The Market for Sharing Interest Rate Risk: Quantities and Asset Prices

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EEA-ESEM Rotterdam 2024

Disclaimer: The views expressed in this paper are those of the authors and not necessarily of the Bank of England or its Committees.

Motivation

- Recent events highlight the extent of interest rate risk in the economy
  - Banks run a positive duration gap - maturity of assets > liabilities , e.g., SVB crisis
  - Pensions and insurers run a negative duration gap, e.g., UK gilt crisis.
  - Increased attention to the role of shadow banking in derivative markets

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  - Pensions and insurers run a negative duration gap, e.g., UK gilt crisis.
  - Increased attention to the role of shadow banking in derivative markets
- Derivatives provide opportunity to swap interest rate risk and reduce exposure to rate changes
  - Interest rate swaps are large and liquid markets with $500 trillion outstanding
  - However, little systematic evidence on **cross-sector** risk sharing using these instruments
  - Need to assess spillover impact of demand shifts to inform policy discussions

This paper

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  - ∗ As interest rates ↑, PF&I ↓ their net receive positions, while banks ↓ their net pay positions
  - ⇒ Opposite exposure to demand shocks
- High segmentation across maturities
  - ∗ PF&I mostly trade swaps $\geq$ 10 years, while banks and corporations trade swaps between 3 months - 5 years
  - ⇒ Expose dealers to demand fluctuations

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  - Quantify the contribution of demand imbalances and supply frictions to the shape of the swap spread curve

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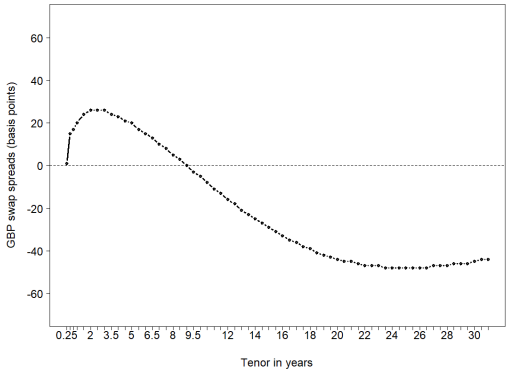

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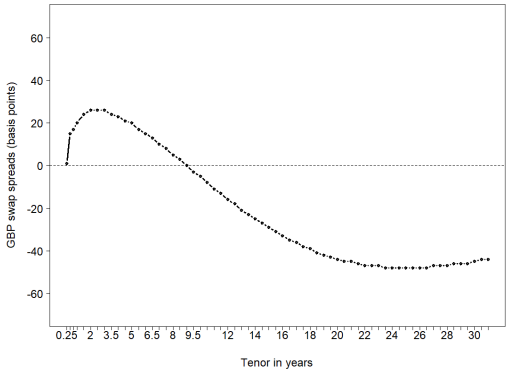
  - Quantify the contribution of demand imbalances and supply frictions to the shape of the swap spread curve

- Counterfactual analysis
  - Spillover effects of demand changes
  - Market integration
  - Dealer constraints



We contribute to three strands of literature

- **Individual sector interest rate risk management**:

  Begenau, Piazzesi, & Schneider (2015), Sen (2019), Kaniel & Wang (2020), McPhail, Schnabl, & Tuckman (2023), Jansen, Klingler, Ranaldo, & Duijm (2023)...

  This paper: jointly studies all sectors, their interaction and demand imbalances

- **Swap spreads**:

  Klingler & Sundaresan (2019), Jermann (2020), Hanson, Malkhozov, & Venter (2022)...

