addresses belong to which domestic entity: the entity mapping makes it possible.

Who are the counterparties? Retail-like vs. institutional

Basic idea: identities are hidden, but behavior is not. Two signals of a large player:

1. **Wallet tier:** transacts with warm/cold wallets
0.77 % of transfers, 57.8 % of volume
2. **Activity:** among the most active addresses on the chain

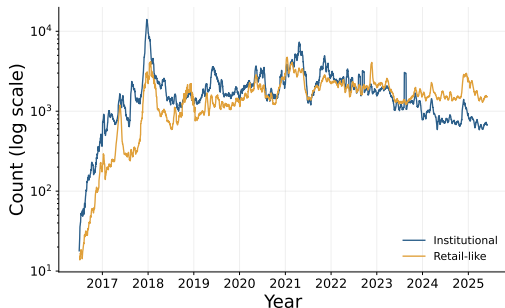
Neither signal $\Rightarrow$ **retail-like**

	institutional	retail-like
warm/cold	OTC desks, custodians	exchanges, market makers
hot only	Retail-like	aggregators, arbitrageurs
	low activity	high activity

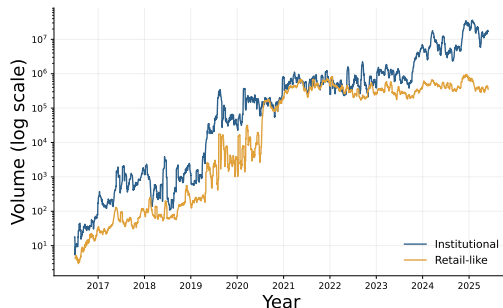
💡 ~98 % of counterparty addresses are **retail-like** (~\$1,500 per transaction), while a few hundred **institutional** addresses carry most of the value.

Retail by count, institutions by value

Daily transaction count



Daily volume (USD)



Retail-like vs. **institutional**: since 2023 retail-like dominates counts, while institutional volume rises $\sim 100\times$ to $\sim \$10^7/\text{day}$.

💡 The two margins move independently. **How do these groups react under stress?**

Event Study: Responses to Major Crypto Shocks

Three shocks (Google Trends salience, AT & worldwide)

Terra-Luna: algorithmic stablecoin
05-05-2022 selling pressure on LUNA
09/11-05 final depeg; failed rescue

FTX: custodial counterparty
02-11-2022 Alameda exposure to FTT
08/09-11 FTT crash; Binance exits deal
11-11 bankruptcy filing

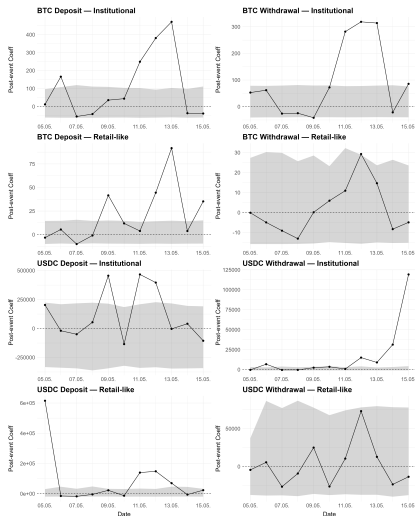
SVB: bank with stablecoin reserves
10-03-2023 SVB fails
11-03 Circle: \$3.3B exposure

Daily abnormal flows (Kothari & Warner 2007)

$$x_t = \alpha + \beta r_t + \sum_{k=0}^{10} \gamma_k D_t^k + \varepsilon_t$$

- x_t : volume in native units per asset $\times$ direction $\times$ group
- r_t : BTC / ETH return control
- 45-day estimation window, 10-day event window
- Bootstrap intervals, 1,000 resamples
- Robust to 30–60 day windows & transaction counts

Terra-Luna crash (May 2022)

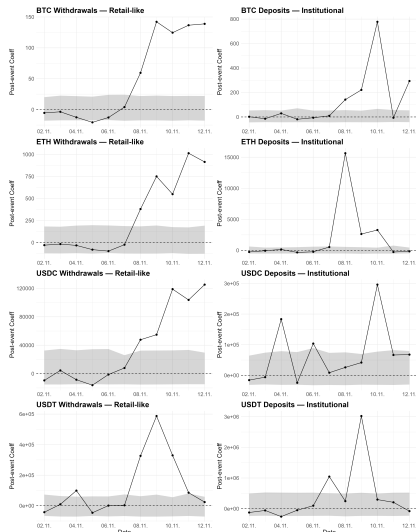


Rows: BTC and USDC, each institutional & retail-like.
Left: deposits, right: withdrawals.

- **BTC institutional:** deposits *and* withdrawals rise after 11 May
→ active rebalancing
- **USDC:** volatile spikes around depeg dates, no persistent inflow
→ short-run liquidity management

💡 Broad reallocation and volatility, *not* a flight into stablecoins.

FTX collapse (November 2022)



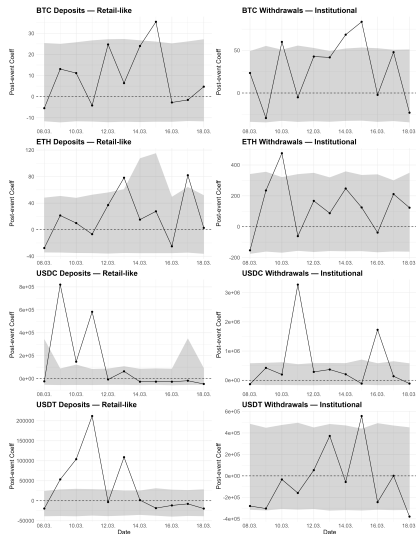
Rows: BTC, ETH, USDC, USDT.

Left: retail-like withdrawals, right: institutional deposits.

- **Retail-like:** withdrawals rise from 8–12 Nov, especially BTC & ETH
→ reduced custodial exposure
- **Institutional:** large deposit spikes 8–10 Nov
→ liquidity & inventory management

💡 Same shock, different margins: retail exits custody, institutions rebalance.

Silicon Valley Bank failure (March 2023)



Rows: BTC, ETH, USDC, USDT.

Left: retail-like deposits, right: institutional withdrawals.

- **BTC, ETH:** no persistent response
- **USDC:** retail-like deposits spike 9 & 11 Mar; institutional withdrawals spike 11 Mar (Circle disclosure)
- Matches USDC's **two-tier redemption**: only institutions redeem at par; retail sells on secondary markets (Ma et al. 2026)

💡 A narrow stablecoin channel, split sharply by group.

No uniform safe haven

Shock	Retail-like	Institutional	Stablecoins
Terra-Luna crypto-native confidence	weaker BTC deposit response	BTC deposits & withdrawals rise together	volatile, no persistent inflow
FTX custodial counterparty	persistent withdrawals (all assets)	large episodic deposits	withdrawn like other assets
SVB bank / reserve exposure	USDC & USDT deposits	USDC withdrawals	two-sided, USDC-specific

- No flight-to-quality reallocation into stablecoins (contra Anadu et al. 2024; Oefele et al. 2024)
- Consistent with heterogeneous dynamics (Aldasoro et al. 2025; Campello et al. 2025)

💡 Opposing retail and institutional flows **cancel out in aggregate data**; only group-resolved, jurisdiction-bound flows reveal them.

Supervisors

- Collect address registries directly from supervised CASPs
- Add counterparty attribution from KYC records
- Basis for a **cross-jurisdictional observatory** of crypto flows

Policymakers

- Stablecoins do not replicate the stabilizing role of safe assets under stress

CASPs

- Abnormal flows within days, no jurisdictional lag
- Ex-ante liquidity & redemption safeguards

Retail users

- Par redemption reserved for institutions; retail sells at a loss when the peg is threatened
- A consumer-protection issue invisible in aggregate metrics

Limitations and conclusions

Limitations

- Relies on complete CASP reporting (we found a few missing addresses)
- Retail/institutional split is proxy-based
- One jurisdiction; Austrian CASPs only
- Four assets; stablecoins on Ethereum only

Conclusions

- A **regulatory entity-to-address mapping** measures jurisdiction-bound crypto flows directly, without heuristics or proxies
- Austrian CASPs: \$30B external activity, globally integrated; retail by count, institutions by value
- Groups respond to shocks on different margins; **stablecoins are no uniform safe haven**

💡 Registry-based, transaction-level measurement is a reproducible, cross-jurisdictional basis for monitoring how crypto markets transmit risk.

Thank you!

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Esther Segalla OeNB

References

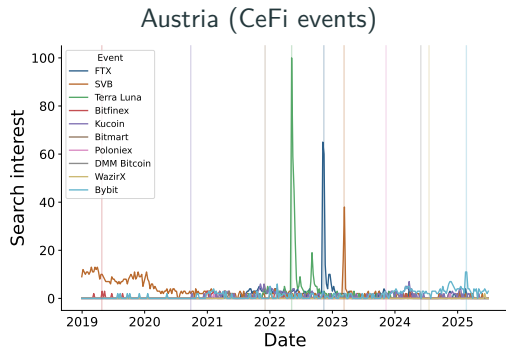
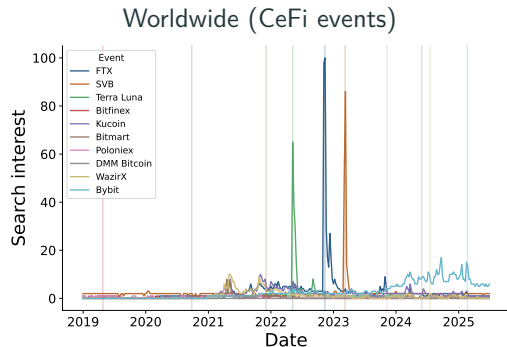
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Backup: registry composition

CASP	Hot	Warm	Cold	Total
1	0	0	0.001	0.001
2	81.846	0.033	0.252	82.132
3	0.148	0	<0.001	0.149
4	0.515	0	0	0.515
5	7.751	0	<0.001	7.752
6	8.826	0	<0.001	8.827
7	<0.001	0	0	<0.001
8	0.130	0	0.006	0.135
9	0	<0.001	<0.001	0.002
10	0.483	0	0.002	0.485
11	<0.001	0	0	<0.001
12	0	0.002	0	0.002
Total	99.702	0.036	0.263	100.000

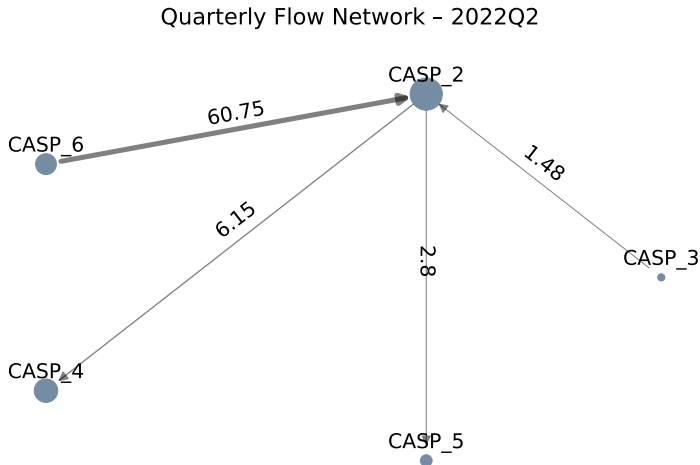
- Share of reported addresses (%) by CASP and wallet tier
- Absolute counts withheld, as agreed with Austrian authorities
- No clustering applied to expand the registry

Backup: event selection via Google Trends



1,141 crypto crime events → 19 events (2019–2025, losses >\$100M, CEX/DeFi/CeFi) → 3 with consistently highest attention

Backup: CASP-to-CASP network (2022 Q2)



3,040 transfers, \$5.774M in total between distinct Austrian CASPs

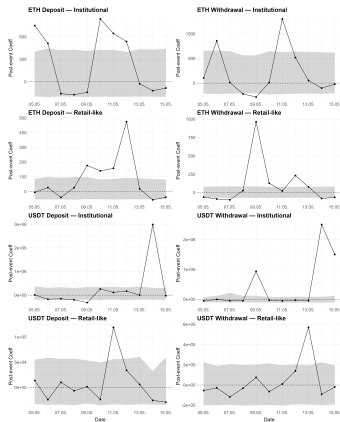
Backup: classification robustness ($z > 2.5$, degree centrality)

Group	Chain	Addresses		Avg. USD per tx	
		baseline	robust	baseline	robust
RL	ETH	534,062	528,400	1,568	1,566
	BTC	1,286,555	1,274,001	1,516	1,532
HI	ETH	472	477	53,539	47,339
	BTC	82	149	80,604	38,903
LI _c	ETH	552	547	72,170	77,747
	BTC	2,815	2,748	378,333	387,853
LI _a	ETH	6,957	12,619	4,458	3,216
	BTC	31,196	43,750	975	680

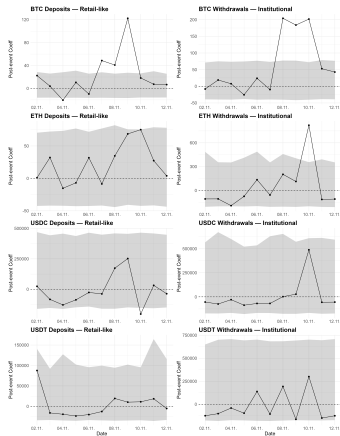
Looser threshold flags more addresses as active; group profiles are unchanged.

Backup: complementary event-study margins

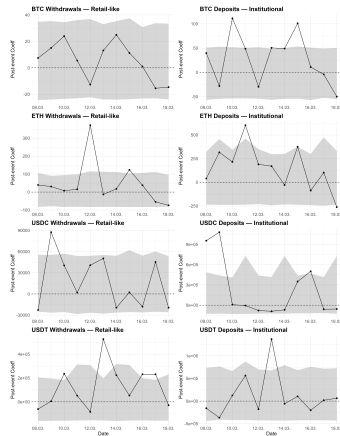
Terra-Luna



FTX



SVB





Discussion of Mobilising Private Capital for the Green Transition: A Blended-Finance Approach in EU Markets

ESMA Research Conference – 22 September 2026

Federico Piazza – Economics, Financial Stability and Risk Department

Motivation of the paper

- EU Common Agricultural Policy not halting biodiversity decline
 - The EU CAP provides EUR~55bn yearly in agricultural support through direct payments, **with broad environmental requirements attached**
 - ...yet **farm biodiversity is declining steadily by ~1.5%** per year, with no differences after the 2003 and 2013 policy reforms

How can public support make environmental performance matter to financing and investment decisions?

- Double materiality:
 - Impact: farming practices drive biodiversity
 - Financial: biodiversity weakly raises farm productivity

The instrument

- make the impact channel financially material, **by pricing biodiversity into the cost of capital**

$$rBF = r(1 - \sigma) - \boxed{\phi b}$$

r = market borrowing rate

ϕ = biodiversity reward

σ = public subsidy

b = biodiversity score

- Interest rate falls as biodiversity improves
- Subsidy conditional to participation to the programme

Main Takeaway

- Conditioning on environmental outcomes can work without tightening credit
 - Voluntary entry and condition-linked benefit make it work:
 - **+ 15%** biodiversity
 - Fiscal cost equivalent to **8%** of direct payments
 - **81%** participate
 - in all **27** Member States
 - Participants access more capital
 - No material change in farm exit

Comments – Measurements

- **High reliance on biodiversity**
 - Farmland Bird Index is also EC's official agri-environment-climate biodiversity indicator
 - Is it robust enough to become a determinant of cost of capital?
- **Is biodiversity alone enough?**
 - Classical problem of multidimensionality of ESG factors
 - Impact of agriculture on climate, water, labour conditions etc.
- **Does it generate additional transition or reward those already transitioned?**
 - Participation driven partly by initial cost of capital
 - Program captures 81% of farms but possibly a lower area-based share
 - Large farms may participate only when they already have high biodiversity scores

Where the framework could go

Beyond agriculture: a framework for transition finance?

- Transferable where:
 - High upfront costs
 - Credit-constrained borrowers
 - A measurable sustainability-related measure
 - Public money to improve financing conditions

Possible extensions

- Building renovations with verified energy-efficiency improvements?
- SMEs and emissions-intensity reduction

EU relevance

- InvestEU program/EIB have public capacity to mobilise private investment



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Mobilising Private Capital for the Green Transition: A Blended-Finance Approach in EU Markets

Davide Stocco Peter Tankov David O. Zerbib

CREST, ENSAE, Institut Polytechnique de Paris

ESMA Research Conference, 22 September 2026

Gap: Financing the **EU green transition needs private capital**: public budgets (CAP $\approx$ €60 bn/yr) cannot cover it, and *unconditional* Direct Payments (DP) do not deliver *sufficient* environmental outcomes.

Idea: **Blended finance (BF)**: a public *credit guarantee* that crowds in private lending, with the loan rate tied to *environmental performance* (vs unconditional DP).

Result: In a calibrated EU model, **BF welfare-dominates DP** by +8–11%, raises biodiversity +15%, at **< 1/10 of the public cost**, 52–61× biodiversity leverage per public euro.

Policy: A scalable, fiscally-efficient **financial instrument** for **mobilising private capital for the green transition**, robust across **all 27 member states**. Gains are largest exactly where biodiversity is declining fastest, and a targeted top-up can extend the scheme to the most degraded farms, all *within* the existing CAP budget.

