The Market for Inflation Risk

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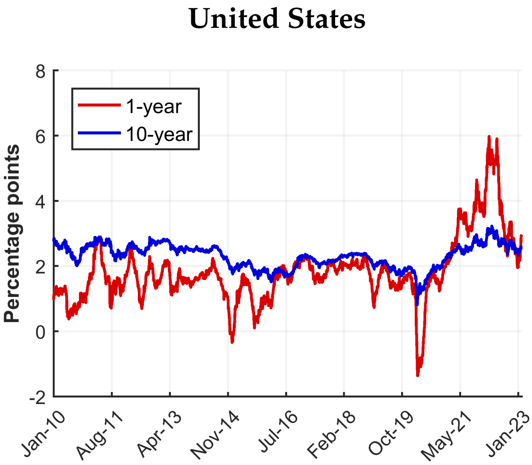
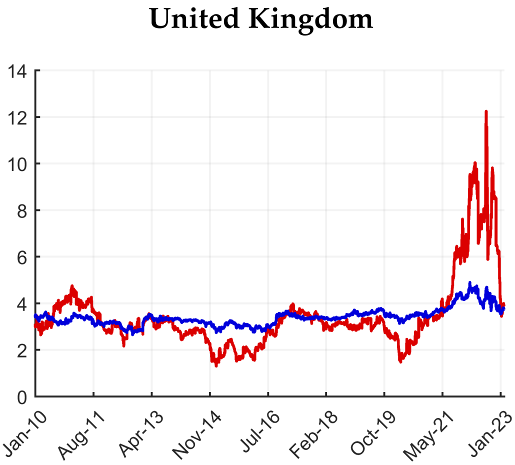
Breakeven prices of inflation swaps





What we do

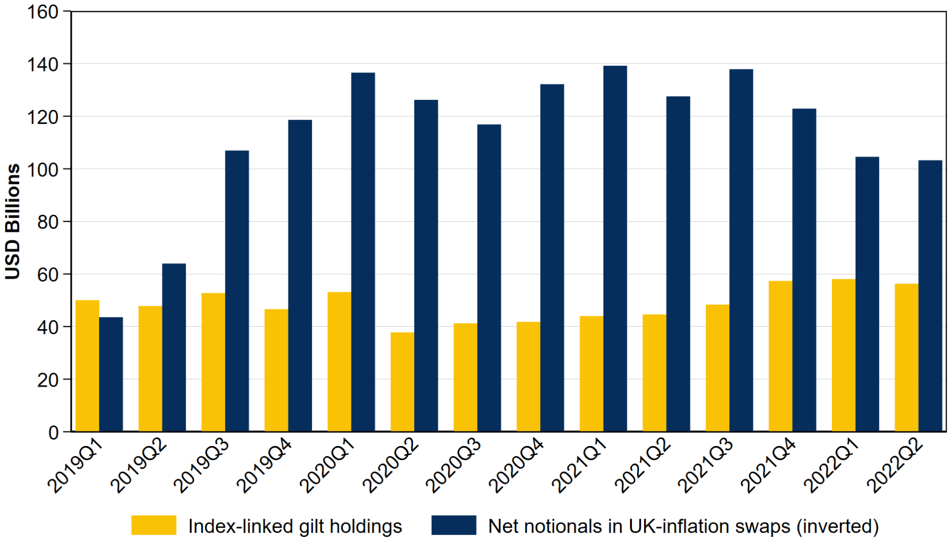
1) **Quantities behind the prices:** universal data on transactions in UK market. Data Source
   → Facts: segmentation across maturities, banks net bearers of inflation risk.

2) **Identification strategies:** for segmented markets' models
   → Decompose price changes into fundamentals and a liquidity premium (frictions).