  This paper: explains the shape of the swap spread curve with quantities data

- **Preferred-habitat investors**:

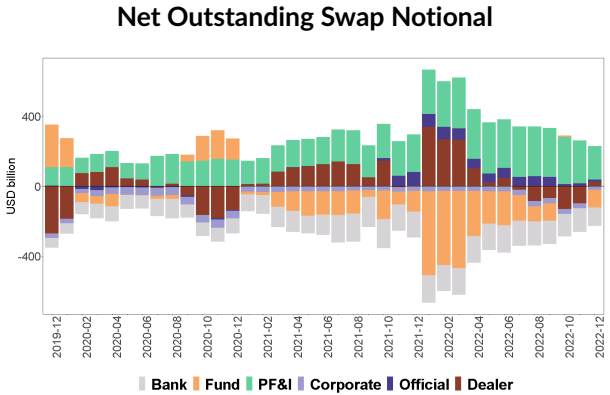
  Vayanos & Vila (2021), He, Nagel & Song (2022), Bahaj, Czech, Ding & Reis (2023)...

  This paper: first study of preferred-habitat investors in interest rate swaps (estimate using quantities data)

Data

- Largest IRS dataset deployed in academic literature: BoE regulatory data in OTC interest rate swaps, with at least one UK entity
  - Monthly stock: snapshots of stock of outstanding trades - quantities
  - Daily flows: new trades initiated - prices
- Sample period: July 2019 - Dec 2022
- Coverage: $\geq$ **60%** global swaps transaction volume and $\geq$ **84%** GBP swaps Details
  - Focus on GBP swaps
- Sector classification for over 6,000 legal entities (LEI)
  - Economically meaningful distinction between end-user banks and intermediary dealers

Fact 1: Risk transfers across and within sectors



- PF&I receive fixed, banks & corp. pay fixed ⇒ natural counterparties All currencies UK entities
- Most PF&I, Bank, Corporate entities behave similarly Within-sector homogeneity
- Funds flip direction; high intra-sector heterogeneity Fund heterogeneity

Fact 2. Sensitivity to interest rates

- Convexity: higher interest rate reduces maturity mismatch and hedging needs
- Interest rate ↑
  - PF & I ↓ position in receiving fixed rate
  - Banks ↓ position in paying fixed rate
- Opposite exposure to aggregate demand shocks

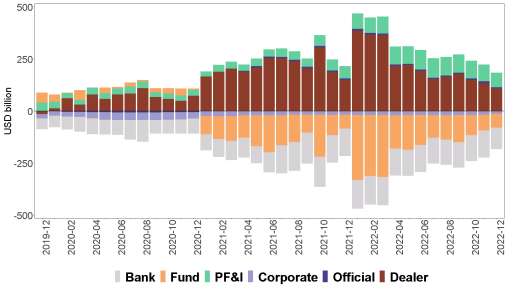
$$\Delta Q_{i,t} = \alpha_i + \beta \Delta Rate_{t-1} + \epsilon_{i,t}$$

	Δ Quantity ($ million)			
Panel A: PC1 (3M, 5Y, 10Y, 30Y)	Bank	Fund	PF&I	Corporate
Δ Bond Yield (PC1, t-1)	55.5**	-112.3*	-14.9***	4.15
	(25.4)	(58.2)	(5.21)	(2.65)
Panel B: 10Y yield	Bank	Fund	PF&I	Corporate
Δ Bond Yield (10Y, t-1)	96.2**	-221.8**	-23.7***	6.11
	(44.3)	(109.9)	(8.66)	(3.97)
N	6,200	9,520	28,400	12,600
Investor FE	Yes	Yes	Yes	Yes

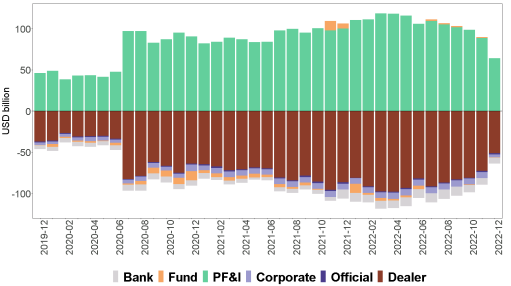
▸ Other yields

Fact 3. Maturity segmentation

- Breakdown of exposures to four maturity groups: below 3 months, 3 months to 5 years, 5 years to 10 years, and 10 years & above