Two faces of European farmland



Valpolicella (Italy)



Loire Valley (France)

The same policy, very different biodiversity. Three factors explain why:

- **Landscape:** hedgerows, buffer strips and semi-natural habitat, versus large uniform plots (Fahrig et al., 2015; Sirami et al., 2019).
- **Farming intensity:** pesticides, fertilisers, mechanisation, irrigation (Donald et al., 2001).
- **Farm structure:** size, crop diversity, monoculture vs polyculture (Stoate et al., 2009).

*All three are **management** choices, so the right policy is one that changes how farmers manage land, not just how much land they hold.*

A biodiversity crisis: a case for better-designed finance

The problem.

- EU common farmland-bird populations have fallen **over 35% since 1990** (Gregory et al., 2019); a leading indicator of ecosystem health on the land that feeds Europe.
- Globally, land use has cut local species richness by $\sim 14\%$, far more on cropland (Newbold et al., 2015).

The money.

- The Common Agricultural Policy spends $\approx$ **€55–60 bn/yr**, one of the EU's largest budgets, mostly as *unconditional* area-based direct payments.
- Independent evaluations find **limited biodiversity “additionality”** from the area-based component: much of it supports practices that would occur anyway (Chabé-Ferret and Subervie, 2013; Wuepper and Huber, 2022).
- Land conversion has been frozen since 2003, so the decline is happening on **existing** farmland, through how it is managed.

The opportunity: make each public euro deliver more for biodiversity, and crowd in private capital alongside it.

Can a credit-based “blended finance” instrument, a public guarantee that mobilises private lending, deliver more biodiversity than unconditional direct payments at a lower public cost?

Our approach.

- A model of the whole EU farm sector: each farm differs in **size** and **biodiversity**, and chooses how much to invest and how to manage its land.
- We design **blended finance (BF)**: rather than a direct transfer, the public purse subsidises the *cost of borrowing*, tied to biodiversity outcomes, so private banks co-finance conservation.
- We compare BF head-to-head with today's direct payments (DP), **calibrated to EU data** (farm accounts, bird index, land use).

1. Current payments have not bent the trend.

- Farmland birds: down $\approx 1.5\%$ *every year* for three decades.
- No statistically detectable break at either CAP greening reform (2003, 2013; joint $p = 0.71$), and no cross-country link between CAP spend per hectare and biodiversity.

2. The driver is farm management, not land conversion.

- Land use is essentially frozen (cropland share flat, $p = 0.73$).
- Within countries, **pesticide intensity** is the single strongest predictor of the decline.

So an effective instrument should: reward **measured outcomes** (not actions), act on **on-farm management** (not acreage), and reach **small, credit-constrained farms**: precisely the comparative advantage of a credit-based instrument.

The model in words (and equations)

Each farm is described by two state variables: its size s and its biodiversity $b \in [0, 1]$, evolving stochastically over time.

$$ds_t = \mu_s s_t dt + \sigma_s s_t dW_t$$

size grows/shrinks (business risk)

$$db_t = \left[\underbrace{\mu_b}_{<0 \text{ decline}} + \underbrace{a(s_t, b_t)}_{\text{conservation effort}} \right] dt + \hat{\sigma}_b d\widehat{W}_t$$

biodiversity declines unless the farm acts

The economics. Left alone, biodiversity drifts *down* ($\mu_b < 0$). A farm can offset this with costly effort a , funded by capital it must borrow. Unprofitable farms **exit**.

The policy lever. The **cost of borrowing is a policy choice**: that is what blended finance acts on.

What is new. We extend the classical model of firm investment and exit (Miao, 2005; Hopenhayn, 1992) to a *coupled economic–ecological* system: a second, correlated state (biodiversity) with endogenous drift, and exit determined jointly by both states. The economy and the ecosystem feed back on each other (Tilman et al., 2014; Bareille and Largier, 2026).

The instrument: a performance-linked credit subsidy

Starting point. Small farms borrow expensively:

$$\delta(s) = \underbrace{r_f}_{\text{risk-free}} + \underbrace{\rho_{ag}}_{\text{sector premium}} + \underbrace{c_\delta s^{-\psi}}_{\text{smaller farm} \Rightarrow \text{higher rate}}.$$

(A documented feature of EU agricultural credit; fi-compass 2022.)

Blended finance cuts that rate, conditional on biodiversity:

$$\delta_{BF}(s, b) = \delta(s) (1 - \sigma_0) - \phi b.$$

Two dials: a **rate cut** σ_0 (helps the credit-constrained most) and a **biodiversity reward** ϕb (the greener the farm, the cheaper its capital $\Rightarrow$ a standing incentive to improve).

Farms opt in only if it pays:

$$\Delta(s, b) = \underbrace{\sigma_0 \delta(s) + \phi b}_{\text{cheaper credit}} - \underbrace{\kappa_B(1 - b)}_{\text{cost of meeting the standard}} > 0.$$

Participation is **voluntary**: no mandates. The catch: the most degraded farms face the highest compliance cost.

The farm's problem

Each farm maximises expected discounted profit, choosing capital $k \geq 0$ and the **BF loan share** $x \in [0, 1]$ (the fraction of capital financed through blended finance), until it optimally exits at time τ :

$$V(s, b) = \max_{k \geq 0, x \in [0, 1]} \mathbb{E} \left[\int_0^\tau e^{-\rho t} \pi(s_t, b_t, k_t, x_t) dt \right].$$

Flow profit = output – financing – conservation effort – fixed costs:

$$\pi = \underbrace{p s^\alpha (k/s)^\beta (1+b)^\xi}_{q = \text{output (higher } b \Rightarrow \text{more)}} - \underbrace{(\delta_{BF}(s, b) + r_d) k}_{\text{cost of capital}} - \underbrace{\kappa_A x^\gamma s^{-\chi} k}_{\text{effort}} - \underbrace{c_F s^\zeta + c_{\min}}_{\text{fixed}}.$$

Subject to a collateral limit $k \leq \theta_k v_A s^{\gamma_A}$ (small farms are credit-constrained), and the biodiversity dynamics of the previous slide, where effort raises b : $a(s, b) = \theta_B \kappa_B (1 - b) k x / s$.

Blended finance enters only through $\delta_{BF}(s, b)$: cheaper, performance-linked capital changes both how much a farm invests and how much conservation effort it chooses.

ρ discount rate; p output price; α, β scale & capital elasticities; ξ biodiversity–output elasticity; r_d depreciation; κ_A, γ, χ effort-cost level, convexity, scale economy; c_F, ζ fixed-cost level & exponent; $c_{\min}$ minimum operating cost; θ_k, v_A, γ_A collateral (LTV, asset value, size exponent); θ_B effort effectiveness; κ_B conditionality (prev. slide).

How the instrument is set (the regulator's problem)

A regulator chooses the three dials $(\sigma_0, \phi, \kappa_B)$ to maximise social welfare (output plus biodiversity, net of public cost):

$$W = \underbrace{w_q \mathbb{E}[q]}_{\text{farm output}} + \underbrace{w_b \mathbb{E}[b] - w_v \text{Var}(b)}_{\text{biodiversity (level \& equity)}} - \underbrace{\kappa_1 C - c_{\text{prog}} \sigma_0^{\gamma_{\text{prog}}}}_{\text{public cost}},$$

subject to two guardrails a real scheme would need:

- **Budget discipline:** BF must cost no more than today's DP ($C_{BF} \leq C_{DP}$): a fair, like-for-like comparison.
- **No arbitrage:** the subsidised rate stays above the risk-free rate ($\delta_{BF} \geq r_f$): farmers can't borrow cheap to invest risk-free.

We also study the **relaxed case where arbitrage is allowed** ($\delta_{BF} \geq 0$): welfare gains are even larger, but at higher public cost.

Solution method.

- HJB variational inequality $\rightarrow$ 2D Fokker–Planck $\rightarrow$ aggregate moments $\rightarrow$ planner optimisation.
- 100×50 finite-difference grid in $(\ln s, b)$.
- Grid convergence at 200×100 : all moments change by $< 1\%$.

Data sources.

- **FADN** (*farm accounts, annual, NUTS 2, 2004–2020*): production function, operating costs, credit rates, leverage.
- **Farmland Bird Index** (*national, annual, 24 EU, 1990–2023*): biodiversity drift μ_b , volatility $\hat{\sigma}_b$.
- **GLOBIO 4 MSA** (*$\sim 300 m$ raster, 2015 + 2050 SSPs*): spatial validation, regional heterogeneity.
- **LUCAS / CORINE** (*sample points, each 3 yrs / 100 m land-cover, each 6 yrs*): land-use composition, margin tests.
- **CAP Pillar I** (*Eurostat, country-level, annual*): direct-payment rate λ .

Two interest-rate regimes (eurozone FADN-estimated):

	High-rate (2004–2011)	Low-rate (2015–2020)
r_f (ECB refinancing)	3.07%	0.50%
ρ_{ag} (sector floor)	0.011	0.017
c_δ, ψ	1.84, 2.0	0.146, 0.95

Main result: more biodiversity, a fraction of the cost

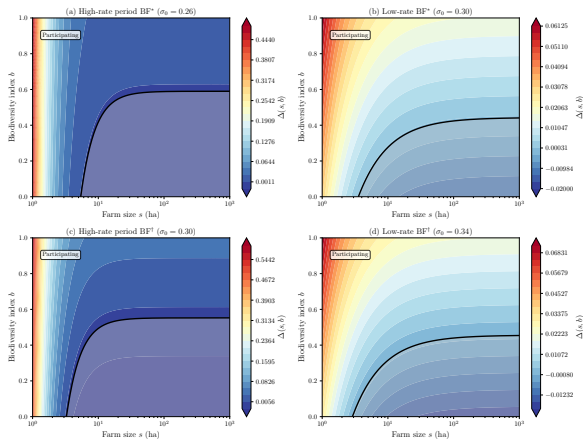
	High-rate			Low-rate		
	NP	DP	BF*	NP	DP	BF*
W	44,781	45,532	50,545	48,837	49,239	53,318
ΔW vs DP (%)	-1.7	-	+11.0	-0.8	-	+8.3
$\mathbb{E}[b]$	0.398	0.408	0.477	0.394	0.407	0.467
$\Delta \mathbb{E}[b]$ vs DP (%)	-2.6	-	+16.8	-3.1	-	+14.8
Net drift $\mathbb{E}[\mu_b + a]$	-0.011	-0.009	-0.003	-0.011	-0.009	-0.003
C (EUR/farm)	0	4,525	397	0	4,468	348
C_{BF}/C_{DP}	-	-	9%	-	-	8%
Bio leverage BF* vs DP	-	-	52×	-	-	61×
Participation (density-weighted)	-	-	70%	-	-	81%

- BF raises biodiversity by $\sim 15\%$ and cuts the rate of decline by **two-thirds**.
- At **$< 1/10$ of the DP budget**: each public euro is matched by private credit.
- **50–60×** more biodiversity per euro than direct payments.
- Robust across **high- and low-interest-rate** environments.

Why it works: four channels of a credit-based design

- (1) **Incentive.** Because a greener farm gets cheaper capital, farms have a *standing reason* to improve, not a one-off action to tick a box. $\Rightarrow$ conservation effort is $\approx 4\times$ that under direct payments.
- (2) **Progressivity.** A proportional rate cut is worth most to **small, credit-constrained farms** (which face the highest rates). $\Rightarrow$ near-100% take-up below 5 ha; large farms opt in selectively.
- (3) **Leverage (the finance point).** The state pays only the *rate spread*, not the capital: **private banks co-finance every public euro**. $\Rightarrow 52\text{--}61\times$ more biodiversity per euro than DP.
- (4) **Externalised supervision.** Banks already screen and monitor borrowers as part of normal lending, so the **cost of oversight falls on the lender**, not the public authority. The state sets the rule; the private sector enforces it (vs. costly on-the-spot CAP inspections).

Who opts in, and who is left out



Take-up is voluntary: the shaded region is where farms choose to join.

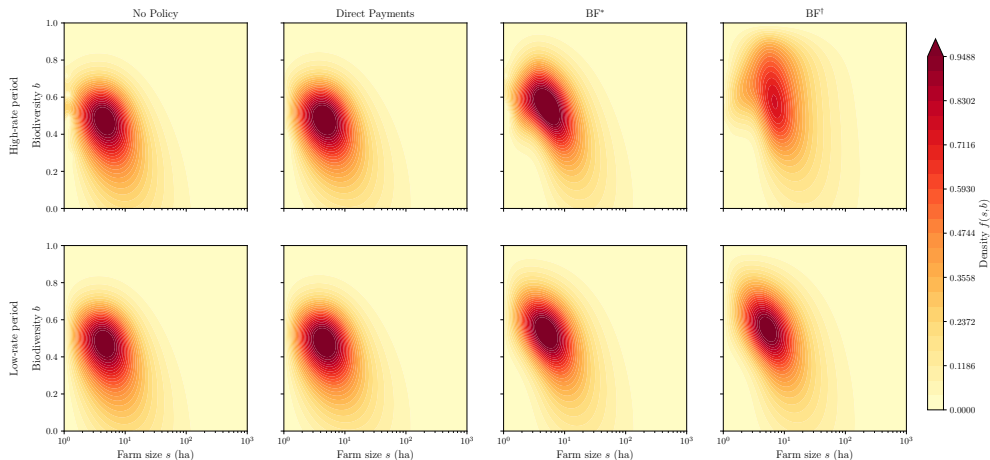
Who joins?

- **Small farms:** almost all, at any biodiversity level.
- **Large farms:** only the greener ones.

The equity catch. The scheme is **pro-small-farm** but **under-serves the most degraded land**: those farms face the highest compliance cost and the smallest credit gain, so they self-select out.

⇒ pair BF with a **targeted top-up** to reach degraded farms.

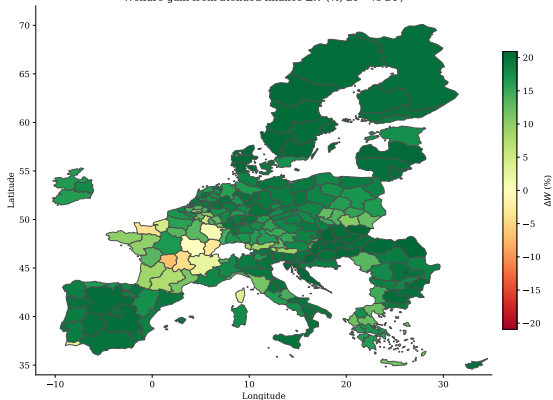
The whole sector shifts to healthier land



No policy and direct payments coincide (mass concentrated at low biodiversity, $b \approx 0.3-0.4$). Blended finance (BF*) moves the entire distribution of farms up to $b \approx 0.5-0.6$: a sector-wide, not marginal, change.

It works EU-wide, and can be paired to reach degraded farms

Welfare gain from blended finance ΔW (%), BF* vs DP)



Robust across all 27 member states.

- 231 of 232 regions gain biodiversity; welfare gain +2.7% (France) to +12.3% (Slovakia), mean +8.6%.
- Why is France the weakest? Its farms are **large and well-capitalised**, so the credit-subsidy channel bites less: the gain is smallest (but still positive).

Reaching the degraded-farm tail. Recycle the BF budget saving as a **targeted top-up** for the farms that opt out, *within* the existing CAP envelope ($C \leq C_{DP}$).

- In hard-hit regions (France-like), this **nearly doubles** the biodiversity gain of BF alone.
- **Division of labour:** private banks monitor the $\sim 80\%$ of farms in BF; the public authority focuses on the $\sim 20\%$ tail.

The one region without a welfare gain is a single Portuguese NUTS2 (PT15).

Does the result survive real-world frictions? Yes

Banks capture part of the subsidy. Even if lenders pocket up to 60% of the rate cut (Lucca et al., 2019), BF still beats DP ($\Delta W = +9.5\%, +8.1\%, +6.7\%$ at 0/30/60% leakage).

Uncertain parameters. Across **12** alternative calibrations (ecosystem value, credit tightness, correlations), BF wins in **every one**; credit-market tightness matters most, exactly where the instrument acts.

It takes time. A switch from DP to BF closes half the biodiversity gap in ~ 50 years, because ecological recovery is inherently slow. **The policy implication: start early.**

(Design also robust to the no-arbitrage guardrail: relaxing it only makes BF look better, +12 to +40%.)

The problem. Europe devotes $\sim\text{€}60$ bn/yr to farm support whose biodiversity impact has proven hard to demonstrate, because payments are tied to area rather than to outcomes.

The proposal. Complement it with **blended finance**: a public guarantee that makes greener farming cheaper to finance and **crowds in private capital**.

What the model shows.

- +15% biodiversity, decline cut by two-thirds, at $< 1/10$ of the public cost, 50–60 $\times$ more per euro than DP.
- Robust across all 27 states, both rate regimes, and realistic frictions.
- Voluntary, incentive-compatible, and budget-neutral vs today's CAP.

