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

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Exposure to interest rate risk is large and pervasive

- Recent events highlight the interest rate risk exposures of several financial sectors
  - Duration gaps faced by banks (e.g., SVB crisis), pension funds (e.g., UK gilt crisis)
  - Regulatory discussions on more comprehensive risk management policies

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  - However, little systematic evidence on **cross-sector** risk sharing
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  - However, little systematic evidence on **cross-sector** risk sharing
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- Important to take a cross-sector perspective to understand:
  1. Size and type of *demand imbalances* that shape asset prices
  2. How demand shifts in one sector affect hedging outcomes of others

We study interest rate risk sharing across the financial system

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1. Do investors swap risk with each other or leave large imbalances?
   - Analyze transaction-level data covering the near-universe of UK swap market
   - Pension & Insurers (PF&I) are natural counterparties to Banks and Corporations
   - Strong maturity segmentation $\rightarrow$ dealers absorb maturity-specific demand imbalances

We study interest rate risk sharing across the financial system

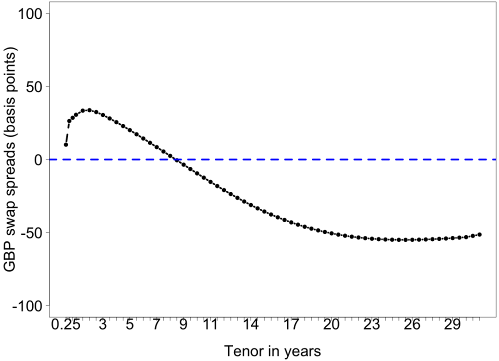
1. Do investors swap risk with each other or leave large imbalances?

2. How does demand imbalance affect asset prices?

- Swap spread :=
  Swap rate$_{c,m,t}$ − Treasury rate$_{c,m,t}$

- Calibrate a structural model to understand price formation

- Demand imbalances affect the shape of swap spread curve



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1. Do investors swap risk with each other or leave large imbalances?

2. How does demand imbalance affect asset prices?

3. What is the cross-sector spillover impact of demand shocks?

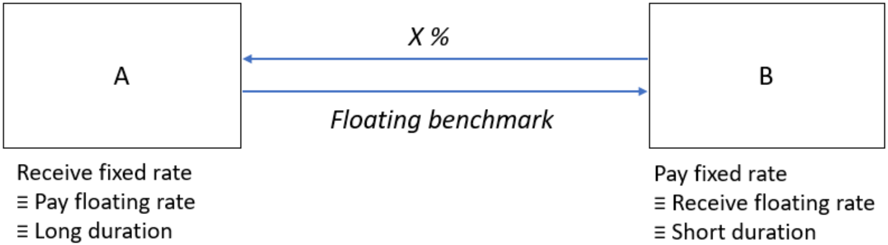
   - Empirically estimate end users' demand elasticities using a novel instrument

   - Investors have low demand elasticity; dealers have high risk aversion

   $\Rightarrow \uparrow$ demand shifts in one sector $\downarrow$ hedging cost for other sectors as prices react sharply

Data and Key Facts

We focus on plain vanilla fixed-to-floating swaps



- Exposure: net receive fixed rate notional (risk measured using DV01)
- Price: Swap spread = Swap rate$_{c,m,t}$ $-$ Treasury/bond rate$_{c,m,t}$

Our data covers $>$ 60% of global swaps turnover

- Granular transaction-level regulatory data involving at least one UK entity
  - Coverage: $\geq$ 60% of all swaps, $\geq$ 84% of GBP swaps Details
  - Sample period: Dec 2019 - June 2024
  - Monthly stock: snapshots of outstanding exposure - quantities
  - Daily flows: new trades initiated - prices

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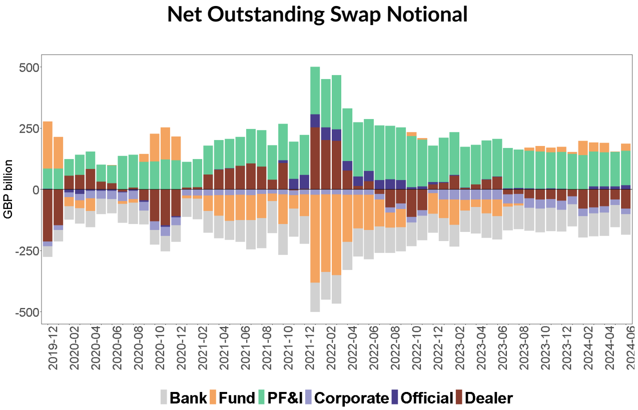
- We assign sectors to over 6,000 individual entities
  - Pension & Insurers, Banks, Corporations, Funds (Hedge Funds, Asset Managers), Dealers
  - Economically meaningful distinction between end-user banks and intermediary dealers