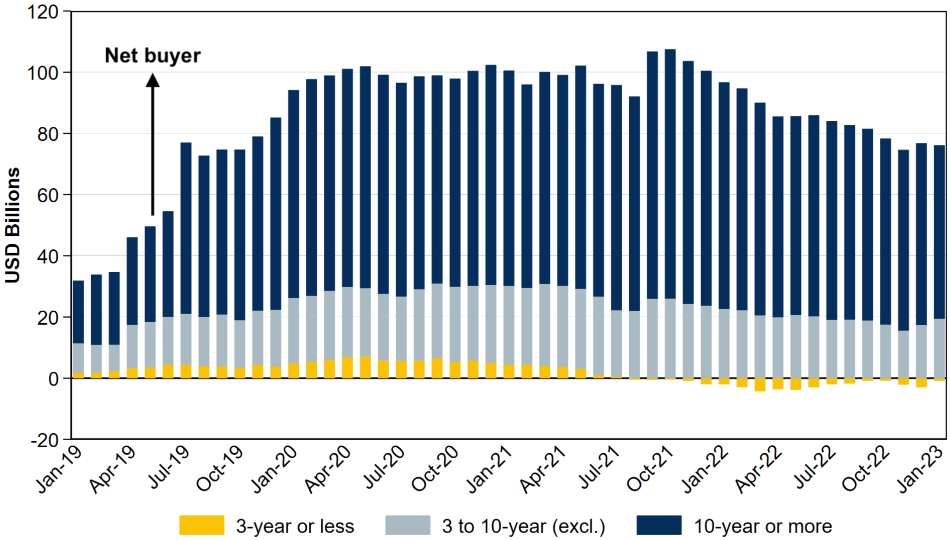
3) **Empirical estimates:** finance, macro and behavioral
   → What shocks drive the market and what are the slopes of supply and demand?
   → How reliable are these measures of expected inflation given liquidity premia?
   → How much dispersion in beliefs is there, and whose beliefs matter?

1. The facts about this market

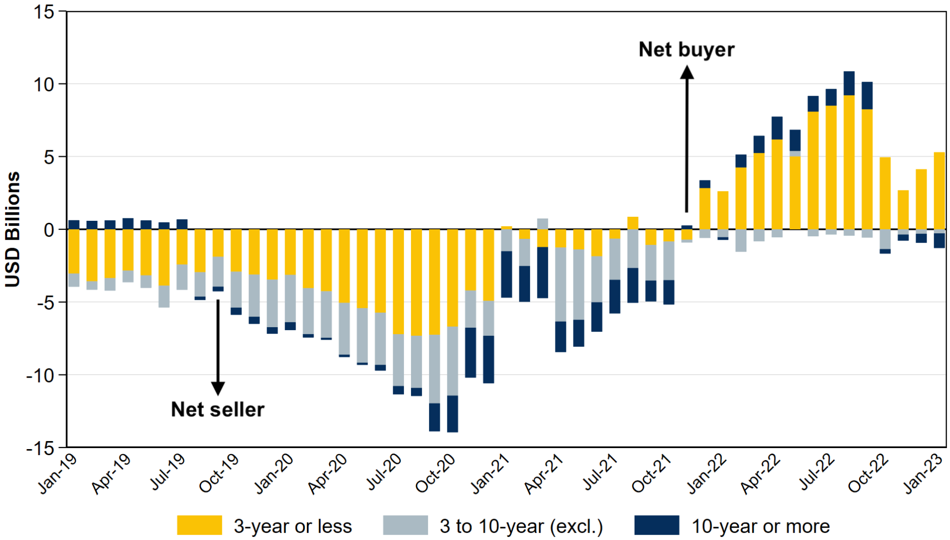
Fact 1: dealer-banks are not neutral market makers



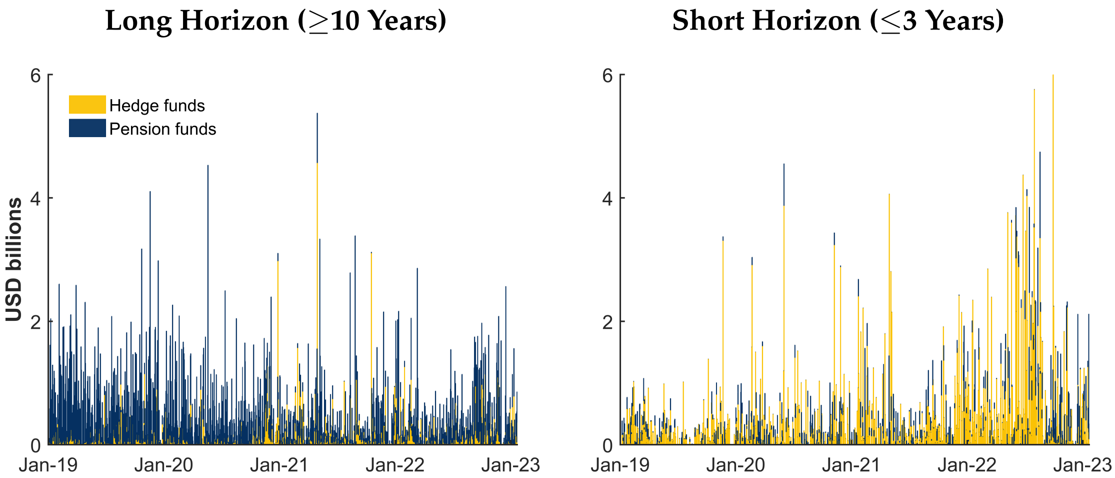
Fact 2: pension funds buy protection at long horizon