*Ongoing work: a results-based, area-scaled variant that also pulls **large degraded farms** into the scheme, aligned with the EU Nature Restoration Regulation (appendix).*

For financing the green transition with private capital:

- **Public guarantees mobilise private capital.** A small public rate-subsidy leverages private credit 52–61× into biodiversity outcomes: the InvestEU / green-guarantee logic applied to farmland.
- **Fiscal efficiency in a volatile world.** Comparable or greater outcomes at < **10% of the direct-payment budget** free scarce fiscal space.
- **Supervision is externalised to lenders.** Banks screen and monitor borrowers as part of normal lending, so the **cost of oversight moves off the public balance sheet**: less need for costly on-the-spot inspection and enforcement.
- **Incentive-compatible and voluntary.** Farms self-select and the loan rate is tied to performance: no mandates, politically feasible.
- **Complement CAP Pillar I.** Redirect a share of area-based support toward **conditional credit instruments**, while retaining targeted direct payments on the degraded-farm tail for equity.

Thank you. Questions?

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Table B1 **Equilibrium outcomes**, NP / DP / BF* in both rate regimes: welfare, biodiversity, net drift, fiscal cost, leverage, participation. (Shown in the main talk.)

Table B2 **FBI trend regressions**: no structural break at the 2003 and 2013 CAP reforms.

Fig. B3 **Optimal design**: welfare over the two policy dials (σ_0, φ); a unique interior optimum.

B4 **Reaching degraded farms**: the BF + DP hybrid and its budget identity.

B5 **Extension**: results-based, area-scaled payments aligned with the EU Nature Restoration Regulation.

B6 **Parameter definitions**: every symbol, its value and meaning (paper Table, “Parameter calibration overview”).

B7 **Extension results**: headline numbers of the results-based, area-scaled model.

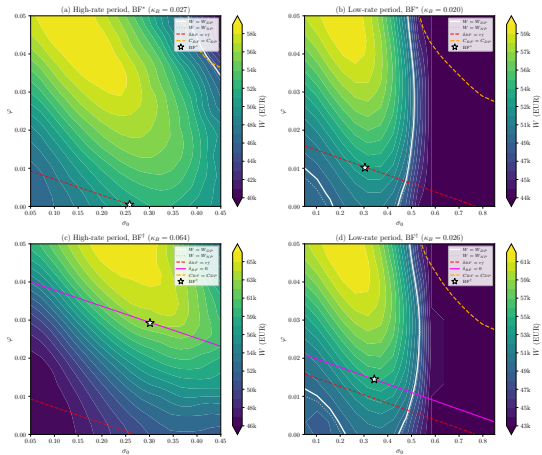
B2: no structural break at the CAP reforms

	(1)	(2)	(3)	(4)	(5)
t (annual trend)	-0.0152***	-0.0116***	-0.0115***	-0.0128***	-0.0157***
$t \times \mathbb{1}_{t \geq 2003}$		-0.0055	-0.0059	-0.0059	-0.0026
$t \times \mathbb{1}_{t \geq 2013}$		+0.0007		+0.0021	+0.0046
Country FE	Yes	Yes	Yes	Yes	Yes
F -test breaks = 0		0.35	0.38	0.51	
[p -value]		[0.710]	[0.696]	[0.731]	

Piecewise-linear trend regressions of the Farmland Bird Index, 24 EU countries, country fixed effects. Interaction terms at both reform dates are individually insignificant; the joint F -test for structural breaks does not reject zero ($p \approx 0.7$).

Column (5) adds a common post-2013 shift.

B3: optimal design (welfare landscape)



Welfare as a function of the two policy dials (rate cut σ_0 , biodiversity reward φ), at the optimal conditionality κ_B^* . There is a unique interior optimum ($\sigma_0 \approx 0.30$, $\varphi \approx 0.01$); the no-arbitrage guardrail bounds how generous the scheme can be.

B4: reaching degraded farms (BF + DP hybrid)

Problem. The most degraded farms self-select out of BF.

Design. Recycle the BF budget saving as a targeted top-up on the non-participants, within the existing envelope:

$$C_{\text{hybrid}} = C_{BF}^* + \frac{\kappa_{DP}^{\text{new}}}{\kappa_{DP}} (C_{DP} - C_{BF}^*), \quad C_{\text{hybrid}} \leq C_{DP}.$$

Result. In moderate-decline regions the extra gain is small; in severe-decline regions (France-like) it **nearly doubles** the biodiversity gain of BF alone, without exceeding the DP budget. Division of labour: private banks monitor the $\sim 80\%$ in BF; the public authority focuses on the $\sim 20\%$ tail.

B5: extension (results-based, area-scaled payments)

Motivation. Baseline BF reaches small/medium farms; the largest farms ($\sim 2\%$ of holdings but $\sim 50\%$ of agricultural area) opt out.

Design. Pay for the *additional* measured improvement, scaled *per hectare*, weighted toward degraded land (Pigouvian shadow price); a restoration-priority baseline on the worst land, anchored to the EU Nature Restoration Regulation ("restore 20% of land by 2030"; it targets the same farmland-bird index we use).

Result. Large degraded farms now participate at high intensity; **area reach** $\rightarrow \sim 77\text{--}84\%$ of farmland; welfare gain $\approx +10\%$; **no incentive to degrade** (farm value is strictly increasing in biodiversity, proven not assumed).

B6: parameter definitions (1/2)

Symbol	Value	Meaning
<i>Stochastic dynamics</i>		
μ_s	0.043	farm-size growth (drift)
σ_s	0.181	farm-size volatility
μ_b	-0.011	baseline biodiversity decline
$\hat{\sigma}_b$	0.041	biodiversity volatility
ρ	-0.20	size-biodiversity shock correlation
<i>Production</i>		
α	0.593	scale elasticity (land + capital)
β	0.299	capital-intensity elasticity
ξ	0.250	biodiversity-productivity elasticity
p	748	output price / scale factor (EUR)
<i>Operating costs</i>		
c_F	136.5	variable-cost level (EUR)
ζ	0.899	variable-cost exponent (scale economies)
$c_{\min}$	14,710	fixed / minimum cost (EUR)
r_d	0.091	capital depreciation
r_f	0.005	risk-free / discount rate
<i>Collateral & credit schedule</i>		
θ_k, v_A, γ_A	0.50, 49,800, 0.599	LTV, per-ha asset value, size exponent
$\rho_{ag}, c_\delta, \psi$	0.017, 0.146, 0.945	sector spread; size-spread level & exponent

B6: parameter definitions (2/2)

Symbol	Value	Meaning
<i>Population dynamics</i>		
η	0.040	exogenous exit rate
ν	0.010	entry rate
ν_s	4.0	entry size dispersion (χ^2 DoF)
(α_g, β_g)	(14.5, 12.6)	entry biodiversity (Beta shape)
<i>Direct payments, biodiversity & admin</i>		
λ	313	per-ha direct payment (EUR)
κ_{DP}	0.03	biodiversity per EUR of DP
κ_A	0.03	BF admin-cost level
χ	0.15	admin-cost scale economy
ϑ_B	3×10^{-4}	spending-to-biodiversity effectiveness
γ	2.0	admin-cost convexity
<i>BF instrument (optimised by the planner)</i>		
σ_0, ϕ, κ_B	optimised	rate subsidy; biodiversity premium; conditionality
<i>Normative weights</i>		
w_q, w_b, w_v	1, 10^4 , 5×10^3	output; biodiversity value; $\text{Var}(b)$ penalty
κ_1	0.30	deadweight loss of taxation
$c_{\text{prog}}, \gamma_{\text{prog}}$	1.5×10^5 , 4.0	programme cost level, convexity
$c_{\text{rate}}, \gamma_{\text{rate}}$	10^5 , 4.0	anti-arbitrage penalty level, convexity

B7: extension: main numbers

	DP	Extension (BF, area-based)
Welfare gain ΔW vs DP	–	+ 10%
$\mathbb{E}[b]$ (per farm)	0.40	0.51
$\mathbb{E}[b]$ (per hectare)	0.30	0.36
Fiscal cost C/C_{DP}	100%	22%
Take-up (share of farms)	–	98%
Farmland reached (by area)	–	77%
Large degraded farms	opt out	participate

Extension = results-based, area-scaled additionality payment with a restoration-priority baseline on the most degraded land (EU Nature Restoration Regulation anchor). Calibrated on the observed EU farm-size distribution (small-farm bulk + large-farm tail); optimal reward rate $\varphi \approx 5$, disciplined to a $\sim 25\%$ -of-payment monitoring cost. Figures indicative.

ANATOMY OF A SAFE ASSET: BUND MARKET STRUCTURE AND REFORM

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September 2026

The views expressed in this paper do not necessarily reflect those of the Deutsche Bundesbank or the Eurosystem.

Why Bund market structure, now?

- Sovereign bonds sit at the core of the financial system
 - Yet repeated stress: Covid 2020, Gilt/LDI 2022, Liberation Day 2025
 - Market functioning key for cost of funding at elevated debt levels
- design, regulation, and reform back at the center of policy debate
- reform proposals include: **central clearing**¹, faster settlement², **venue consolidation**³, consolidated tape⁴, capital regulation⁵
- ⇒ requires transparent market structure information and evaluation of policy

¹ US: mandatory central clearing by 2027

² EU: T+2 → T+1 by Oct 2027

³ EU: Merz & Lagarde, pan-EU stock exchange

⁴ EU: CT for bonds by 2027?

⁵ US: SLR reform in 2026?

What we do

The most granular Bund transaction record to date

≈ 14 million transactions, 2008–2025, **both counterparties identified** (LEIs)

► Construction

Three structural facts – and they are the primitives a reform counterfactual runs on:

1. a **thin dealer core** → imperfect dealer competition
2. **sticky relationships** → relationship value
3. **sorted venue choice** → matching, not cost, is the margin

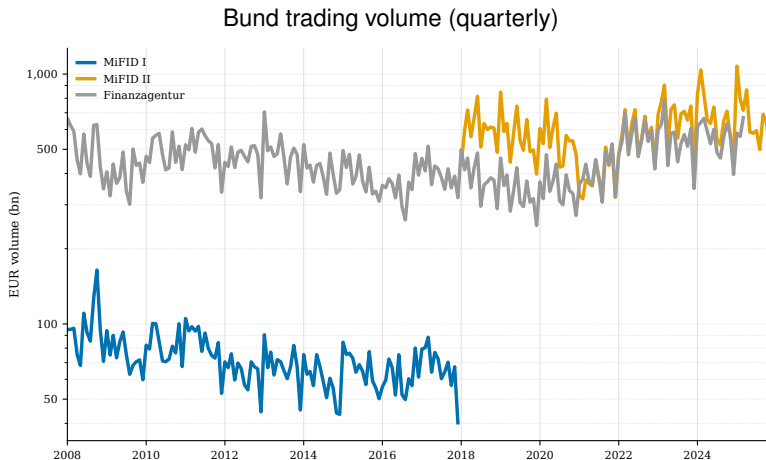
→ **Reform that leaves matching intact pays off; reform that overrides it does not.**

Central clearing: large mechanical gain. Platform centralization: welfare falls.

On the way: who moves prices, and who pays for execution – they are not the same.

► Literature

Near-complete coverage of the Bund cash market under MiFID II

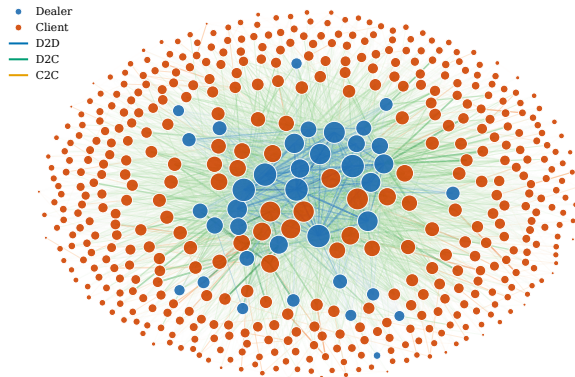


≈€24 bn average daily volume in Bunds. The MiFID II regime (2018–2025) is the core analysis sample for this paper; MiFID I (2008–2017) provides the longer historical window.

We share the cleaned dataset with eligible researchers (Bundesbank access).

The market is *hierarchical, relationship-based, segmented*

Fact 1: a thin, concentrated dealer core

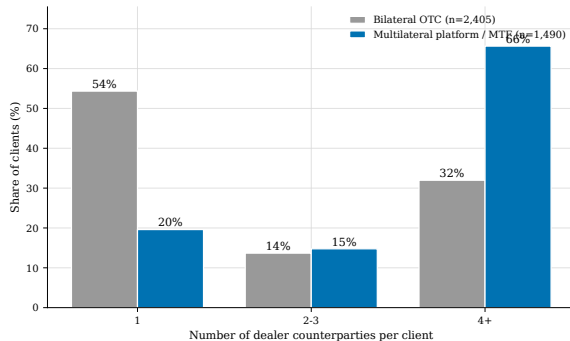


- Only **38** primary dealers – they stand on at least one side of **84%** of all volume
- Top 5 = **44%** of dealer volume; top 10 = **70%**
- Clients are far more dispersed: top 20 = **30%**
- Direct client-to-client trading is rare

► Concentration

⇒ **imperfect dealer competition is a measured fact, not an assumption.**

Fact 2: sticky dealer–client relationships

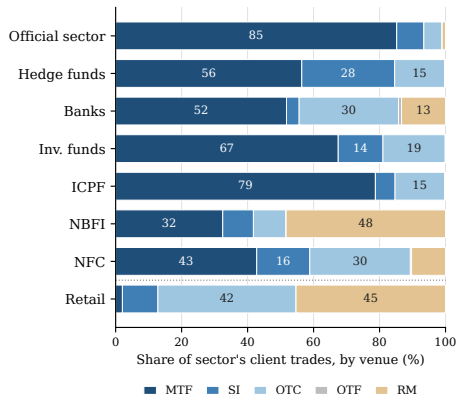


- OTC: **54%** use a single dealer; mean home-dealer share **80%**
- MTF: more breadth (**66%** use 4+ dealers), home share **55%**
- Home dealer identity unchanged across years for **67%** of OTC clients (**42%** MTF)
- Larger footprint → more dealers, but far below random matching

[▶ Appendix](#)

Platforms broaden access, but do not deliver all-to-all.

Fact 3: sectors sort across venues



- Funds, ICPF, official → **platforms** (MTF/SI)
- Banks → split between OTC and platforms
- Retail → regulated exchange + OTC

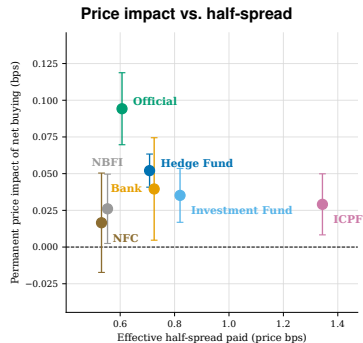
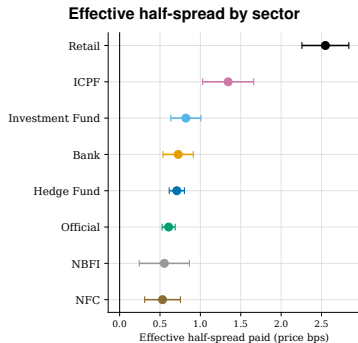
Sector resolves 39.1% of within-bond-day venue uncertainty (vs. 20.2% null) – an excess of **18.9 pp.**

Five venue types; the top three groups carry 95% of MTF and 99% of OTF volume.

► Venue architecture

**Who moves prices? Who pays for execution?
(They are not the same.)**

Execution cost is an immediacy premium, not adverse selection



- **Who moves prices** (y-axis, right): permanent impact of net flow +0.09 bps/SD for official ($t = 7.5$), +0.05 for hedge funds ($t = 9.0$); banks, NBFI, NFC no comparable signal
- **Who pays** (x-axis): retail **2.55** bps vs. banks **0.72** – ratio $\approx 4\times$, *widening* to +3.64 bps with ISIN $\times$ day, venue, size FE ($t = 15$)
- The most informed pay *middling* spreads (hedge funds 0.71, official 0.61); cross-sector $\rho = +0.29$, and driven by banks – cheapest *and* least informed

► Horizons

⇒ **effective half-spread is an immediacy premium, not a price of adverse selection.**

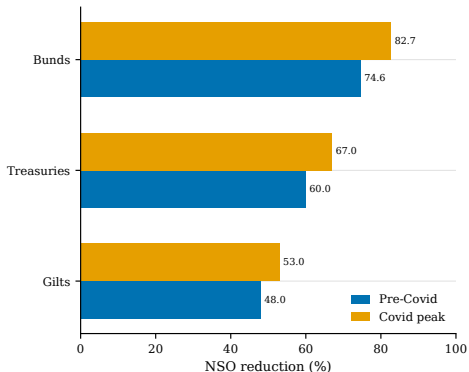
Two reforms target the dealer core, at different stages of the trade

Clearing – post-trade settlement: *mechanical netting*

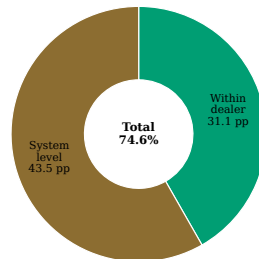
Platform centralization – pre-trade matching: *equilibrium welfare*

Central clearing: Bund NSO reductions exceed UST and Gilt estimates

Cross-market comparison



Within-dealer vs. system-level netting



- Under a common netting set: **74.6%** pre-Covid, **82.7%** at the Covid peak
- Restricted nets: **64.7%** (venue buckets), **54.7%** (MIC silos) – the gain survives fragmentation

Mechanical: excludes CCP fees, margin, liquidity, behavioral adjustment.