(a) 3 months to 5 years



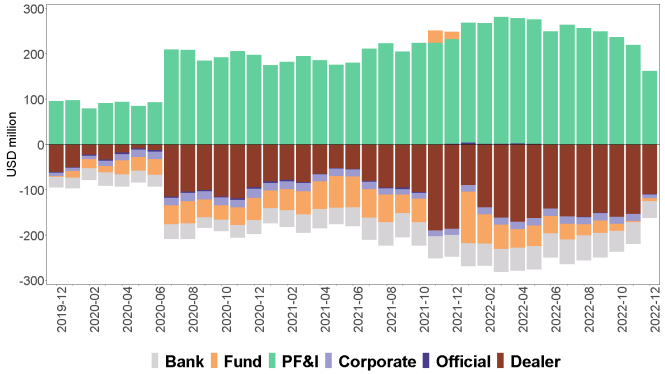
(b) 10 years and above

Below 3 months | Between 5y to 10y

Fact 4. Dealers absorb residual imbalances

- Dealers participate in all maturity segments: receive fixed rate in the short-end, and pay fixed rate in the long-end
- On net, dealers have negative DV01

Net DV01 by Sector



A preferred-habitat investors model (Vayanos and Vila, 2021)

Goal:

1. Decompose and quantify the drivers of the shape of the swap spreads curve
2. Spillover effects from demand changes across sectors

The economy:

- Preferred habitat investors: PF&I, banks, corporations...
  - Predominantly trade in one maturity bucket – key source of market segmentation (fact 3)
- Arbitrageurs: dealers and certain funds
  - Profit from price deviations through **carry trade** (subject to risk aversion and funding cost)

Model: habitat investors in maturity group τ

$$Q_t(\tau) = \overbrace{-\alpha(\tau)}^{\text{demand elasticity}} \underbrace{log(P_t(\tau))}_{\text{swap spreads}} - \underbrace{\theta_0(\tau)}_{\substack{\text{demand intercept} \\ \text{(fact 1)}}} - \overbrace{\theta_1(\tau)}^{\text{loading}} \underbrace{\beta_{1,t}}_{\substack{\text{aggregate factor} \\ \text{(fact 2)}}}$$

* Price of swap - value of fixed payments *relative to* a government bond of same maturity $P_t(\tau) \equiv exp(-\tau s_t(\tau))$

Model: arbitrageurs

- Arbitrageurs: Risk-averse mean-variance dealers who can trade across all maturity groups

$$\max_{\{X_t(\tau)\}_{\tau=0}^{\infty}} \left[\mathbb{E}_t(dW_t) - \frac{a}{2} Var\left(dW_t\right) \right]$$

$$\text{where} \quad dW_t = \int_0^{\infty} X_t(\tau) \left(\frac{dP_t(\tau)}{P_t(\tau)} - c_t \right) d\tau$$

  - a - risk aversion coefficient
  - c_t - time-varying funding cost

Equilibrium and calibration

- State variables $g_t \equiv (c_t, \beta_{1,t})^\top$: AR(1) with potentially correlated shocks

$$dg_t = \underbrace{-\Gamma}_{\text{mean reversion speed}} (g_t - \bar{g})dt + \underbrace{\Sigma}_{\text{shock variances}} dB_t$$

- Markets clear for all $\tau > 0$
- Moments targeted: average swap spreads, average quantity, price and quantity dynamics Details Moments match

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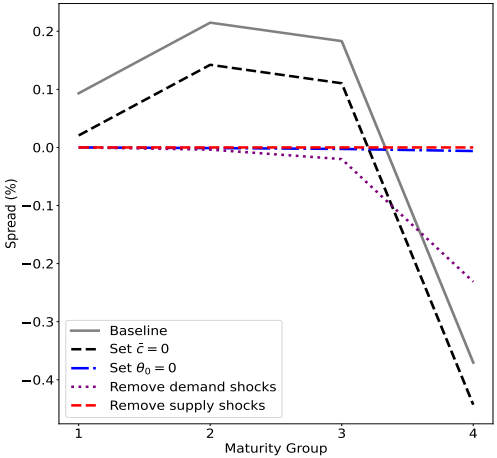
- Markets clear for all $\tau > 0$