Fact 1a: PF&I, banks, and corporates have opposite risk exposures



- Pension funds and insurers (PF&I) receive fixed, banks & corporations pay fixed
  $\Rightarrow$ natural counterparties; less risk borne by dealers
- Direction of exposure consistent with balance sheet duration hedging

Fund details | All currencies | UK entities

Fact 1b: Opposite reaction to aggregate shocks

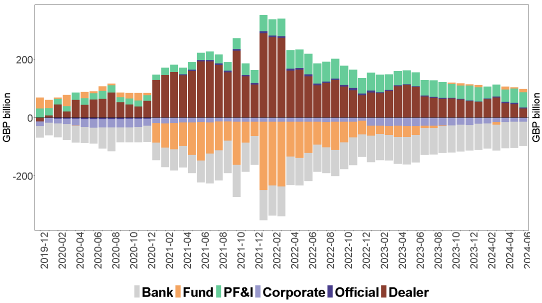
$$\Delta q_{i,t} = \alpha_i + \beta \, \Delta \text{MPS (or Rate)}_{t-1} + \epsilon_{i,t}$$

	Δ Quantity (scaled)			
Panel A: Monetary Policy Shock	Bank	Fund	PF&I	Corporate
MPS (10Y yield, t-1)	0.677**	-1.01***	-0.366**	0.067
	(0.277)	(0.237)	(0.144)	(0.165)
Panel B: 10Y yield	Bank	Fund	PF&I	Corporate
Δ Rate (10Y, t-1)	0.099**	0.004	-0.083***	0.190***
	(0.043)	(0.033)	(0.019)	(0.025)
N	6,264	22,536	29,901	13,965
Investor FE	Yes	Yes	Yes	Yes

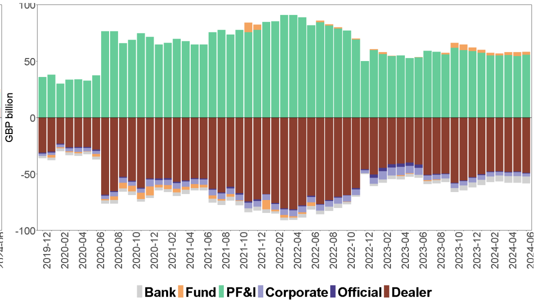
Other yields

- Cross-sector risk sharing holds as interest rates change
- When interest rates $\uparrow$, swap demand $\downarrow$, consistent with convexity and lower duration mismatch

Fact 2: Strong maturity segmentation



(a) 3 months to 5 years



(b) 10 years & above

Below 3 months Between 5y to 10y

- With sectors, $\sim$ 90% of investors trade in a single maturity bucket “Preferred Habitats”
- Dealers receive fixed rate in the **short-end** and pay fixed rate in the **long-end**
  $\Rightarrow$ exposed to local demand fluctuations

Demand Estimation

We estimate end users' demand elasticities using *portfolio compression*

- Need exogenous variation in prices (supply shocks) to estimate demand elasticities
- Novel instrument: **portfolio compression** that relaxes dealers' balance sheet constraints

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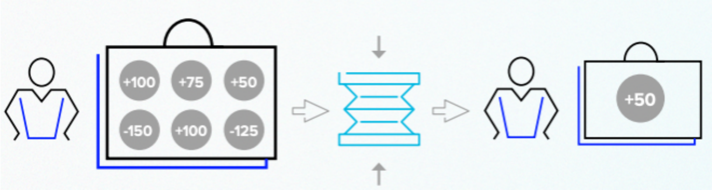
    - **Idea**: Basel III leverage ratio requirement linked to gross notional of derivative portfolio
    - Compression reduces gross notional by netting trades with offsetting cash flows



- Economically significant activity: $2,656 trillion compressed between 2016 and 2019

Relevance and exclusion restrictions

- **Relevance:** $\uparrow$ in compression $\Rightarrow$ dealer willing to trade swaps at worse terms