Central clearing: why a mandate? The wedge between private and social gains

- **Within-dealer (31.1 pp)** – dealers can internalize this via voluntary clearing
- **System-level (43.5 pp)** – only realized when *all* dealer positions enter a common netting set – and it is the *larger* half
- Dealer heterogeneity: median dealer-level reduction **33%**, range from <15% to >60%

⇒ **an aggregate netting externality – the rationale for a mandate**

Consistent with [European Systemic Risk Board \(2024\)](#) incentives-based recommendation for the EU.

Venue centralization: a *matching* reform

The three facts are the model's primitives:

Fact 1 thin dealer core → imperfect dealer competition

Fact 2 sticky relationships → non-price relationship value, $\hat{r} = 0.61$ bps

Fact 3 sorted venue choice → matching is the margin

[Allen and Wittwer \(2023\)](#) on Bund D2C trades, 2023–2025, top 20 dealers.

Venues collapsed: **bilateral** (OTC + SI) vs. **platform** (MTF).

→ **Does forcing trading onto platforms raise welfare?**

Platforms already execute tighter within the same client–dealer pair (-0.24 bps) – but a transfer is not yet welfare.

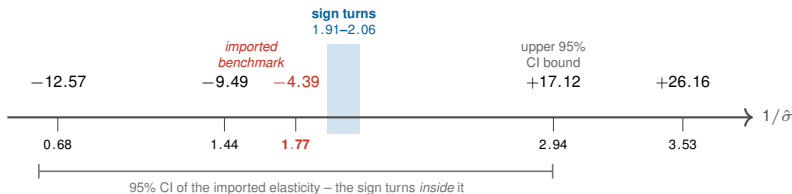
► Home dealer

► Platform execution

Venue centralization: a small net, and the sign is conditional

Benchmark spec, vs. a fully bilateral market: current access -0.83% , **full centralization** -4.39% — Canada -3.02%

► Full Table 6



- Negative on **every margin we estimate**: dealer set -4 to -18% , volume weights -7%
- The sign turns only on the *imported* elasticity – inside its own confidence interval

⇒ **clearing is arithmetic** on observed trades; centralization is an *equilibrium* result whose sign rests on an imported parameter.

Conclusion

Three facts about how the euro area's benchmark safe asset trades:

1. a **thin dealer core** – 38 primary dealers on 84% of volume
2. **sticky relationships** – 54% of OTC clients use a single dealer
3. **sorted venue choice** – sector resolves 39.1% of within-bond-day venue uncertainty

Two consequences:

- (i) **Incidence.** Hedge funds and official accounts carry the price-relevant flow, yet pay middling half-spreads; retail pays $4\times$ what banks pay → execution cost is an *immediacy premium*, not a price of adverse selection
- (ii) **Reform.** Clearing leaves matching intact → $\approx 75\%$ mechanical NSO reduction, above UST and Gilt. Centralization overrides it → welfare falls (-4.39%), conditional on an imported demand elasticity

Dataset shared with eligible researchers (Bundesbank access).

Appendix

Welfare counterfactuals in full (Table 6)

		Account I	Account IR	No Fee	Central
With loyalty	Imperfect	-0.83	-3.73	-3.78	-4.39
	Perfect	+16.05	+23.63	+25.66	+28.31
Switching cost	Imperfect	+21.41	+21.40	+25.31	+30.54
	Perfect	+39.87	+53.23	+58.42	+65.44
No loyalty	Imperfect	+27.05	+27.31	+30.80	+34.69
	Perfect	+54.07	+69.95	+74.72	+80.70

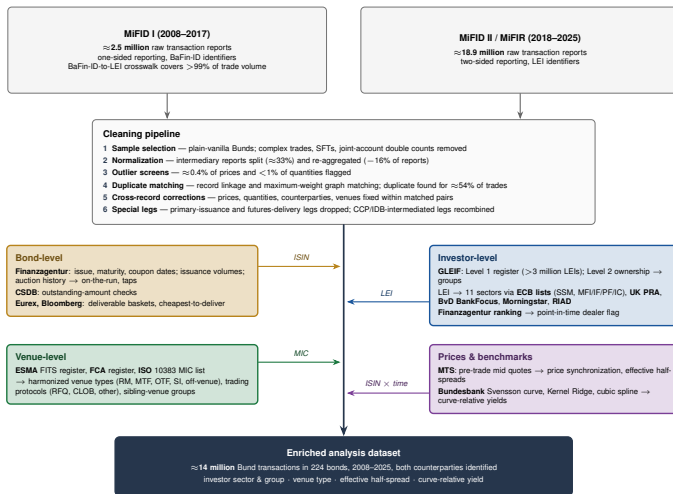
% welfare change relative to a fully bilateral market; replicates Table 6 of [Allen and Wittwer \(2023\)](#). The benchmark row is “With loyalty / Imperfect”. The sign reverses under *perfect competition*, or when the home-dealer premium is not read as surplus.



- Hedge funds: +0.05 bps / SD ($t = 9.0$)
- Official sector: +0.09 bps / SD ($t = 7.5$)
- Banks, NBFIs, NFCs: no comparable signal
- Funds: small, transitory

Ranking is the contribution.
Magnitudes are within-curve, not tradable.

From raw regulatory reports to the analysis dataset

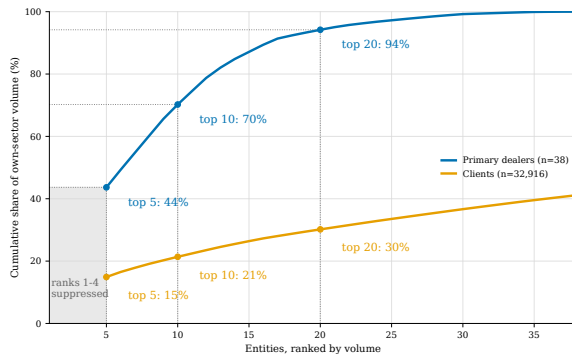


≈ 21M raw reports → ≈ 14M Bund transactions (2008–2025); enriched with >12 external reference datasets.

Related literature – four margins

- **Dealer cores** – Bessembinder et al. (2020); Biais and Green (2019); Wang (2016); Li and Schürhoff (2019); Colliard et al. (2021); Duffie (2023)
- **Relationships** – Allen and Wittwer (2023); Di Maggio et al. (2017); Kondor and Pintér (2022); Allen and Wittwer (2025)
- **Venue sorting and information** – Hasbrouck (1995); Czech et al. (2021); Pintér et al. (2024); Kersefischer and Helmus (2024); Lee et al. (2025)
- **Market design** – Fleming and Keane (2021); Baranova et al. (2023); Allen and Wittwer (2023); Kutai et al. (2025); Chaboud et al. (2025); Duffie (2025)

Dealer dominance: the dealer core is thin

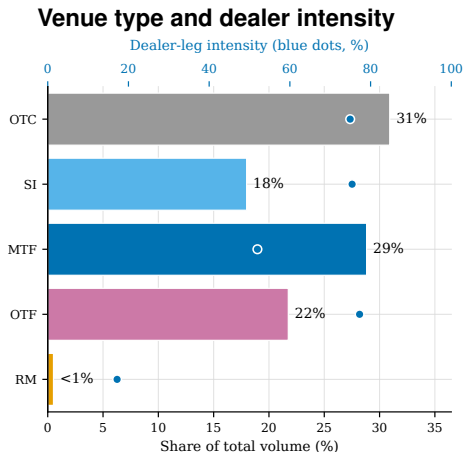


- Only **38** primary dealers active in our sample
- Dealers stand on at least one side of **84%** of all volume
- Top 5 dealers = **44%** of dealer volume
- Top 10 dealers = **70%**
- Top 20 clients = only **30%** of client volume

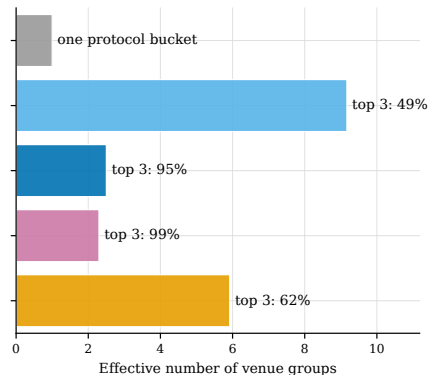
Client side is much more dispersed

Inventory–competition tradeoff (Li and Schürhoff 2019; Colliard et al. 2021); also sizes the clearing exercise below.

Fragmentation: multiple venue types, dealer-centered



Effective number of venue groups (1/HHI)

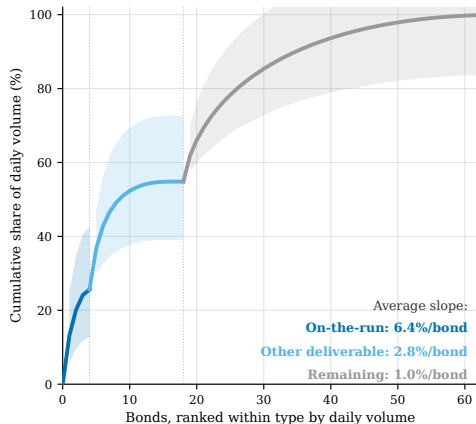


OTFs $\approx$ interdealer-broker; SIs and OTC remain dealer-centered; MTFs broaden access but do not eliminate dealer intermediation; regulated markets are peripheral in volume.

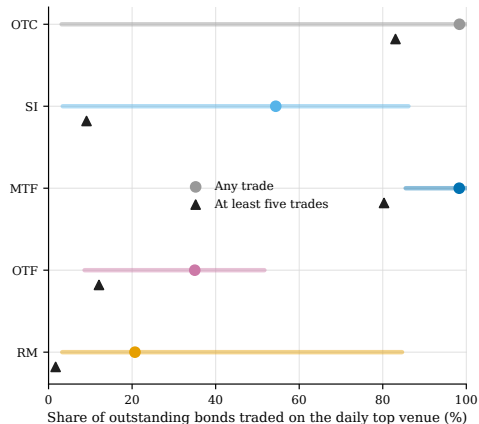
Top three groups: **95%** of MTF, **99%** of OTF volume.

Fragmentation: concentrated bonds, sparsity

Concentration by bond type

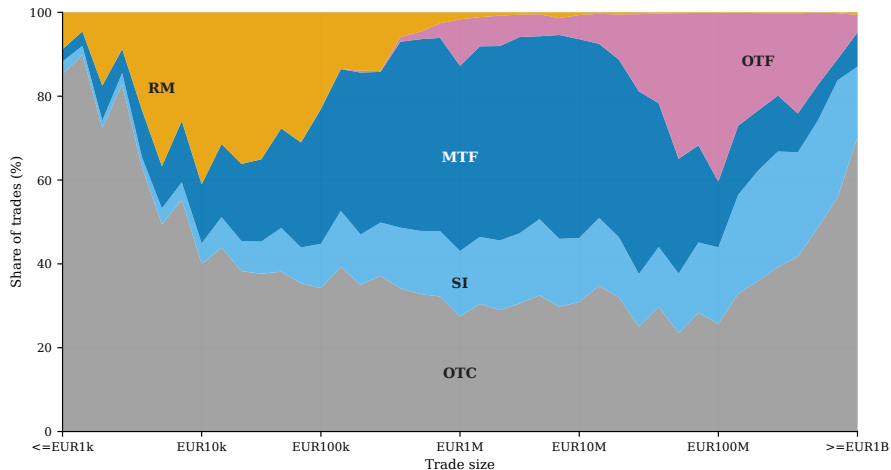


Bond coverage on top venues



≈ 62 Bunds outstanding on a typical day; on-the-run + other deliverable = **55%** of daily volume. Each OTR carries **6.4%** of daily volume; each remaining bond **1.0%**. Most bonds trade only sporadically on a given venue.

Fragmentation: venue choice varies with trade size



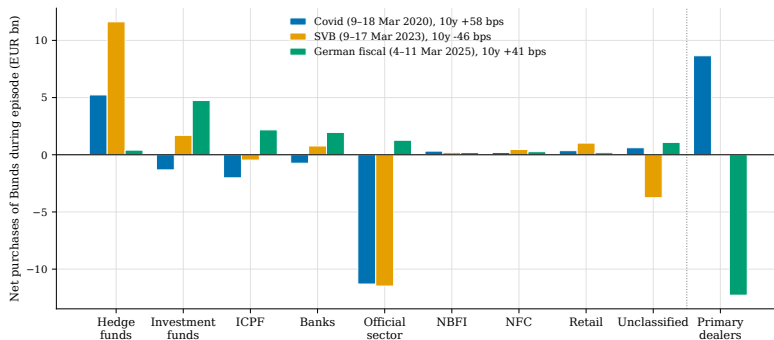
Small trades → on-exchange; medium → MTF/SI platforms; large blocks → interdealer and single-dealer platforms.

Further descriptive evidence

The data also let us document several other features of the market.

- Bund trading is **predominantly cross-border**: domestic German counterparties account for only 10% of trade-leg volume ▸ Geography
- **Dealer concentration is cyclical, not secularly rising**: effective dealer count peaks, falls under stress, recovers ▸ Dealer dynamics
- Dealer **principal trading capacity has declined** (62% → 53%); matched-principal rises ▸ Capacity
- Brexit shifted venue *location*, not counterparty domicile ▸ Brexit
- **Retail returned** after ECB rate lift-off: retail trade share jumped from 11% to 46% in 2024; volume share still negligible ▸ Retail
- **Algorithmic execution rose** (21% → 28% of trades), but humans retook the wheel in the deepest stress (March 2020) ▸ Algo

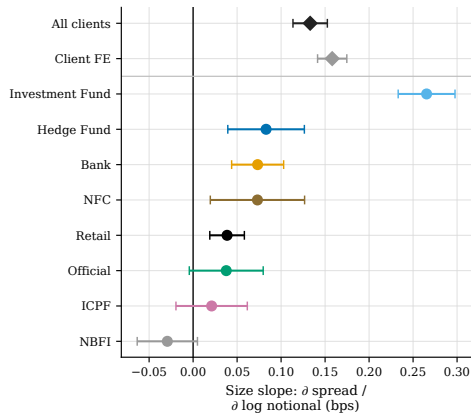
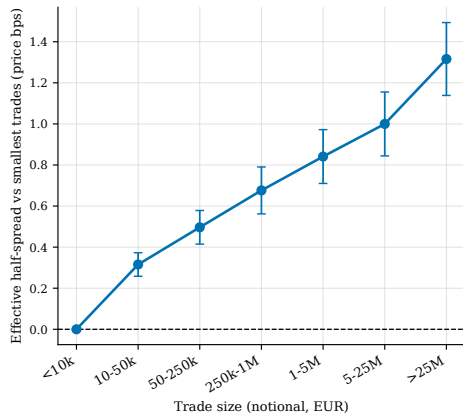
Pricing: stress flows — who supplies, who absorbs the safe asset?



- **Mar 2020** (dash for cash, yields ↑58 bps): foreign official sold ~€10.0 bn; hedge funds + dealers absorbed
- **Mar 2023** (SVB flight to safety, yields ↓46 bps): foreign official *again* sold; hedge funds bought
- **Mar 2025** (German fiscal supply news, yields ↑41 bps): dealers *distributed* Bunds; buy-side absorbed

Identified flows, not stock-based inference. Same core flips between absorbing and redistributing.