FACT 3: HEDGE FUNDS TRADE INFLATION RISK AT SHORT HORIZON



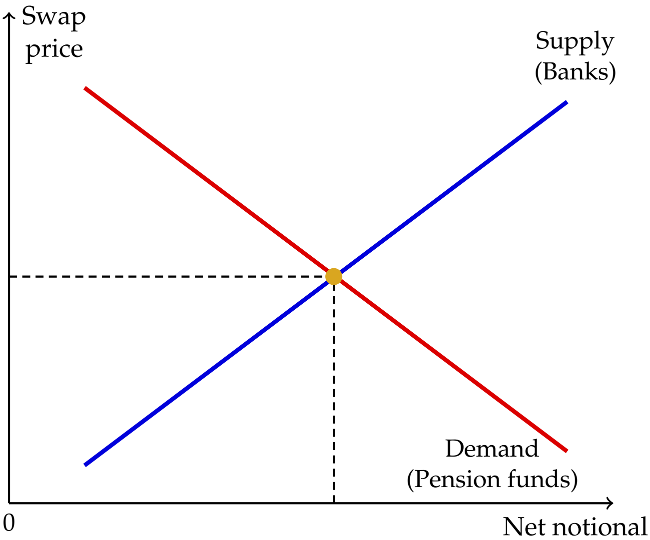
Segmentation even clearer in trading activity



Full Picture

2. Shocks in markets and identification

The long market

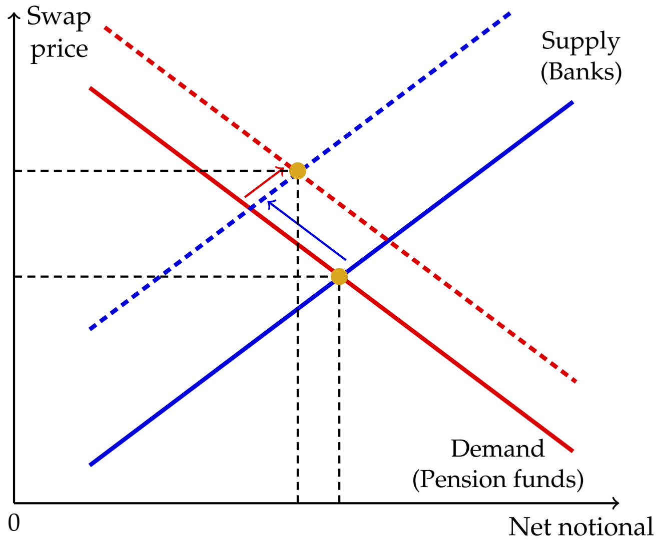


Banks supply insurance and pension funds demand it because of:

(i) Disagreement about expected inflation.

(ii) Different risk aversion or hedging of other assets.

THE LONG MARKET



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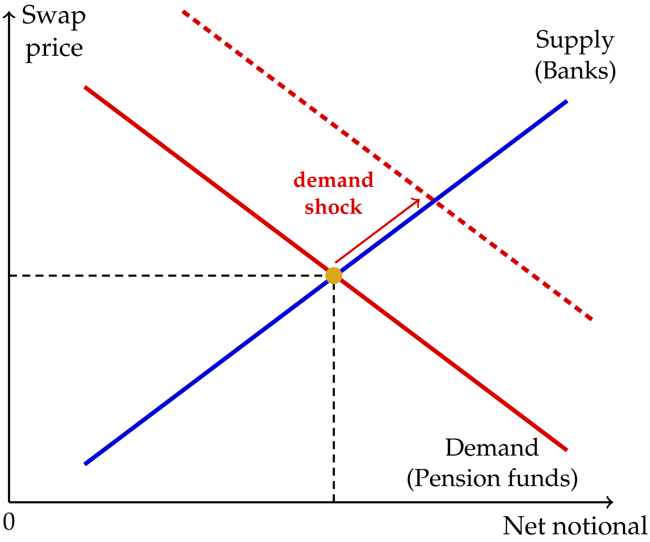
When expected inflation changes, this fundamental drives both supply and demand, price reflects it.