First stage	Δ Swap spread	
	3M to 5Y	10Y & above
Δ Compression ratio	-0.378***	0.400***
	(0.082)	(0.109)
N	2,501	2,436
Instrument F-statistic	21.74	13.46
Controls, Dealer FE, Time FE	Y	Y

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- **Exclusion**: compression affects end-user demand only through its impact on prices
  - To be compressed, offsetting trades should have *exact cash flow settlement* dates

    $\Rightarrow$ meeting the eligibility criteria is plausibly random across dealers

Cross-sectional variation in estimated demand elasticities

Second stage	Δ Quantity (scaled)	
	3M to 5Y	10Y & above
$\Delta\widehat{\text{Swap spread}}$	0.812***	0.242
	(0.224)	(0.435)
N	2,501	2,436
Controls, Dealer FE, Time FE	Y	Y

- 3M to 5Y: 10 bps $\uparrow$ in swap spreads $\Rightarrow$ 8.1% $\uparrow$ in net receive fixed position
- Banks are more elastic than PF&I: $\underbrace{\alpha([3m, 5y))}_{\text{banks}} > \underbrace{\alpha([10y, \infty))}_{\text{PF\&I}}$
- Use the *distribution of* estimated elasticities as model inputs

Model

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

Goals:

1. Decompose the drivers of the swap spread curve into supply and demand factors
2. Counterfactuals: quantify the direct + spillover effects of demand shifts

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The economy:

- Preferred-habitat investors: PF&I, banks, corporations...
  - Predominantly trade in one maturity bucket (fact 2)
- Arbitrageurs: dealers and certain funds
  - Profit from cross-maturity price deviations (subject to risk aversion and funding cost)

Key economic intuition:

- The shape of swap spread curve reflects *local* demand when arbitrageur risk aversion rises

Demand function of preferred-habitat investors in maturity τ

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

Arbitrageurs are risk-averse mean-variance optimizers

- Arbitrageurs can trade across all maturity groups

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

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

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

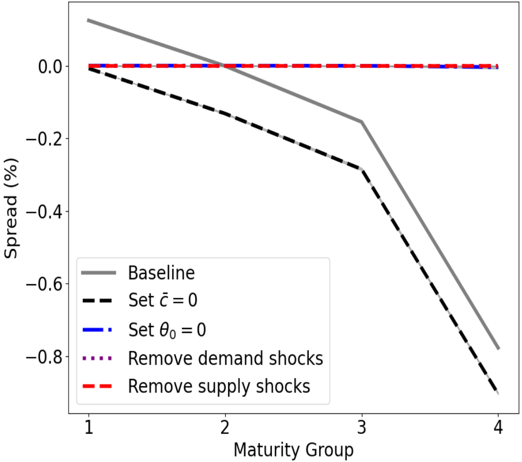
Equilibrium and Calibration

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

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

- **Solving for equilibrium price**: markets clear for all $\tau > 0$
- Discretize into five maturity groups:
  $(0, \epsilon)$ (boundary condition), $[\epsilon, 3m)$, $[3m - 5y)$, $[5y, 10y)$, $[10y, \infty)$
- Moments targeted: average swap spreads, average quantity, price and quantity dynamics
  Details Moments match

Decomposition of the swap spread curve



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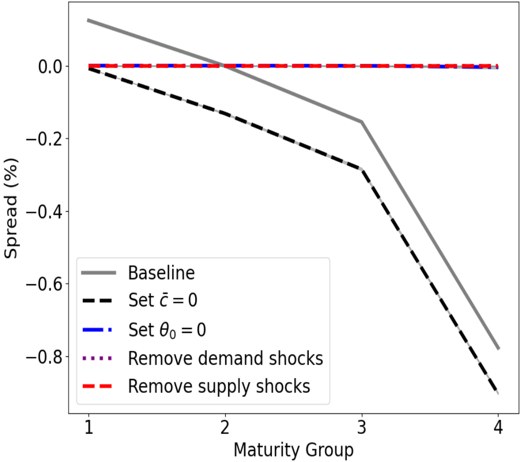

- Demand imbalances interact with dealers' risk aversion to quantitatively explain swap spreads
- Distribution of demand imbalances determines whether the curve slopes upward or downward