- Moments targeted: average swap spreads, average quantity, price and quantity dynamics Details Moments match
- Cross-sector ranking of demand elasticity: $\underbrace{\alpha([\epsilon, 3m))}_{\text{funds}} > \underbrace{\alpha([3m, 5y))}_{\text{banks + funds}} > \underbrace{\alpha([10y, \infty))}_{\text{PF\&I}}$

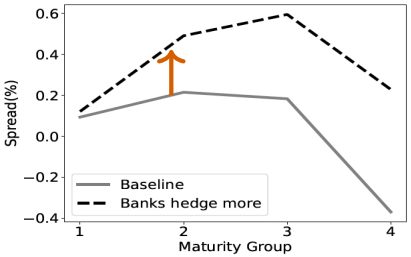
Decomposition of the swap spread curve



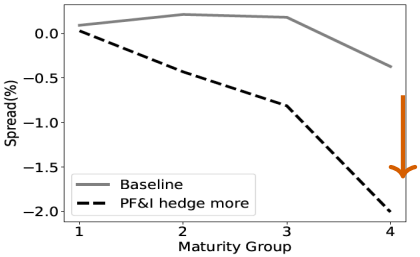
Demand imbalance, interacted with dealer risk aversion, is quantitatively more important for explaining the shape of swap spread curve

Counterfactual: spillover impact of sector-specific demand shifts

- Regulations on risk-management of banks and PF&I increase the level of demand, $|\theta_0(\tau)|$



(a) Banks Hedge More



(b) PF&I Hedge More

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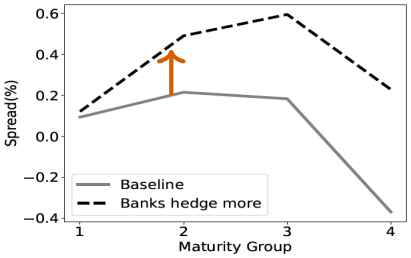

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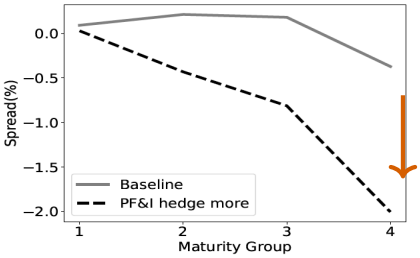

(b) PF&I Hedge More

- Back-of-the-envelope: one unit increase in demand for
  - banks would save PF&I approx. \$1.2 bn. a year ($0.60\% \times 200$ bn)
  - PF&I would save banks approx. \$3.8 bn. a year ($0.75\% \times 500$ bn)

Conclusion

- First large-scale and cross-sector empirical study of interest rate swaps market
- Banks/Corporations and PF&I exchange risks but across different maturities
- Demand imbalances in different maturity buckets play a quantitatively important role in shaping the swap spread curve
- Quantify the spillover effects of demand shifts across sectors

Other counterfactuals

Appendix

Estimated volume coverage by currency

	Average daily turnover in April 2022		
	Our data ($ billion)	BIS benchmark ($ billion)	Coverage
All currencies	3,425	4,987	69%
Pound sterling (GBP)	287	341	84%
Euro (EUR)	1,328	1,688	79%
US dollar (USD)	1,460	2,209	66%
Australian dollar (AUD)	141	279	51%
Other currencies	209	470	44%

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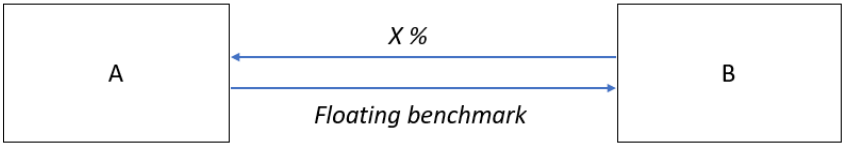
Focus on plain vanilla fixed-to-floating swaps



- Measures of exposure and risk:
  1. Net receive fix rate notional
  2. DV01 - the dollar value of a change in the value of a swap position for a 1 bp parallel shift in interest rates
- Price of a swap: Swap spread = Swap rate$_{c,m,t}$ — Treasury/bond rate$_{c,m,t}$.