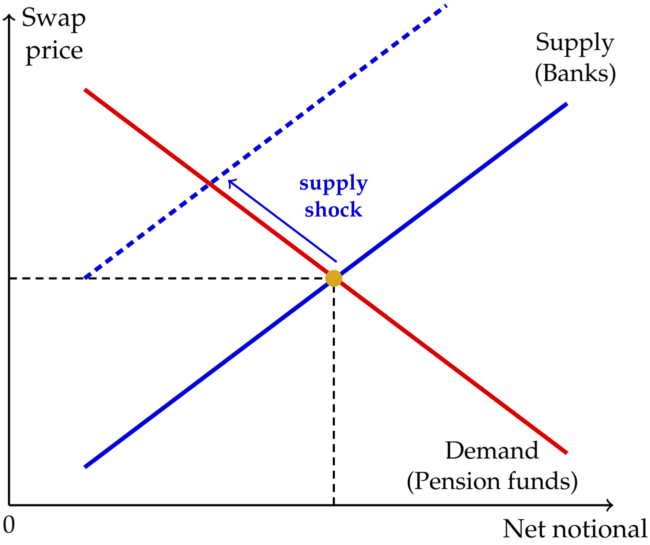
The long market (II)



Identification problem

(i) Pension fund mandates generate background risk and trading constraints. Shift demand, change price.

The long market (II)

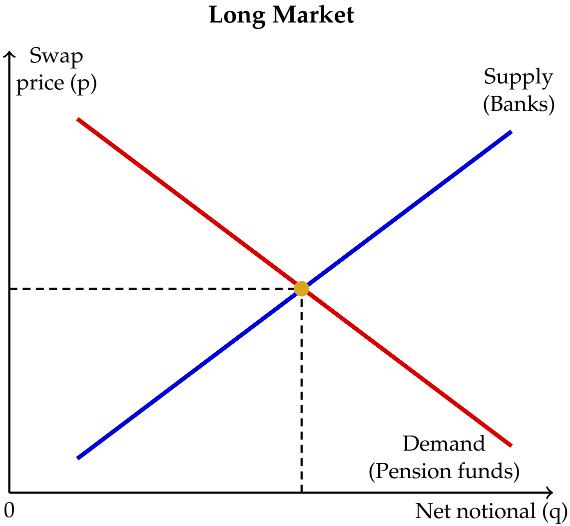


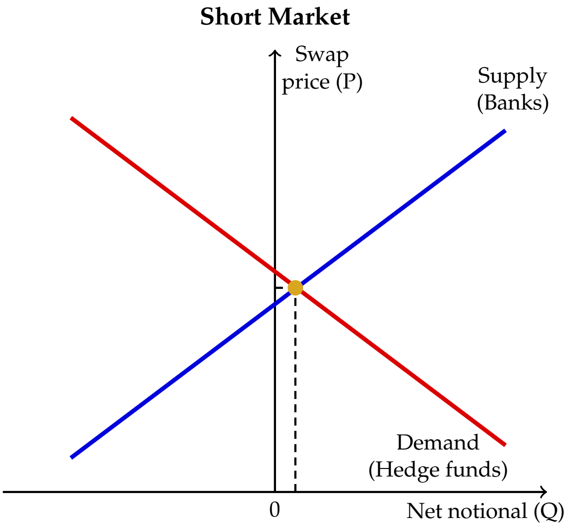
Identification problem

(i) Pension fund mandates generate background risk and trading constraints. Shift demand, change price.

(ii) Banks also have trading constraints (e.g. regulatory) and have operational reasons to be long/short inflation. Shift supply, change price.