Counterfactual: spillover impact of sector-specific demand shifts

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

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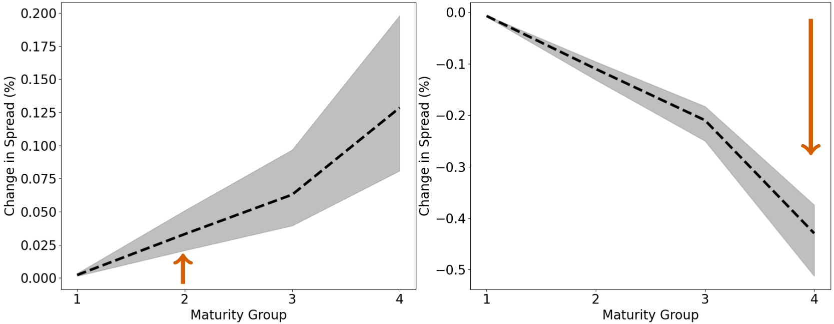

(a) Banks hedge more

(b) PF&I hedge more

Counterfactual: spillover impact of sector-specific demand shifts

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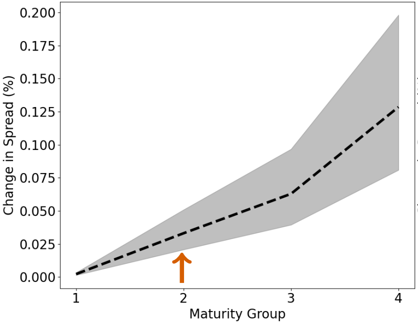

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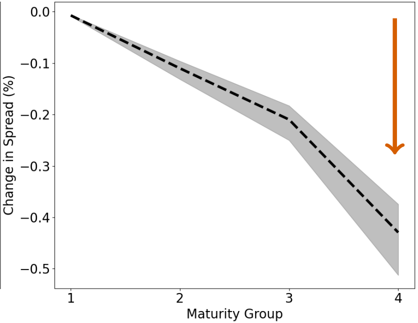


(b) PF&I hedge more

- Back-of-the-envelope: 20% increase in demand for
  - banks would save PF&I $\sim$ £2 bn., cost banks $\sim$ £150 mn. over the lifetime of trades
  - PF&I would save banks $\sim$ £450 mn., cost PF&I $\sim$ £8 bn. over the lifetime of trades

Main takeaways

- First large-scale cross-sector study of interest rate swaps using traded quantities and prices
- We use transactions data to calibrate a quantitative structural model to make 3 contributions:

  1. End-user demand is highly segmented across maturities; dealers absorb large imbalances
  2. Demand imbalances play an important role in shaping the swap spread curve
  3. Spillover effects of demand shifts on other investors can be economically large

Appendix

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 using quantities data to estimate cross-maturity spillover effects

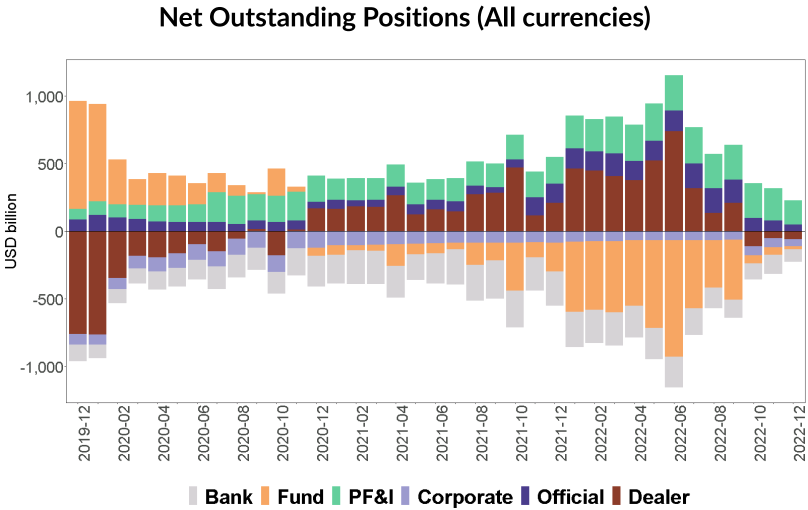
Back

Estimated coverage of transaction volume 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%