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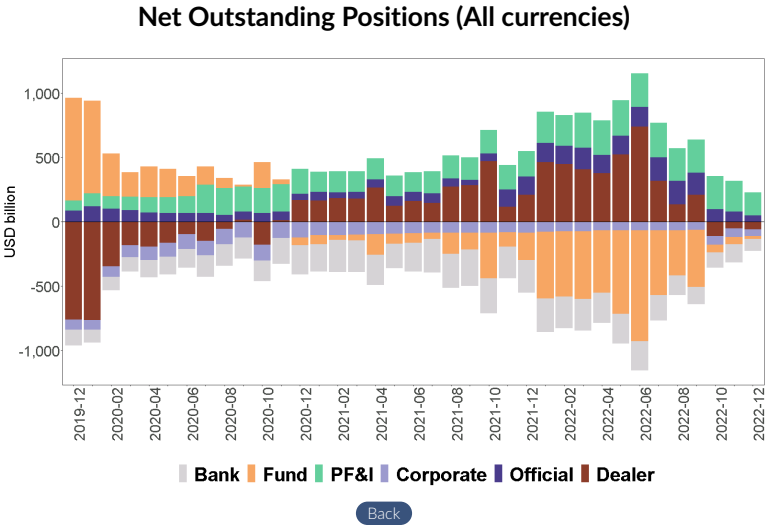
Net exposure across all currencies



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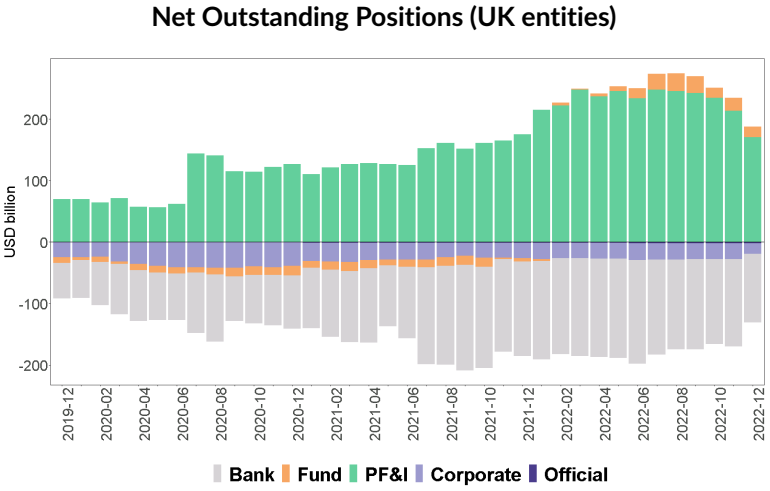
Net exposure for UK entities



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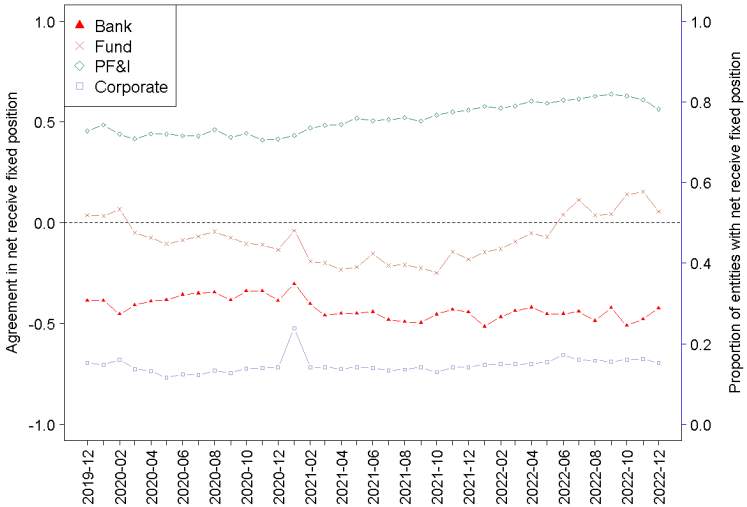
Fact 2: Risk transfers within sectors