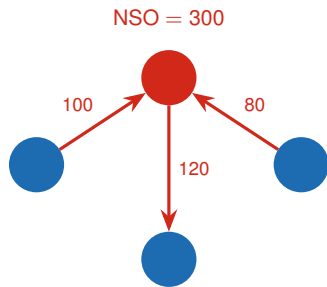
Execution costs: size penalty — but no Gilt-style size discount



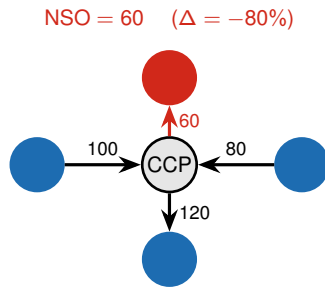
- Largest blocks ($>€25\text{M}$) pay **+1.32 bps** vs. smallest; log-notional slope **+0.133 bps** ($t = 13.3$)
- Within-client (single investor, varying ticket): **still positive**, +0.158 ($t = 18.6$)
- Raw pooled slope -0.001 – flat, not negative → **no Gilt-style size discount**

⇒ **price of immediacy for a block is passed back to the client.**

Central clearing: the mechanics



(a) Bilateral settlement

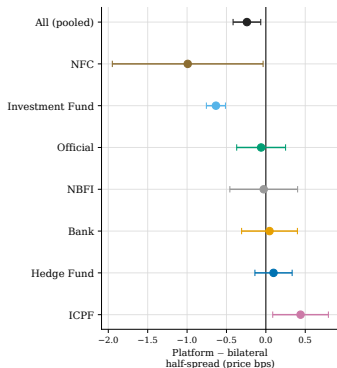


(b) Central clearing

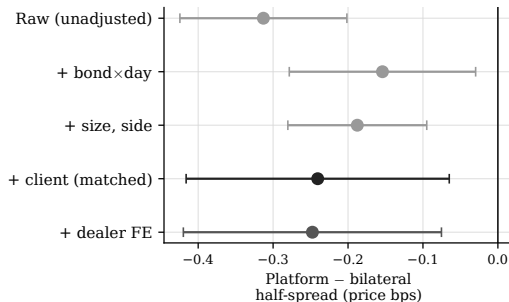
- Holding observed trades fixed, ask: how much do gross/net dealer settlement obligations fall?
- Replicates [Fleming and Keane \(2021\)](#) for USTs and [Baranova et al. \(2023\)](#) for Gilts

Venue centralization: platforms execute tighter – even for the same client–dealer pair

Matched platform differential, by sector



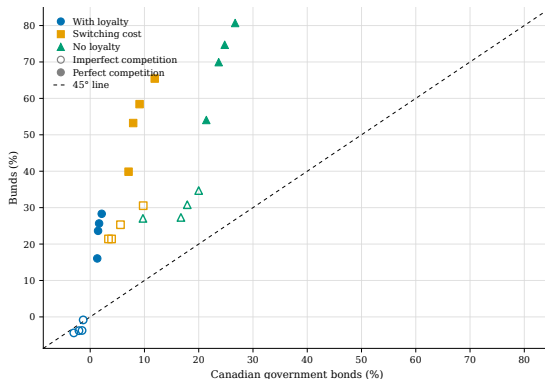
Raw vs. matched, with dealer FE



- Within client $\times$ bond $\times$ day, matched on size/side (10-dealer model sample): platform **-0.24 bps** ($t = 2.7$); full 34-dealer cross-section **-0.63 bps** ($t = 8.2$)
- With dealer FE: still **-0.25 bps** – **same dealer quotes more competitively on platform**
- Concentrated in investment funds; platform flow is, if anything, more informed

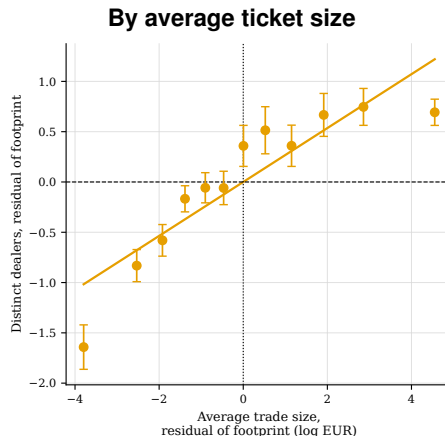
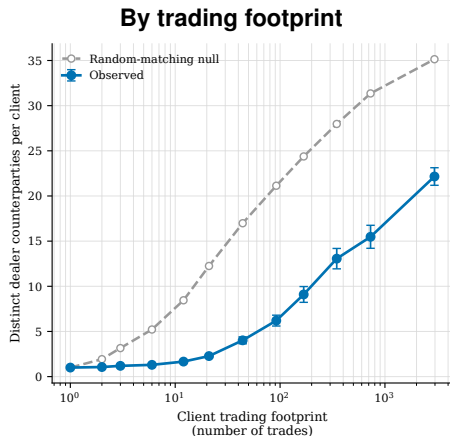
Disciplines the model. But a transfer is not yet welfare.

Venue centralization: Bunds vs. Canadian government bonds



- At the benchmark, magnitudes are *comparable* to [Allen and Wittwer \(2023\)](#): -0.83% / -4.39% in Bunds vs. -1.29% / -3.02% in Canada
- Imperfect competition + valued loyalty $\rightarrow$ centralization *loses* welfare in both markets
- Direction of bias on cross-market differences (institutions, single-bond model) is unclear

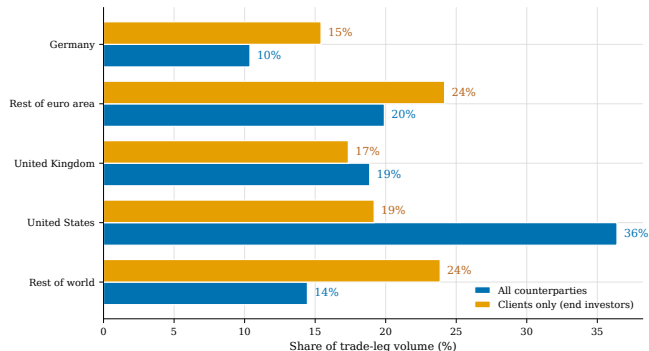
Dealer breadth by trading footprint (Fig. 6 in paper)



Left: observed mean number of dealer counterparties per client (red) vs. i.i.d. random-matching null (gray). Real clients fall *far below* the null across the activity distribution.

Right: holding footprint fixed, larger *tickets* are associated with more dealer relationships – a margin a count-only model cannot generate.

Cross-border participation (Appendix C)

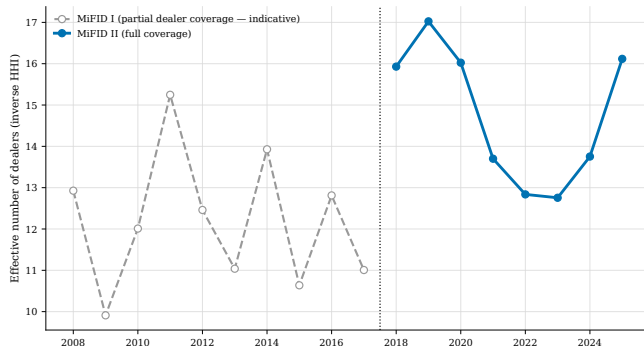


Share of trade-leg volume by counterparty region. Dark bars: all counterparties. Light bars: client legs only (intermediaries excluded).

All-leg: Germany 10%, rest of euro area 20%, UK 19%, US 36%, RoW 14% – 90% of activity involves a non-domestic counterparty.

Client-only: US share *falls* (19%) and RoW *rises* (24%) – part of the headline US footprint is dealer intermediation, not end-investor activity (a distinction transaction data can draw and holdings cannot).

Dealer concentration over time – cyclical, not secular (Appendix C)

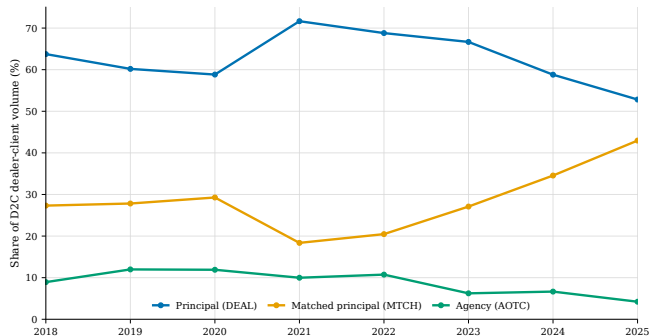


Annual inverse-HHI effective number of primary dealers in intermediation volume; lower = more concentrated.

Within the full-coverage MiFID II window: effective dealer count *peaks* at **17.0** in 2019, *falls* to **12.8** in 2023 (inflation/rate-hike regime shift), *recovers* to **16.1** by 2025. Consistent with intermediation tightening under stress, not a secular decline.

Dotted line marks 2018 MiFID II break; pre-2018 MiFID I segment is not directly comparable (dealer-side weighted, misses ~8 dealers including UK-reporting ones).

Dealer trading capacity over time (Appendix C)

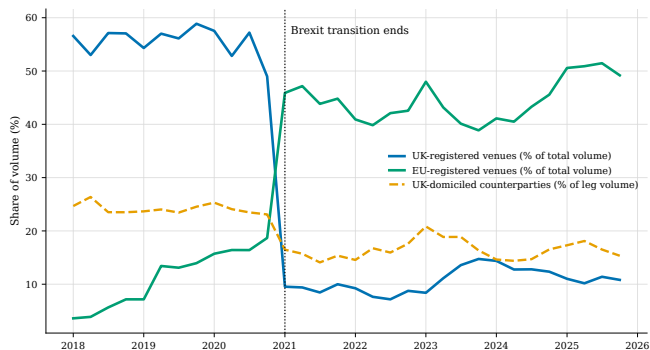


Annual share of D2C volume by MiFIR “trading capacity” field: **principal** (dealer trades on own account, warehouses risk), **matched principal** (riskless simultaneous offset), **agency**.

Principal share **falls from 62% (2018–19) to 53% by 2025**; matched principal **rises from 28% to 43%**.

Not monotone – principal trading was elevated in 2021–23 – so we read this as evidence that dealer balance-sheet use *varies*, not as a clean secular retreat from risk-taking (He and Krishnamurthy, 2013; Duffie et al., 2023).

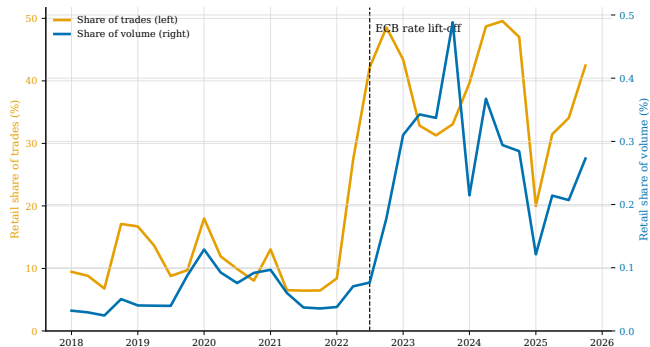
Brexit shifted venue *location*, not who trades (Appendix C)



At end of Brexit transition (1 Jan 2021), UK trading venues left the EU-MiFIR reporting perimeter. UK-registered venue share **collapses from ~56% to ~11%**; EU-registered venues absorb much (11% → 44%) as Bloomberg, Tradeweb, MarketAxess open EU platforms; total on-venue share contracts (reporting scope shrinks). UK-domiciled counterparty share falls far less (24% → 16%): the break was relocation of trading *infrastructure*, not exit of UK participants.

Post-2021 venue composition = change in coverage, not in economics.

The return of the retail investor (Appendix C)

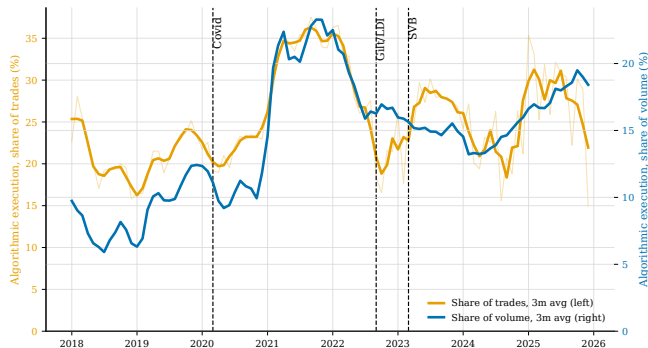


Quarterly share of trades (orange, left) and volume (navy, right) with ≥ 1 retail counterparty. Dashed line: ECB's first rate hike (July 2022).

After ECB rates turned positive, retail share of *trades* jumped from $\sim 11\%$ to $\sim 46\%$ in 2024 – a $>4\times$ increase – as households returned to positively yielding Bunds.

But *volume* share stayed negligible at $\sim 0.1\%$ (very small ticket sizes). Retail is by far the most exchange-reliant segment ($\sim 11\%$ of retail trades execute on regulated exchanges), so the surge lifted exchange trade counts without materially affecting market-wide liquidity.

Algorithmic execution rose – humans retook the wheel in March 2020 (App. C)



Monthly algo share from MiFIR “execution within firm” field; trade-count share (orange, left) and volume share (navy, right), 3-month centered averages.

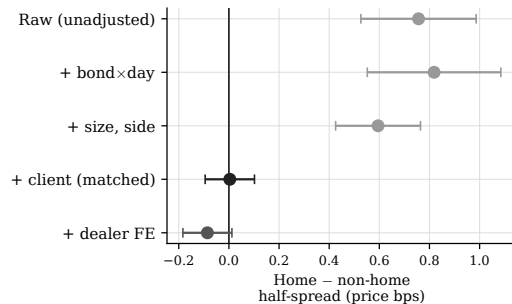
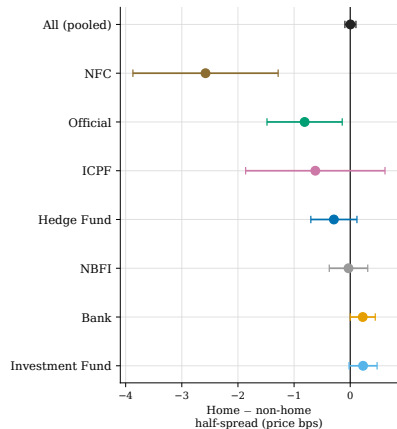
Algo share *climbs* from ~21% (2018–19) to ~28% by 2025 (trade count); by volume 8% → 18% (algos execute disproportionately *small* tickets; large blocks remain human-handled).

Not monotone: in March 2020 (Covid) algo share *fell* from a 23% baseline to 19% – humans stepped in at peak stress. No retreat in the localized Gilt/LDI (Sep '22) or SVB (Mar '23) episodes.

Echoes man-vs-machine evidence on Gilts ([Guimaraes et al., 2025](#)).

oooooooooooooooooooooooo●

Home-dealer execution: no separate price discount



Within client, matched on bond-day, size, side: home-dealer differential is small. Supports modeling loyalty as non-price value, not as a price wedge.

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Discussion “Anatomy of a Safe Asset: Bund Market Structure and Reform”

Katia Vozian*

ESMA Research Conference || September 22, 2026

All views expressed here are the author's solely and do not represent any institutions with whom the author is affiliated. The views expressed herein can in no way be taken to reflect the official opinion of the European Union.

This paper

- This paper offers important evidence on how the German Bund market is structured, how trading activity and price discovery are distributed across market participants and venues, and how different market “reforms” may affect its functioning and welfare.
- The authors rely on a unique dataset of **14 mln Bund transactions** (based on MiDFID I and MiFID II / MiFIR reports) covering nearly **two decades (2008-2025)**.
- The paper argues that **mandatory central clearing** can substantially reduce settlement obligations while **forced platform centralization** may reduce welfare by weakening dealer-investor relationships despite improving access to competing dealers.
- This is a timely and valuable contribution to both academic and policy debates, particularly in light of evolving market dynamics on sovereign bonds and in my opinion also for the SIU.



Very compelling

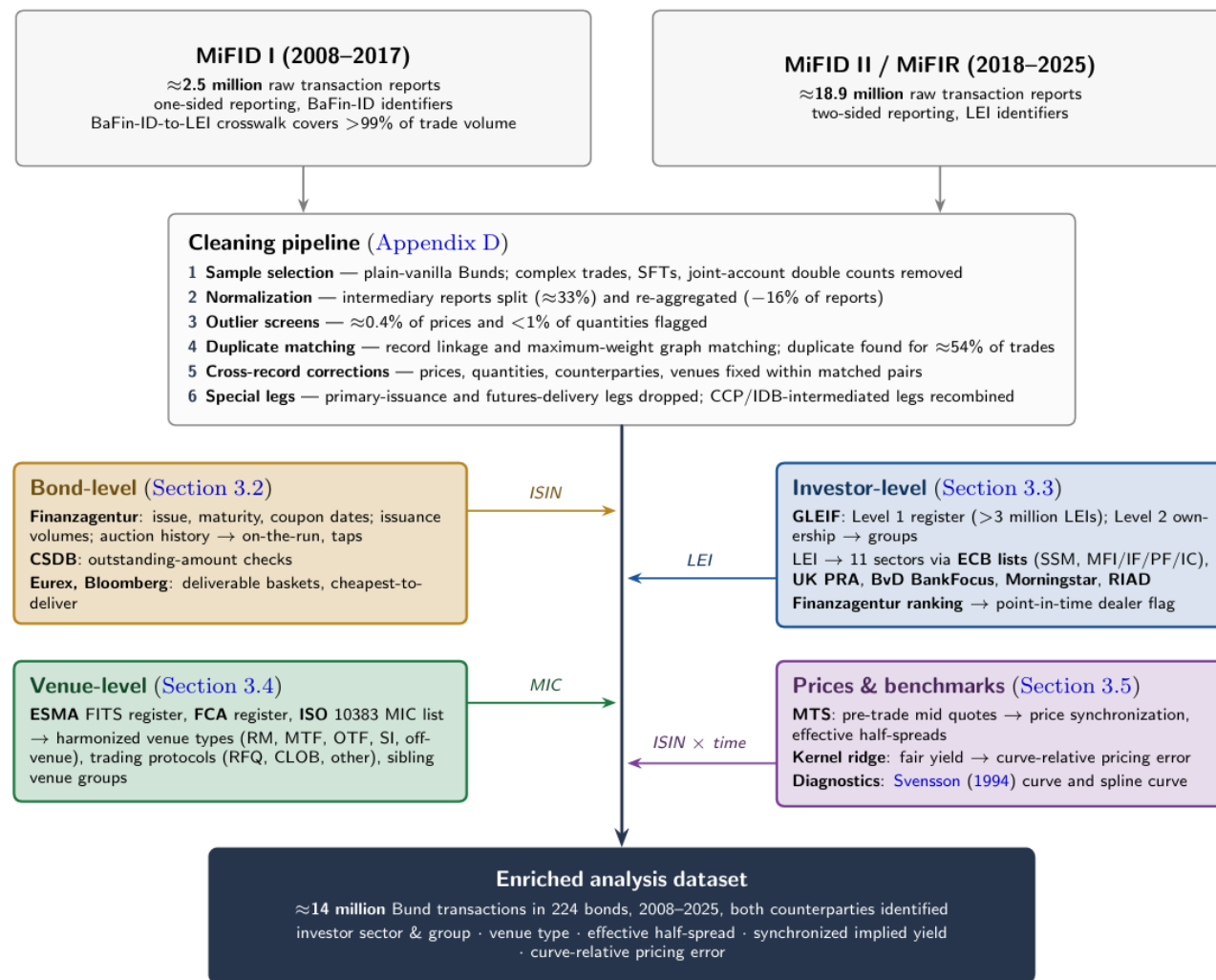
Excellent data contribution: Building a dataset from over 20 mln MiFID I and MiFID II/MiFIR raw transaction reports and enriched with relevant data from Finanzagentur, CSDB, Eurex, Bloomberg, ESMA FITS, GLEIF, etc.