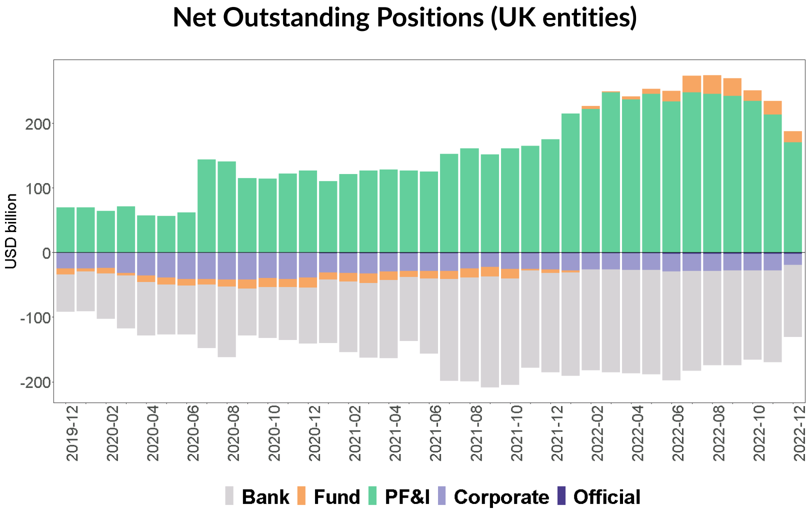
Back

Net exposure across all currencies



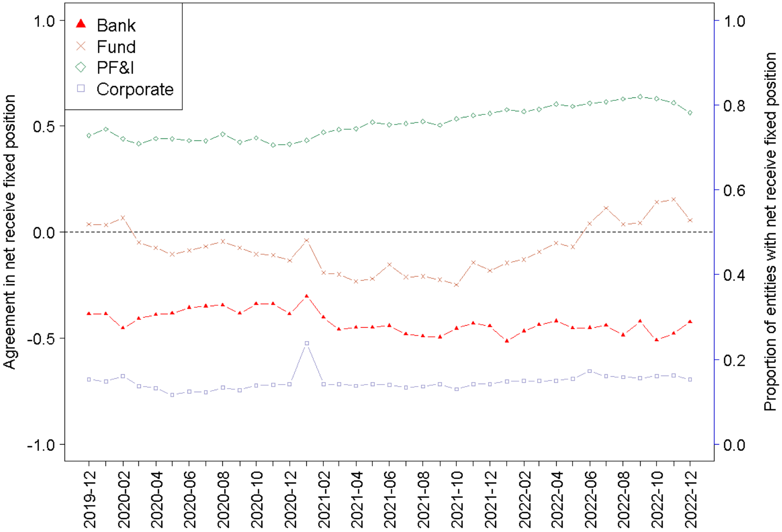
Back

Net exposure for UK entities



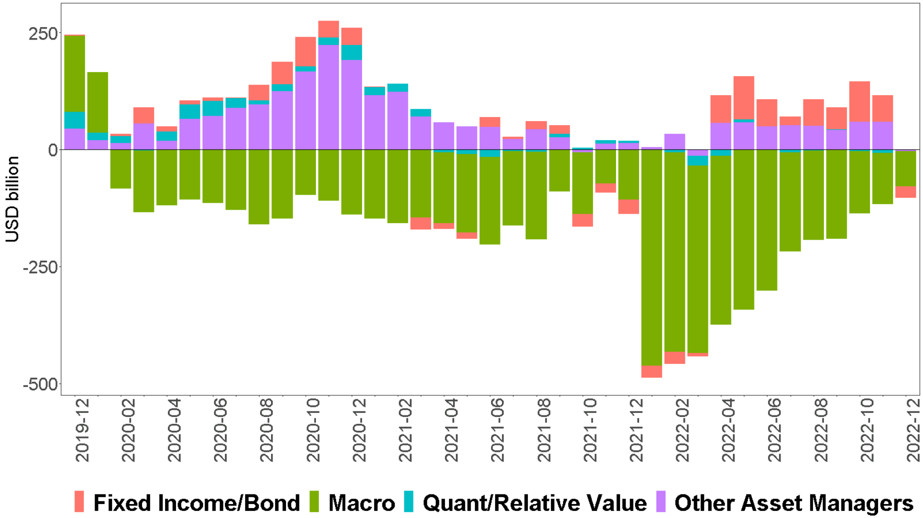
Back

Fact 2: Risk transfers within sectors



Back

Hedge fund heterogeneity



Back

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

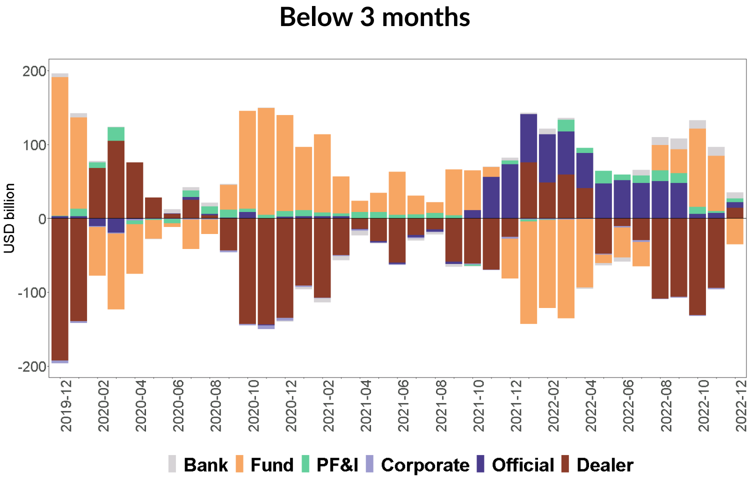
Back

Monetary policy shocks and quantities demanded II

	Δ Quantity (scaled)			
	Bank	Fund	PF&I	Corporate
MPS (10Y yield, t-1)	0.677**	-1.01***	-0.366**	0.067
	(0.277)	(0.237)	(0.144)	(0.165)
MPS (5Y yield, t-1)	0.755***	-0.725***	-0.257**	0.338**
	(0.247)	(0.202)	(0.121)	(0.157)
MPS (2Y yield, t-1)	0.605***	-0.634***	-0.105	0.150
	(0.219)	(0.183)	(0.108)	(0.140)