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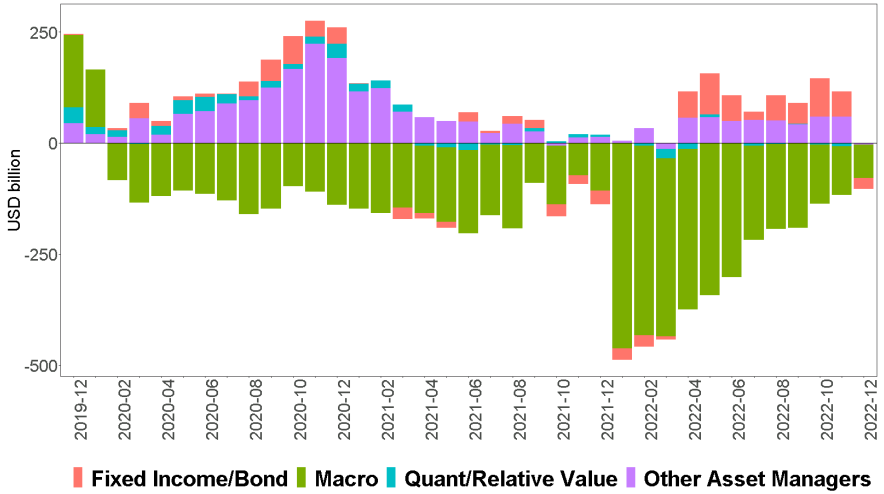
Hedge fund heterogeneity



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Interest rates and quantities demanded II

	Δ Quantity ($ million)			
Panel C: 5Y yield	Bank	Fund	PF&I	Corporate
Δ Bond Yield (5Y, t-1)	87.3**	-210.7**	-25.4***	6.10
	(39.1)	(98.2)	(8.70)	(4.04)
Adj. R^2	0.02	0.00	0.01	0.01
Panel D: 3M yield	Bank	Fund	PF&I	Corporate
Δ Bond Yield (3M, t-1)	97.8**	-101.0	-32.7***	12.1
	(46.6)	(121.2)	(10.6)	(8.24)
Adj. R^2	0.02	0.00	0.01	0.01
Observations	6,200	9,520	28,400	12,600
Dominant maturity group	3M-5Y	Below 3M	10Y & above	3M-5Y
Investor FE	Yes	Yes	Yes	Yes

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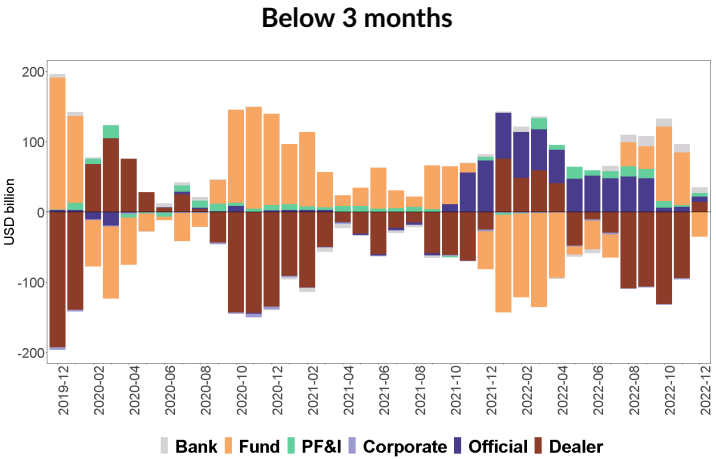
Maturity segmentation