Genuine granularity and time coverage: The breadth of the data provides an unusually detailed view of the Bund market spanning nearly two decades from 2008 to 2025, incl. GFC, Brexit, 2020-Cash-for-Dash.

Subsample 2018–2025 period offers particularly rich coverage for the paper’s empirical analysis.

“Deliberately descriptive” evidence of nearly two decades for the part of Market Structure

Extract from the paper: Figure 1



Comment 1: More on “Safe Asset”

Observation: “Safe Asset” occurs once in the text in section 5.1. Investor Flow and Intermediation (except for the Abstract, Introduction, and Conclusion) and one reference to Duffie (2025, “How US Treasuries can remain the world’s safe heaven”).

If the paper is about “Safe Asset”, and given the seminal literature on what determines a “Safe Asset”, then which claim does the paper supports for the Bund as a “Safe Asset”?

Gorton, G. (2017). The History and Economics of Safe Assets. *Annual Review of Economics* 9: 547-586.

Caballero, R. J., Farhi, E. and Gourinchas, P.-O. (2017). The Safe Assets Shortage Conundrum. *Journal of Economic Perspectives* 31(3): 29-46.

He, Z., Krishnamurthy, A. and Milbradt, K. (2019). A Model of Safe Asset Determination. *American Economic Review* 109(4): 1230-62.

Duffie, D. (2025). How US Treasuries Can Remain the World's Safe Haven. *Journal of Economic Perspectives* 39(2): 195-214.

Acharya, V. V., Augustin, P., Subrahmanyam, M. G. and Tomio, D. (2025). "Safety" by Designation: How Regulatory Treatment Affects the Convenience Yield of Near-Safe Assets. Work-in-progress.

If the paper approaches the “Safe Asset” concept in connection to Duffie (2025, “*How US Treasuries can remain the world’s safe heaven*”), who treats Treasuries as the safe-haven asset, then...

One may measure dealer BS-capacity per Bunds outstanding, the 3% leverage ratio requirement, binding on EU banks since June 2021, to show whether Bund liquidity weakens when dealers are constrained.

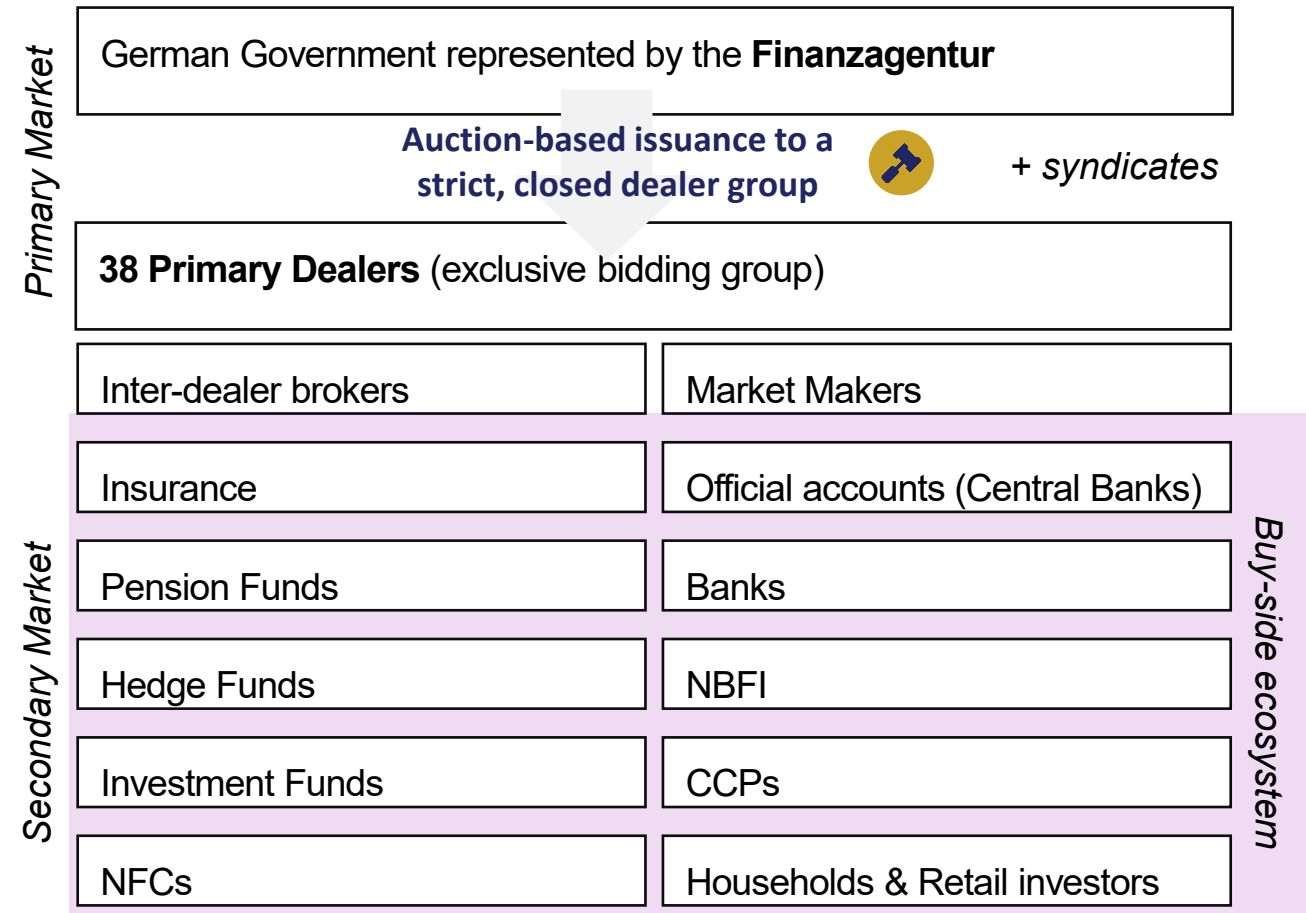
One may also test HKM (2019) who predict that during stress, i.e. high demand for safety (flight-to-safety), a larger debt float enhances market depth and liquidity, whereas during calm periods larger supply does not yield this liquidity premium.



Comment 2: Market design and market structure (ch. 4)

- Start with market design and acknowledge pre-defined market design relative to market structure.
- Example: The paper documents that: *Across 38 dealers active in the sample, Top5-dealers account for 42% of all dealer-intermediated volume and Top10 – 69%.*
- Consider and discuss whether some of the observations in market structure are genuine economic outcomes or are shaped by the existing market design.

Fig. Schematic representation of the German Bund Market Design



Continuous dealer-to-client trading across a broad domestic and international investor base; CCPs clear part of this activity.



Comment 3: “Reforms” (ch. 6)

- The “reforms” announced in the title are not actual reform proposals in the pipeline of policy makers in the EU; rethink the framings as hypotheses.
- On Mandatory Clearing for all Bund trades
 - Add the counterparty risk perspective
- Platform centralization hypothesis (moving OTC to Platform, i.e. electronic venues).
 - Show what is happening in stressed markets; how big are the welfare losses then? [Electronic venues are mostly used for everyday volume, whereas OTC trades for large blocks and stressed markets]
 - Disentangle: D2D and D2C. For D2D, on-platform is dominant, but there is still OTC (& interestingly there is more OTC in the Bund than in other Sovereign Bonds e.g. Italian BTP; for D2C, 67% on platforms and still 33% on OTC (quite large). Your paper focuses on D2C – this may be interesting also for the **SIU**.

A thoroughly compelling and promising research paper.

I look forward to the next version and recommend readers lean into its extensive analysis of the Anatomy of the German Bund Market Structure.

Thank you



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Appendix: Clearing vs Venue, considering trade type

	Through-CCP	Off-CCP
On-Platform	D2D: growing majority	D2C: residual
	D2C: early stage	D2C: sizeable
Off-Platform / OTC	D2D: uncommon	D2D: residual
	D2C: very rare	D2C: sizeable

Repo Collateral Reuse and Liquidity Windfalls

Georgios Angelis Alexiou^{1,2} Sofia M. Pereira² Victor Rodrigues-Gomes¹

$\left[\begin{array}{l} ^1 \text{ Goethe University Frankfurt} \\ ^2 \text{ European Central Bank} \end{array} \right]$

ESMA Research Conference 2026

Disclaimer: The views expressed do not necessarily reflect those of the European Central Bank.

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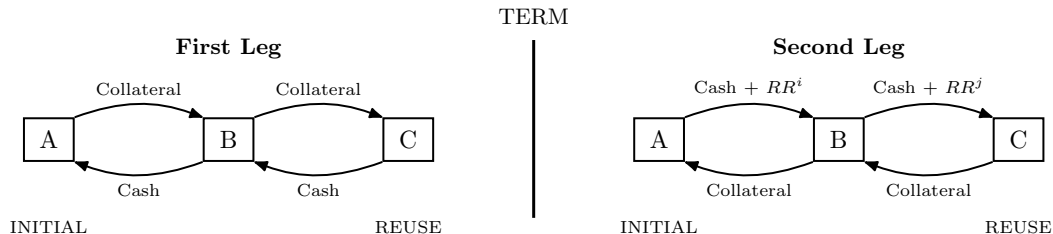
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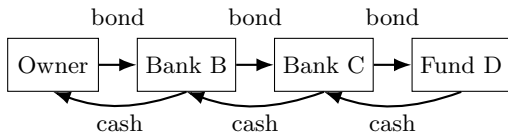
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- Repo markets are a very important source of wholesale funding for banks, funds, and other market participants.
- The outstanding amount of repos in Europe has been reaching new highs, **surpassing EUR 12.5 trillion in 2025** (ICMA, 2025).

- In repos, the cash lender gains full legal rights over collateral, unless otherwise agreed.

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- Institutions can then transfer the same securities in their own repos, a practice known as *collateral reuse*.

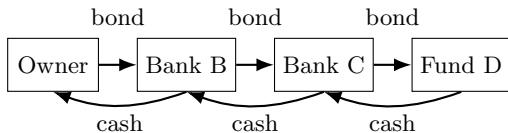
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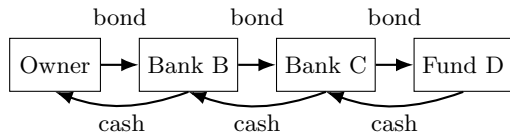
one bond $\rightarrow$ several funding links

- Reuse means that the same collateral can support multiple repo transactions.



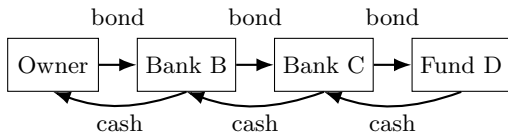
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- This can improve collateral circulation and funding efficiency (Infante, 2019; Accornero, 2020).



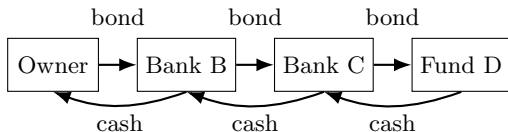
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- Reuse means that the same collateral can support multiple repo transactions.
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- But it also creates interdependence across institutions, raising systemic-risk concerns (FSB, 2017a; Infante et al., 2020).



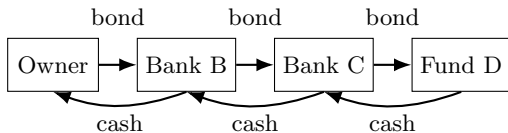
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Our first task: to map collateral reuse in the euro repo market.

$$\text{Haircut} = \left(\frac{P_m - P_p}{P_m} \right) \times 100$$

where P_m is the market value of the collateral and P_p is the purchase price.

- To protect against fluctuations in the market value of collateral, repo transactions usually involve **over-collateralization**.
- This is done through a discount applied to the market value of the collateral relative to the cash exchanged. This discount is known as the **haircut**.

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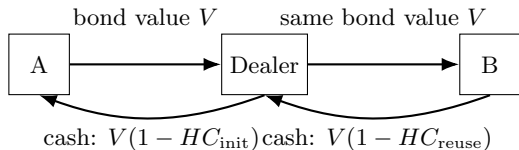
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Example

If a cash borrower wants to obtain \$100 and faces a haircut of 2%, they must pledge collateral with market value

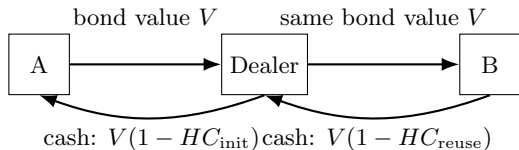
$$\frac{100}{0.98} \approx 102.04$$

So, to borrow \$100, the borrower needs to deliver about \$102.04 of collateral.



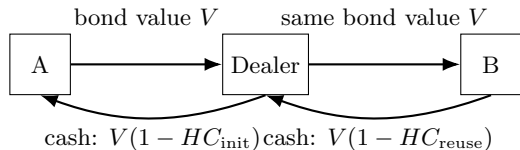
- A well-accepted strand of the literature argues that dealers reuse collateral in the repo market to obtain temporary extra cash via haircut differences (Eren, 2014; Infante, 2019).

$$HC_{init} > HC_{reuse} \Rightarrow V(HC_{init} - HC_{reuse}) > 0$$



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- These are called *liquidity windfalls*.

$$HC_{\text{init}} > HC_{\text{reuse}} \Rightarrow V(HC_{\text{init}} - HC_{\text{reuse}}) > 0$$



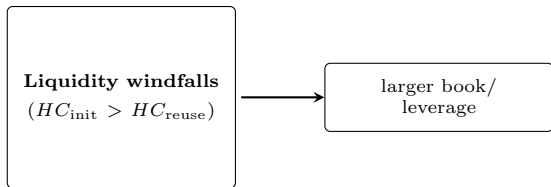
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- A well-accepted strand of the literature argues that dealers reuse collateral in the repo market to obtain temporary extra cash via haircut differences (Eren, 2014; Infante, 2019).
- These are called *liquidity windfalls*.
- This mechanism has become a standard reference point in both the theoretical and empirical literature (e.g., Infante and Vardoulakis, 2021; Kruttli et al., 2022).

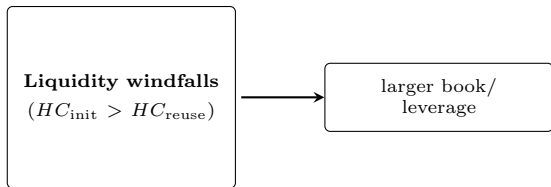
Liquidity windfalls
($HC_{\text{init}} > HC_{\text{reuse}}$)



larger book/
leverage



- If dealers obtain temporary extra cash from reuse, this can loosen internal liquidity constraints and support a larger matched-book position (Andolfatto et al., 2017; Infante, 2019).

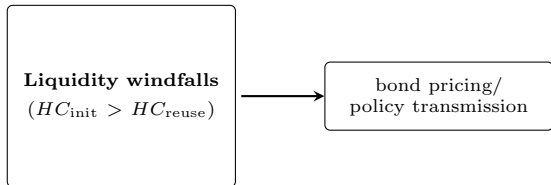


- If dealers obtain temporary extra cash from reuse, this can loosen internal liquidity constraints and support a larger matched-book position (Andolfatto et al., 2017; Infante, 2019).
- This means more intermediation capacity can be sustained by the same collateral before the dealer needs to raise additional funds externally, which makes reuse a different kind of leverage.

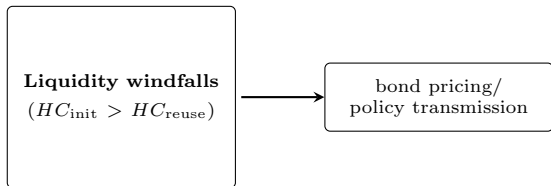
Liquidity windfalls
($HC_{\text{init}} > HC_{\text{reuse}}$)



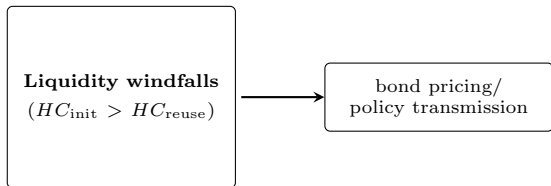
bond pricing/
policy transmission



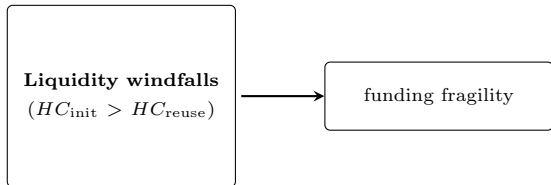
- By relaxing effective liquidity constraints, windfalls support dealers' ability to intermediate customer trades and provide liquidity in bond markets (Adrian et al., 2017; Huh and Infante, 2021).