N	4,055	14,489	19,353	8,989
Investor FE	Yes	Yes	Yes	Yes

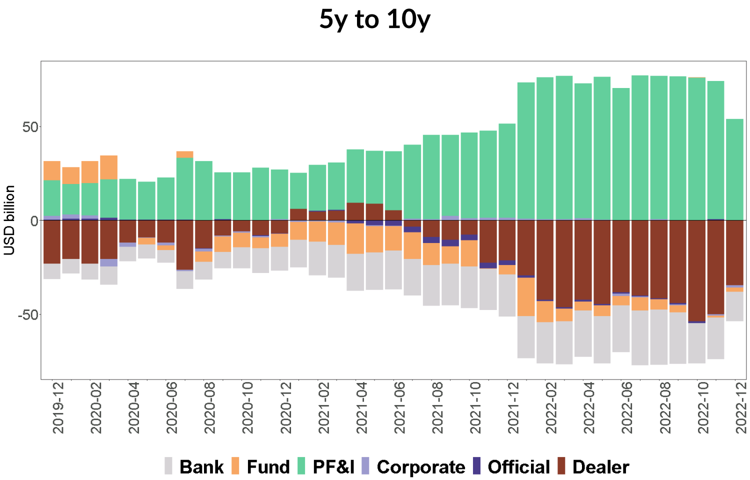
Back

Maturity segmentation



Back

Maturity segmentation



Back

Fact 2: Investors exhibit preferred-habitat behavior

	Fraction of investors trading in one maturity group	
	Equally-weighted	Notional-weighted
Bank	0.94	0.91
Fund	0.93	0.97
PF&I	0.88	0.70
Corporate	0.96	0.95

Back

Empirical moments - targeted

Moments	Data
Ave. swap spreads in group 1-4 (spread quoted in %)	[0.104, 0.029, -0.162, -0.779]
Ave. quantity in group 1-4 (GBP billion)	[-42.4, 144.7, -1.0, -62.3]
Variances of swap spread changes in group 1-4	[0.037, 0.089, 0.395 , 0.142]
Variances of scaled quantity changes in group 1-4	[0.926, 0.042, 1.390, 0.015]