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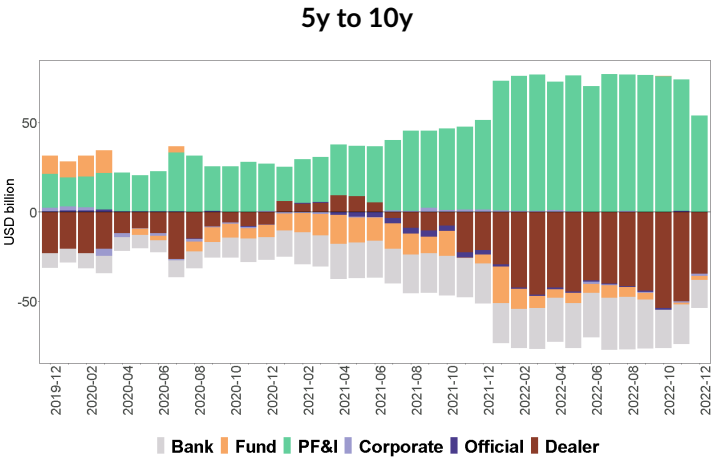
Maturity segmentation



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Empirical moments - targeted

Moments	Data
Ave. swap spreads in group 1-4 (spread quoted in %)	[0.108, 0.176, 0.215, -0.375]
Ave. quantity in group 1-4 (100 Billion $)	[2, -7.959, -0.009, 3.278]
Variances of swap spread changes in group 1-4	[0.028, 0.03, 0.105 , 0.058]
Variances of scaled quantity changes in group 1-4	[0.73, 0.476, 0.980, 0.222]
Regression coefficients of scaled quantity changes on the corresponding swap spread changes for group 1-4	[0.493, 0.441, -0.168, -0.188]

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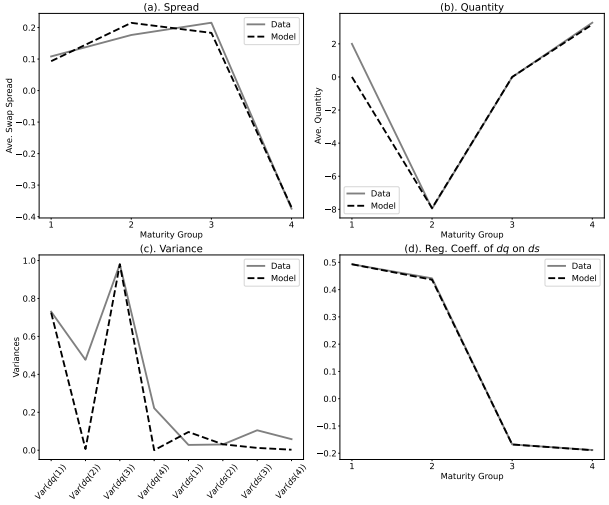
Simulated moments closely match empirical moments



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Targeted empirical moments - details

- Average swap spread: volume-weighted average swap spreads by end-users in each maturity group during our sample period
- Average quantity: average net notional held by end-users in each maturity group during our sample period
- Variance of change in swap spread $Var(\Delta s_t(\tau))$
  - $\Delta s_t(\tau)$ change in volume-weighted average swap spreads from activity files
- Variance of change in quantity $Var(\Delta q_t(\tau))$, where $\Delta q_t = \frac{Q_t - Q_{t-1}}{(|Q_t| + |Q_{t-1}|)/2}$
- Correlation of price change and quantity change: $\frac{Cov(\Delta q_t, \Delta s_t)}{Var(\Delta s_t)}$