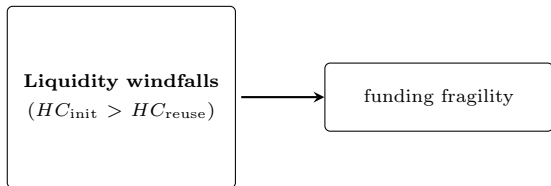


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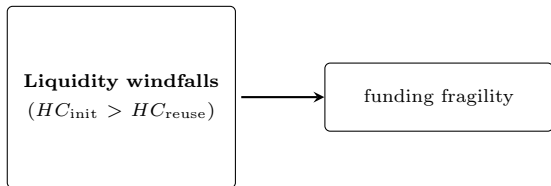


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- Greater intermediation capacity can affect bid-ask spreads and the relative pricing of securities whose valuation depends on repo financing and balance-sheet costs (Huh and Infante, 2021; Du et al., 2023).
- This also affects how monetary policy is passed through to end-users, since repo rates are shaped by dealer intermediation frictions (Eisenschmidt et al., 2024).

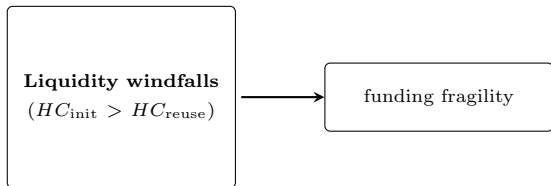




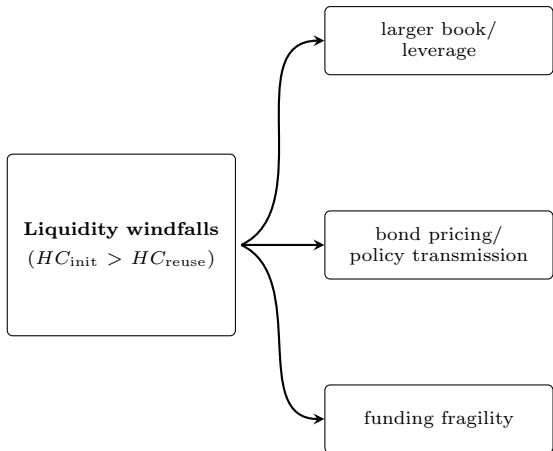
- Reliance on temporary liquidity generated through reuse can make dealers more exposed to disruptions in collateral chains and refinancing conditions.

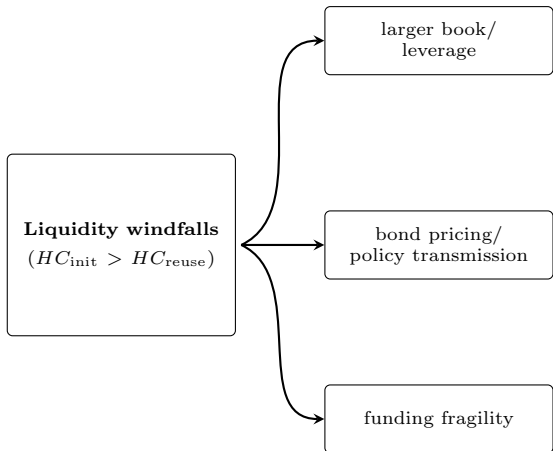


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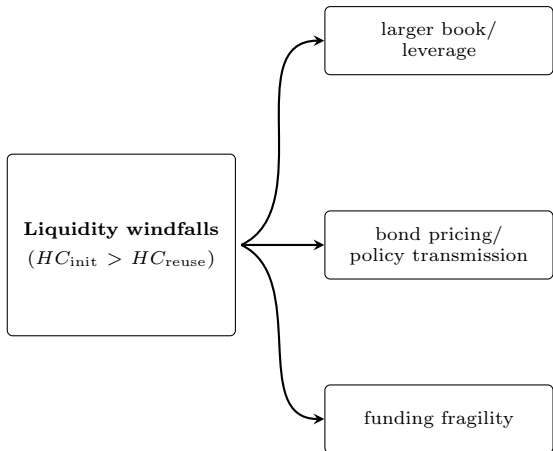
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- Dealers are also exposed to collateral-provider withdrawals: if clients pull back collateral, reuse becomes impaired and the dealer's liquidity position deteriorates (Infante and Vardoulakis, 2021).





Takeaway:

If liquidity windfalls exist in repo collateral reuse, they create a hidden liquidity channel with consequences for both stability and pricing.



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Our second task: to test the existence of liquidity windfalls.

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No windfalls

haircut wedge is absent on average
no systematic “free cash”

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- Novel transaction-level SFTDS data
- Roughly **15 million** repo transactions
- January 2021–February 2025
- True **repo-to-repo** reuse mapping
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 - This paper can isolate where and through whom reuse happens.

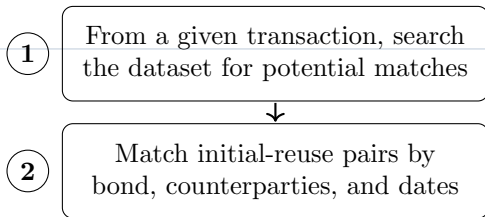
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- Some assumptions are motivated by market practice.
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1

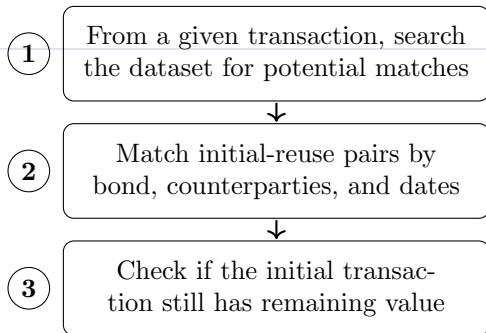
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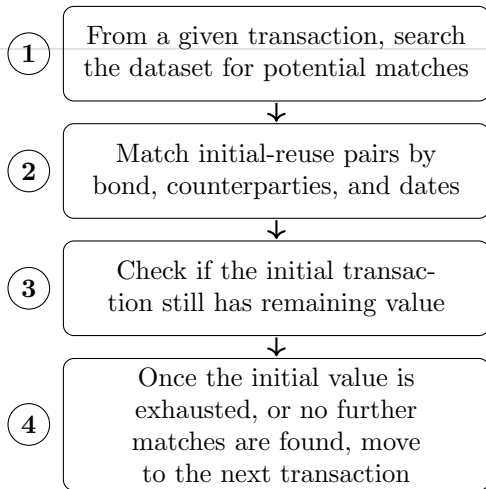
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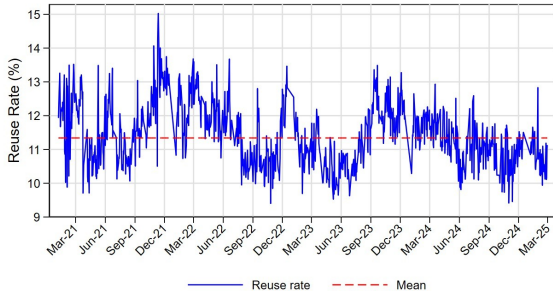


Fact 1: Reuse is material, although not dominant

11.6% reuse rate

Daily Average

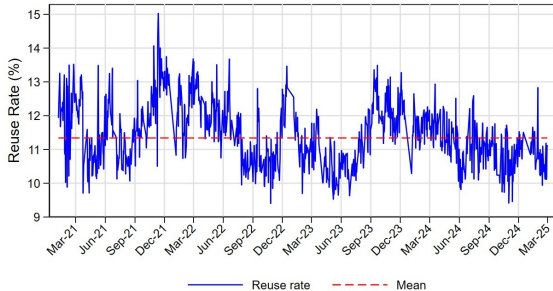
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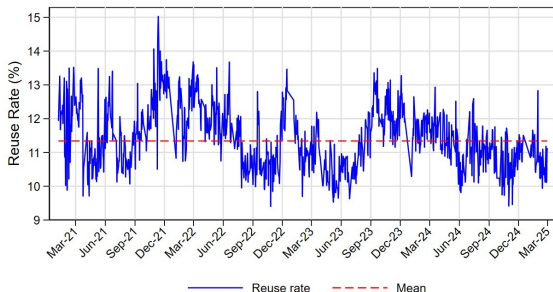


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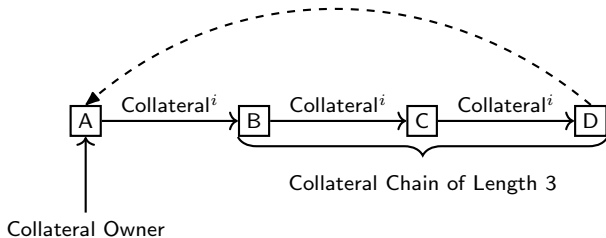


- Average reused volume is about **€ 49bn per day**.
- So collateral reuse in repos is not a niche behavior, but also not the norm.
- Our results are in line with similar studies in other markets:

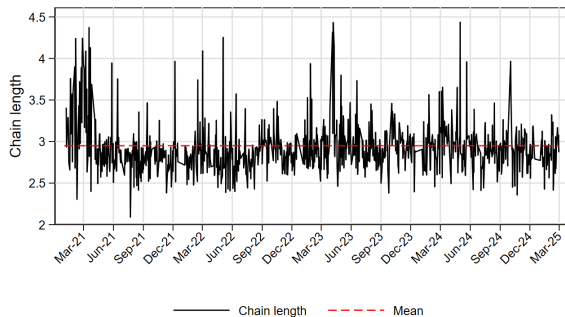
Study	Reuse rate
Swiss repos	5% ^[1]
Australian repos	3.4% ^[2]
This paper (EU repos)	11.6%

[1]: Fuhrer et al., 2016; [2]: Issa and Jarnećic, 2024.

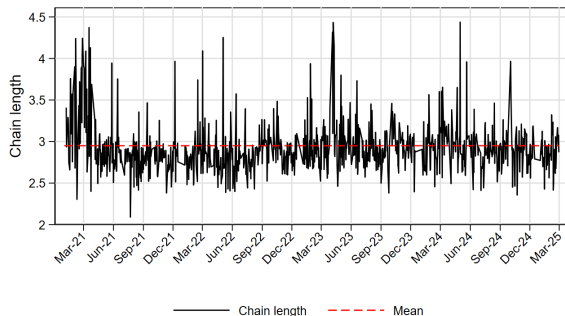
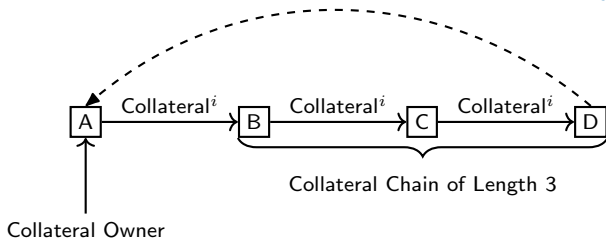
Fact 2: Interconnectedness is a key externality



- The average reused bond passes through about **three links** before returning.

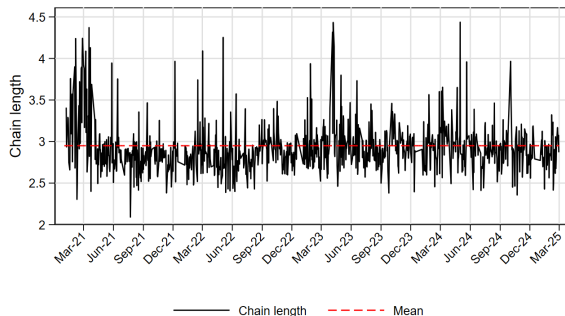
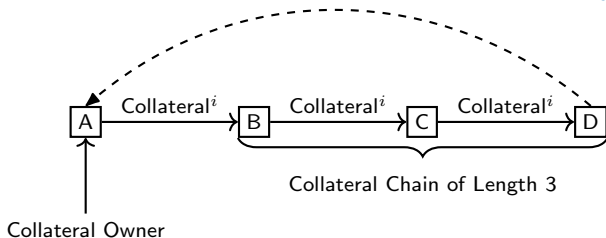


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- The average reused bond passes through about **three links** before returning.
- If any of those institutions fail to return the collateral, the previous node is forced to source it.
- Every extra link creates another point where stress can propagate.

$$Reuse_i = \beta_0 + \Phi X_i + \beta_1 OISSpread_i + \beta_2 Hike_i + \beta_3 March23_i + \gamma + u_i$$

$$X_i^{tx} = [\ln(Notional_i), \ln(Term_i), Haircut_i, RepoRate_i]$$

$$X_i^{cp} = [DealerBorrower_i, HedgeFundBorrower_i, BorrowerCountry_i, Rating_i, Exposure_i]$$

$$X_i^{coll} = [RemMaturity_i, \ln(Outstanding_i), Issuer_i, AskBid_i, Specialness_i, CTD_i, OTR_i, ECBHaircut_i]$$

	<i>Dependent Variable: Reuse</i>		
	OTC	CCP	OTC non-zero
ln(Notional)	−0.03***	−0.03***	−0.03***
ln(Term)	−0.02***	0.02***	−0.02***
Haircut/Margin	0.002	0.002	0.002
Repo Rate	−0.007	0.004**	−0.01
⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮
$t \times b \times bw$ FE	Yes	No	Yes
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Adj. R^2	0.60	0.24	0.62
Number of obs	1,499,713	12,953,080	836,874

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- Reuse is more likely for **smaller**.
- Reuse is more likely for **shorter** trades in OTC transactions, but for longer ones in CCP trades.
- Haircuts and repo rates show up statistically, but they are not the main economic story.

	<i>Dependent Variable: Reuse</i>		
	OTC	CCP	OTC non-zero
Dealer Borrower	0.005	0.03	-0.02
Hedge Fund Borrower	-0.08	—	-0.17***
German Borrower	-0.01	0.03	0.05
French Borrower	-0.04	-0.01	-0.03
Italian Borrower	-0.08*	-0.12***	-0.19***
Borrower Rating	-0.003	0.004	0.001
Borrower Exposure	-0.18***	-0.68***	-0.15***
Lender Exposure	0.09**	0.41**	0.04
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<i>time</i> × <i>bond</i> FE	Yes	Yes	Yes
Adj. R^2	0.27	0.09	0.35
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- Italian entities are less likely to reuse collateral.
- Reuse is contingent on the **interdependence** between (cash) lender and borrower.

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	OTC	CCP	OTC non-zero
Remaining Maturity	0.001**	−0.001*	0.000
ln(Outstanding)	0.05***	0.02	0.06***
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- German and French bonds are less likely to be reused.
- Bonds on special are more likely to be reused in OTC trades, while cheapest-to-deliver ones are less.
- Economically, however, collateral specifics other than outstanding amount add **relatively little** explanatory power.

Fact 3: Who trades matters more than the collateral

Strong predictors of reuse

- Trade size
- Trade tenor
- Counterparty type
- Relationship / exposure structure

Weaker/insignificant predictors

- Collateral (ex-Outstanding)
- Dealer Status
- Haircut level
- Repo rate level

Fact 3: Who trades matters more than the collateral

Strong predictors of reuse

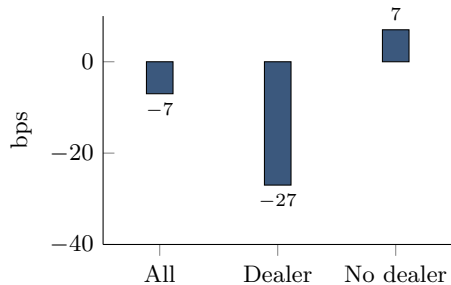
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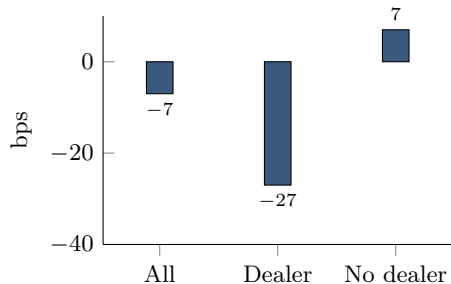
Counterparty structure
is the main lens

Collateral/Pricing
matter less at the margin



(Margins)

- Full sample: **-7 bps**
- Dealer-intermediated chains: **-27 bps**
- Non-intermediated chains: **+7 bps**



(Margins)

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Empirical test

$$\Delta HC = HC_{init} - HC_{reuse}$$

- **Windfall:** $\Delta HC > 0$
- **No windfall:** $\Delta HC \leq 0$

Stage I: selection into reuse

$$\Pr(\text{reuse}_i = 1) = \Phi\left(\beta_0 + \beta_1 \ln(\text{Notional}_i) + \beta_2 \text{Specialness}_i + \beta_3 \text{HFB}_i + \beta_4 \text{ITB}_i + \beta_5 \text{EXPOB}_{bwi} + \beta_6 \text{EXPOL}_{li} \right. \\ \left. + \beta_7 \text{IssuerDE}_{bi} + \beta_8 \text{IssuerFR}_{bi} + \beta_9 \ln(\text{Outstanding}_{bi}) + \beta_{10} \text{CTD}_{bi} + \beta_{11} \text{OISSpread}_i + \gamma_t\right)$$

Stage II: haircut differentials

$$\Delta H_j = \phi_0 + \phi_1 \ln(\text{Notional}_{j2}) + \phi_2 \ln(\text{Term}_{j2}) + \phi_3 \text{DEALERINT}_j + \phi_4 \Delta R_j + \phi_5 \text{Specialness}_{j2} \\ + \phi_6 \text{CTD}_{j2} + \phi_7 \text{Hike}_{j2} + \phi_8 \text{March23}_{j2} + \phi_9 \text{IMR}_{j2} + \gamma_{t,b,bw} + \varepsilon_j$$

- DEALERINT: dealer intermediates between two non-dealers.
- ΔR : repo-rate differential between reuse and initial trade.
- IMR : inverse Mills ratio from Stage I.
- Stage II is estimated by **WLS**, weighted by reuse-transaction size.