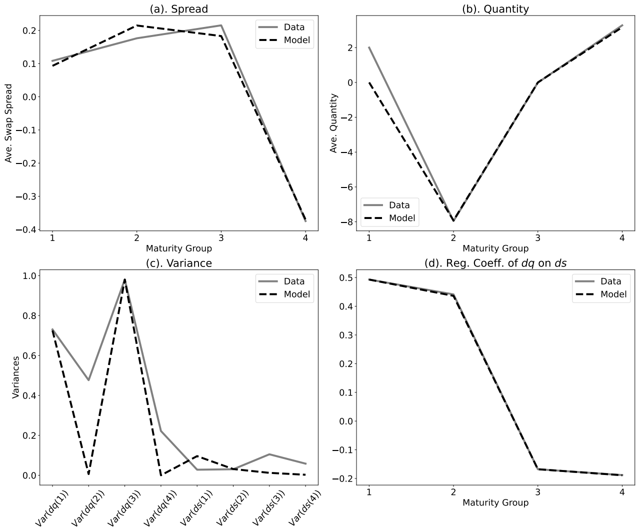
Back

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: $\frac{Cov(\Delta q_t, \Delta s_t)}{Var(\Delta s_t)}$

Back

Simulated moments closely match empirical moments



Back

Calibrated parameters

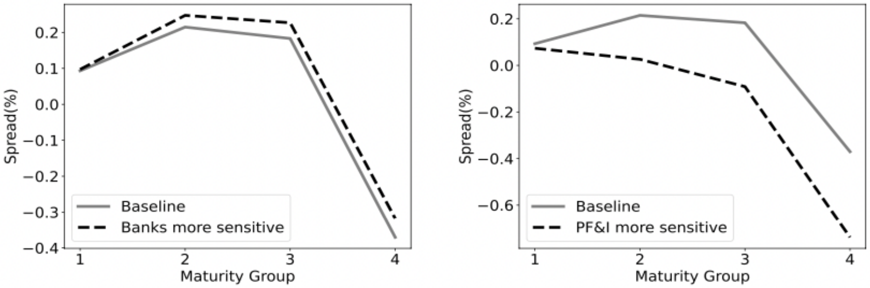
Parameters	Values
Arbitrageur risk aversion coeff. a	123.05
Arbitrageur ave. cost $\bar{c}$	7.26×10^{-4}
Demand elasticities α	$[1.51 \times 10^{-2}, 4.55 \times 10^{-5}, 1.14 \times 10^{-8}, 2.73 \times 10^{-7}]$
Demand intercepts θ_0	$[1.23 \times 10^{-6}, 7.925, 0, -3.17]$
Demand sensitivities to 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	$\begin{pmatrix} 3.03 \times 10^{-3} & 1.19 \times 10^{-3} \\ 3.196 \times 10^{-1} & 1.585 \times 10^{-1} \end{pmatrix}$

Back

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

Counterfactual - demand sensitivity

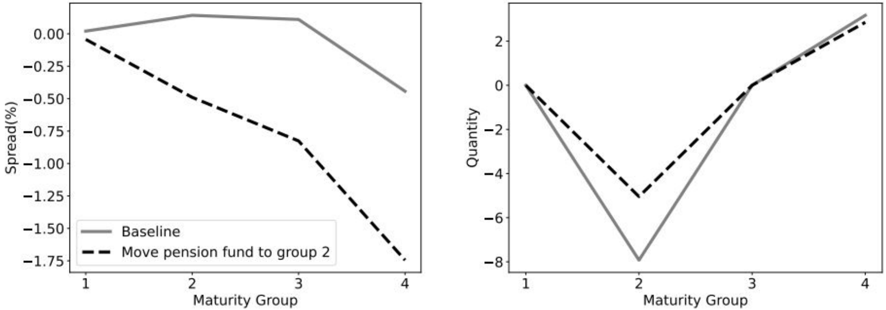


(a) Banks More Sensitive

(b) PF&I More Sensitive

Back

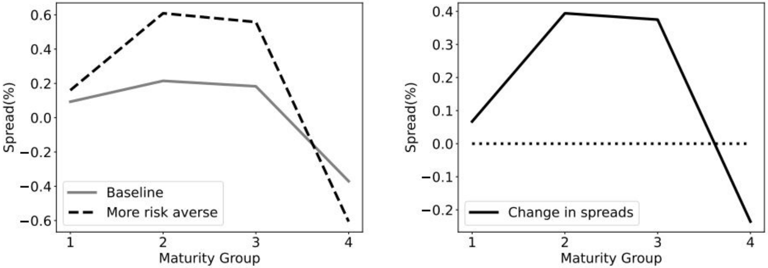
Counterfactual - increased market integration



(a) Spread (b) Quantity

Back

Counterfactual - arbitrageur's risk aversion - *a*



(a) Spreads (b) Change in Spreads

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