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Calibrated parameters

Parameters	Values
Arbitrageur risk aversion coeff. a	123.05
Arbitrageur ave. cost $\bar{c}$	7.26×10^{-4}
Demand elasticities α	$[1.51 \times 10^{-2}, 4.55 \times 10^{-5}, 1.14 \times 10^{-8}, 2.73 \times 10^{-7}]$
Demand intercepts θ_0	$[1.23 \times 10^{-6}, 7.925, 0, -3.17]$
Demand sensitivities to aggregate demand factor θ_1	$[1.93 \times 10^{-5}, -1.741, 0, 1.12 \times 10^{-1}]$
Speed of mean reversion Γ	$\begin{pmatrix} 7.16 \times 10^{-4} & 0 \\ 0 & 7.96 \times 10^{-3} \end{pmatrix}$
Variances of supply and demand shocks Σ	$\begin{pmatrix} 3.03 \times 10^{-3} & 1.19 \times 10^{-3} \\ 3.196 \times 10^{-1} & 1.585 \times 10^{-1} \end{pmatrix}$

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Other counterfactuals

- Demand sensitivity to aggregate demand factor - $\theta_1(\tau)$
  - Effects similar to level of demand shifts Details
- Market integration: moving part of PF&I demand to the same group as bank demand
  - Reduce outstanding positions and risks borne by dealers Details
- Arbitrageur's risk aversion - a
  - Higher a tilts the swap spread curve to reflect more "local" demand Details

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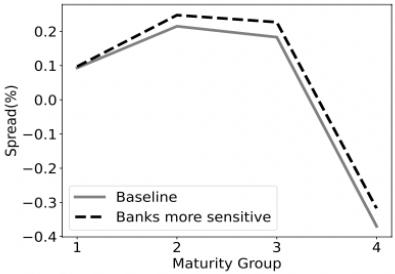
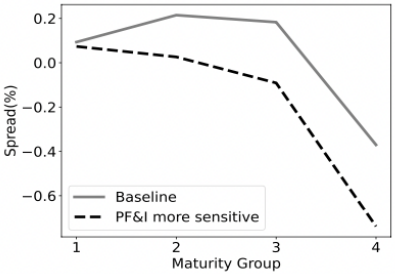
Counterfactual - demand sensitivity



(a) Banks More Sensitive



(b) PF&I More Sensitive

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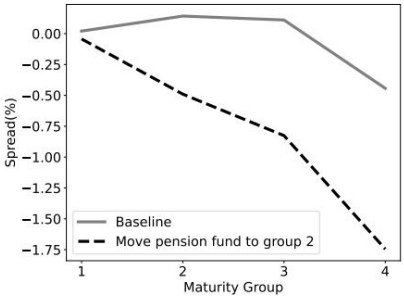
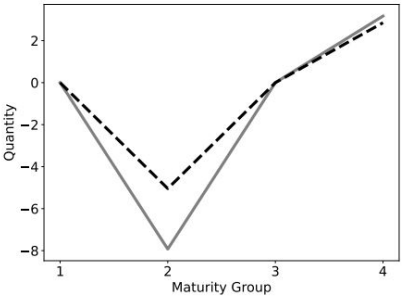
Counterfactual - increased market integration



(a) Spread



(b) Quantity

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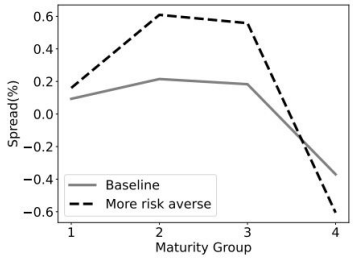
Counterfactual - arbitrageur's risk aversion - *a*



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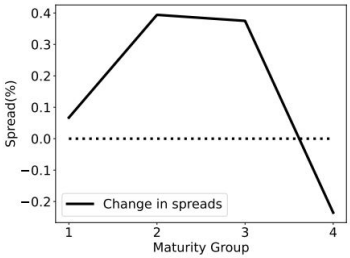

(b) Change in Spreads

- Stronger reflection of preferred habitat demand: arbitrageurs more concerned about demand shocks $\Longrightarrow$ less carry trade Back