Stage I: selection into reuse

$$\Pr(\text{reuse}_i = 1) = \Phi\left(\beta_0 + \beta_1 \ln(\text{Notional}_i) + \beta_2 \text{Specialness}_i + \beta_3 \text{HFB}_i + \beta_4 \text{ITB}_i + \beta_5 \text{EXPOB}_{bw_i} + \beta_6 \text{EXPOL}_{li} \right. \\ \left. + \beta_7 \text{IssuerDE}_{bi} + \beta_8 \text{IssuerFR}_{bi} + \beta_9 \ln(\text{Outstanding}_{bi}) + \beta_{10} \text{CTD}_{bi} + \beta_{11} \text{OISSpread}_i + \gamma_t\right)$$

Stage II: haircut differentials

$$\Delta H_j = \phi_0 + \phi_1 \ln(\text{Notional}_{j2}) + \phi_2 \ln(\text{Term}_{j2}) + \phi_3 \text{DEALERINT}_j + \phi_4 \Delta R_j + \phi_5 \text{Specialness}_{j2} \\ + \phi_6 \text{CTD}_{j2} + \phi_7 \text{Hike}_{j2} + \phi_8 \text{March23}_{j2} + \phi_9 \text{IMR}_{j2} + \gamma_{t,b,bw} + \varepsilon_j$$

Liquidity Windfalls hypothesis: If $HC_{init} > HC_{reuse}$, the dealer can recycle the same bond and temporarily end up with extra cash.

	No FE (1)	t FE (2)	$t \times b$ FE (3)	$t \times b \times bw$ FE (4)	$t \times b \times bw$ FE (5)	Non-zero haircut (pair) (6)
ln(Notional)	0.001	0.001	-0.02*	-0.02	-0.02	-0.01
ln(Term)	-0.04	-0.04	-0.02	-0.02	-0.02	-0.01
Dealer intermediary	-0.31***	-0.30***	-0.34***	-0.03	-0.03	-0.08
ΔR	0.05	0.03	-0.03	-0.03	-0.03	-0.02
Specialness	-0.03	-0.05	-0.12***	-0.03	-0.03	-0.08
Cheapest-to-deliver	-0.006	-0.01	0.09**	-0.14***	-0.14***	—
ECB Hike	0.05	-0.05	-0.04	-0.05	-0.05	-0.03
March 2023	-0.005	0.05	0.04*	-0.01	-0.01	-0.02
IMR	0.29***	0.29***	0.34***	0.43	0.43	0.32
Constant	-0.34*	-0.27	-0.08	-0.22	-0.22	-0.41
Observations	259,450	259,450	246,552	197,875	197,875	75,784
Adjusted R^2	0.054	0.070	0.428	0.764	0.764	0.802
Within R^2	0.054	0.050	0.058	0.003	0.003	0.001
Clustered SE	Borrower	Borrower	Borrower	Borrower	Borrower–Week	Borrower

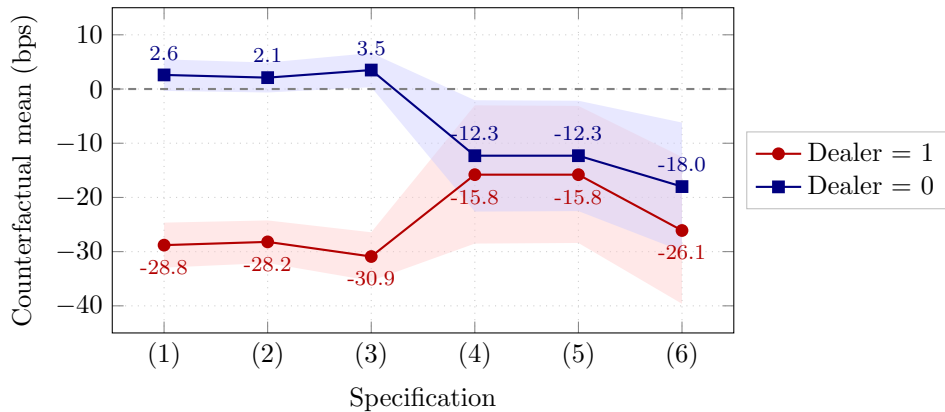
	No FE (1)	t FE (2)	$t \times b$ FE (3)	$t \times b \times bw$ FE (4)	$t \times b \times bw$ FE (5)	Non-zero haircut (pair) (6)
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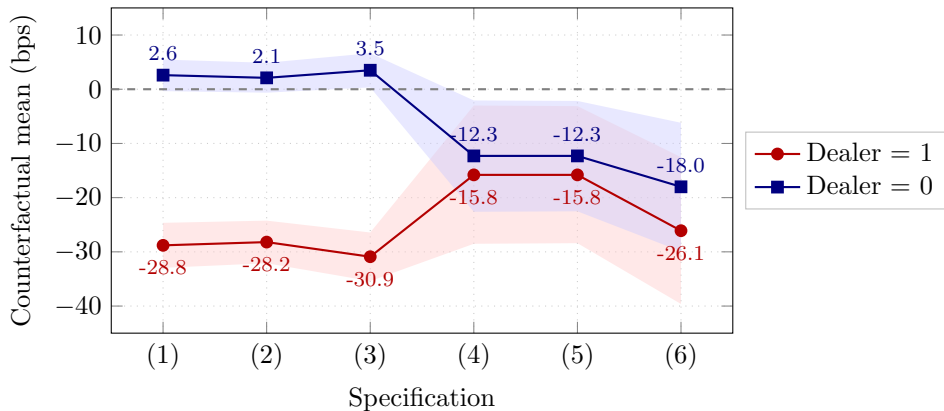
- The key coefficient is are *DEALERINT*; it captures they whether dealer intermediation is associated with an increase in the haircut wedge.

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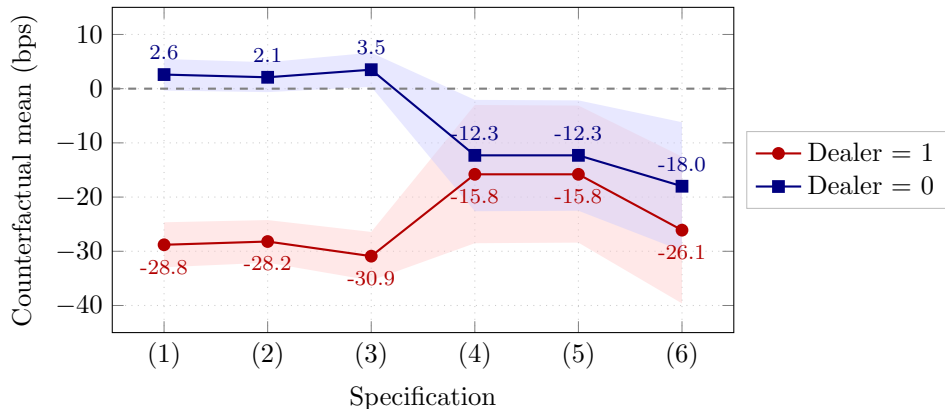
- The key coefficient is $DEALERINT$; it captures whether dealer intermediation is associated with an increase in the haircut wedge.
- The resulting coefficient is negative in all specifications, albeit always not statistically significant.

- In this setup, we cannot immediately observe the mean conditional haircut differential.
- To make the estimation clearer, we estimate the average conditional on dealer intermediation being present or not.
- 95% confidence intervals come from the cluster-robust standard error of the dealer coefficient, rescaled by the dealer-intermediated share of the estimation sample.

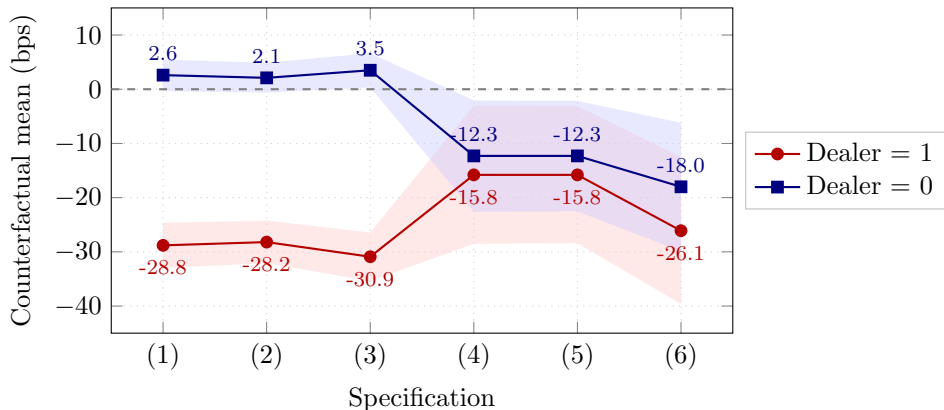




- The dealer-conditional wedge has the wrong sign for the liquidity-windfall hypothesis to hold, and the sign is preserved across all six specifications.



- The result is not driven by which bonds, borrowers, or weeks dealers happen to trade in: within the same borrower–bond–week cell, dealer chains still embed a negative wedge.



- Rather than extracting free cash from haircut asymmetries, dealers in euro repos appear to surrender collateral value as bonds pass through their books.

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1. Reuse in euro-area repos is **common enough to matter**.
2. Reuse also creates **interconnected chains**.
3. The data do **not** support systematic haircut-based liquidity windfalls.
4. So the policy discussion should move from “*hidden liquidity subsidy*” to **network resilience**.

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Appendix: common controls across reuse specifications

	(1) Transaction	(2) Counterparty	(3) Collateral
OIS Spread	−0.01**	−0.00	−0.01***
March 2023	−0.007*	0.01	0.01
ECB Hike	−0.015***	−0.00	−0.00
Fixed effects	Week × ISIN × Borrower	Time × Bond	Time × Borrower
Adj. R^2	0.61	0.09	0.08
Observations	14,751,691	12,217,900	11,749,718

[← Back](#)

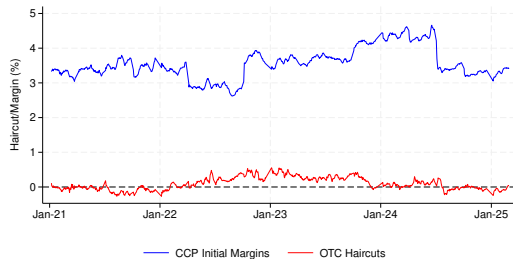


Figure: Initial Margins v. Haircuts

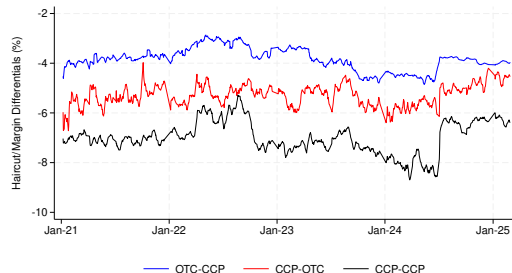


Figure: Haircut Differentials With CCPs

Repo collateral reuse and liquidity windfalls

Georgios Angelis Alexiou Sofia M. Pereira
Victor Rodrigues-Gomes

Discussion by
Alessandro Spolaore (ESMA)

ESMA Research Conference
September 22, 2026

Summary

- ▶ Paper uses novel, confidential SFTDS transaction-level data (2021–2025, $\sim 15\text{M}$ obs) to estimate repo-to-repo collateral reuse in the EU
- ▶ Two key contributions:
 1. **Reuse volume estimation:** large and structural ($\sim \text{€}49\text{bn/day}$, i.e. 11.6% of overall daily volumes), with average chain length ~ 3
 2. Contrary to theory, **no evidence of "liquidity windfalls"** (Infante (2019)) - haircut differentials between initial and reuse trades are negative, and even more negative for dealer-intermediated chains
- ▶ **Policy relevance:** collateral rehypothecation at the core of repo and securities financing transaction markets (Singh (2016)); leverage/collateral-run amplification channel weaker than theory predicts, yet interconnectedness risk persists

Overview of main comments

- ▶ Reconciling re-use rate estimates
 - ▶ Partial alignment with previous literature, with some discrepancies
- ▶ Clarifying terminology and discussion of CCP risk management practices
- ▶ Sample restriction to OTC–OTC pairs for the windfall test
- ▶ Counterparty identification in centrally cleared repos

Re-use: benchmarking against prior literature

Estimates of re-use rate broadly in line with:

- ▶ Fuhrer et al. (2016): $\sim 5\%$, peaking at 20% in August 2007.
Data: Swiss repo market;
- ▶ Issa and Jarnecic (2024): $\sim 3.5\%$ between 2006 and 2013.
Data: Australian repo market;

However, misalignment with comparable studies using EU data:

- ▶ Jank et al. (2022) report a 75% average re-use rate using quarterly data from German banks
- ▶ Inhoffen and Lelyveld (2024) report a 53% average re-use rate using MMSR data on EU
 - ▶ Sec lending and margin lending in EU much smaller in size & collateral composition only partially overlapping → robustness check with subsample of **MMSR reporting banks?**

In the EU: two key repo segments

Repos currently the largest part of EU Money Markets: ~ 7 tn EUR in outstanding amounts (ESMA 2024) and ~ 1 tn EUR in daily transaction volumes (ECB 2024) - significantly larger than **unsecured interbank lending market**.

Two distinct segments:

1. **Centrally-cleared**: characterised by the involvement of a Central Counterparty (CCP). A predominantly interbank segment, it accounts for the majority of trading volumes and for $\sim 40\%$ of outstanding amounts (ESMA 2024).
2. **Bilateral, non centrally-cleared**: variety of participants, e.g. smaller banks and NBFIs, access the repo market through bilateral repo. In the EU, $\sim 30\%$ of trading volumes and more than half of outstanding amounts (Bassi et al. 2024). Key intermediation role played by banks and dealers.

Margins in centrally cleared repos

The paper might benefit from a more careful explanation of CCP practices before Sections 4.2 and 5, as the term **Initial Margin** (IM) may be ambiguous:

- ▶ In centrally cleared repos, IM → forward-looking margin requirement at **portfolio level**, already incorporating offsets and cross-correlation effects - see Boudiaf et al. (2023);
- ▶ In this paper, IM → **security-level** margin parameters employed in the CCP risk model (**theoretical** inputs);

→ Actual margin requirements by CCPs also influenced by size of gross positions, directionality, cross-correlation and a range of other factors...

Nevertheless, comparison with trade-level haircuts in the bilateral segment is indeed difficult.

Sample restriction for windfall test

- ▶ Liquidity windfall hp tested only in the OTC-OTC sample, as no viable alternative. However, how representative is this subsample?
 - ▶ Brand et al. (2019): centrally cleared repo mostly a specials market in the EU → [relevant for collateral sourcing](#)
 - ▶ OTC-OTC reuse amounts to a small share of overall reuse (282k pairs out of 3.85m reuse transactions)
- ▶ Analysing OTC bilateral haircut may be insufficient to estimate potential gains for dealers' intermediation activity through collateral allocation, from a system perspective.

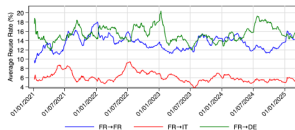
In addition, no detectable differential in repo rates among reuse transactions - how do balance-sheet constraints play a role here? What other factors affect the choice and the conditions of reuse by dealers? Open research topic, with relevant links to NBFIs...

Counterparty identification in centrally cleared repos

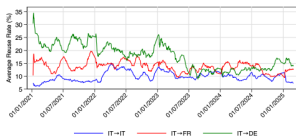
- ▶ Centrally cleared repos are mostly traded anonymously on-venue (ECB 2024; ESMA 2024); in this setting, repo participants do not know the identity of their counterparty.
- ▶ Suggest clarifying if Figure 7 includes bilateral or centrally cleared repos (or both). Visible trends may be driven by bilateral trades or may not be meaningful at all...



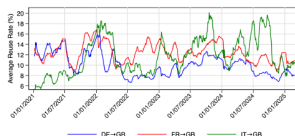
(a) Reuse Rates by Counterparty Country Pair - German Lender



(b) Reuse Rates by Counterparty Country Pair - French Lender



(c) Reuse Rates by Counterparty Country Pair - Italian Lender



(d) Reuse Rates by Counterparty Country Pair - British Borrower

Minor comments

- ▶ Cite source for data on CCP margin parameters, if possible
- ▶ Clarify possible interpretation of Figure 7 and related caveats
- ▶ Repeated paragraphs on p.30 and p.34

Takeaways

- ▶ Very strong data and robust methodological approach.
- ▶ Policy-relevant questions: (1) estimation of collateral reuse in repo markets and (2) analysis of potential liquidity windfalls obtained by dealers through reuse.
- ▶ As possible follow-up or enhancement, suggest to monitor reuse dynamics under market stress, potentially for specific collateral or NBFIs types (e.g. Figure 6 - spike in reuse rate around UK Gilt stress episode?)

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