Exploit segmented markets





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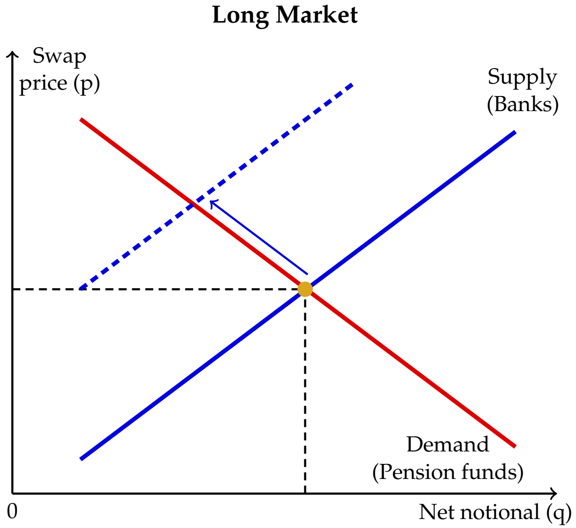
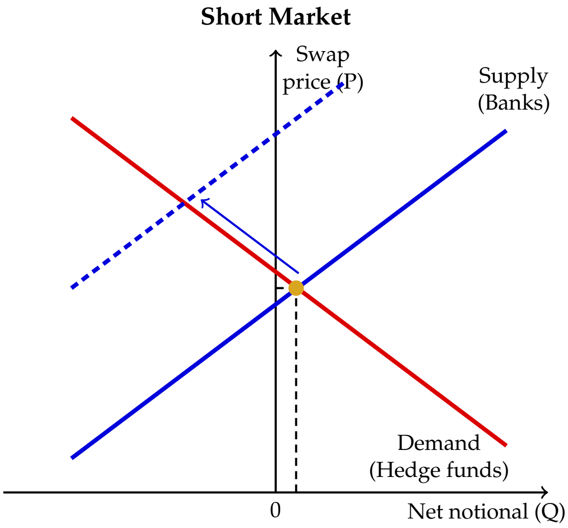
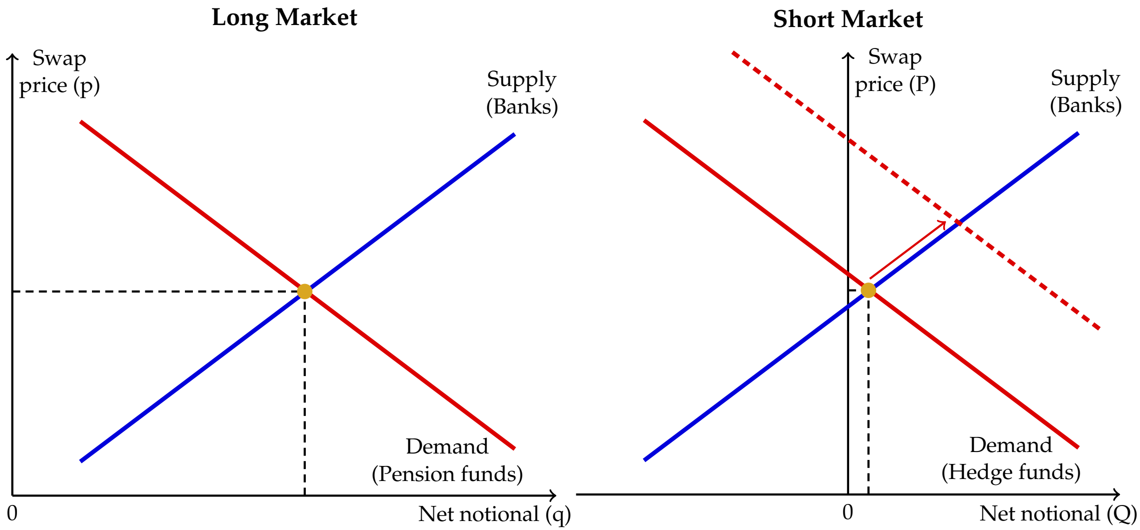




Exploit segmented markets



More formally (I)

Consider the portfolio choice problem of pension fund (f, i):

- CARA-normal (wealth, $a_{f,i}$, risk aversion, $\gamma_{f,i}$), LT inflation swap, other asset.
- Expected inflation $\pi^e_{f,i} = \mu_{f,i}\pi^e$
- Background risk + generic trading constraints in $\lambda_{f,i}$.

Demand for LT inflation swap ($q_{f,i}$):

$$\frac{q_{f,i}}{a_{f,i}} = -\gamma_{f,i}p + \underbrace{\mu_{f,i}(\pi^e - \rho_{\pi,d})}_{\text{exp. inf \& risk}} + \lambda_{f,i}.$$

Hedge Funds: same problem but ST swap market (segmentation)

OTC market: banks (b) on other side, present in both markets, supply curve.

CARA-Normal microfoundation

More formally (II)

- Equilibrium price:

$$p^* = \underbrace{\left[\frac{\sum_{i\in\Theta_f} a_{f,i}\mu_{f,i} + \sum_{i\in\Theta_b} a_{b,i}\mu_{b,i}}{\sum_{i\in\Theta_f} a_{f,i}\gamma_{f,i} + \sum_{i\in\Theta_b} a_{b,i}\gamma_{b,i}}\right](\pi^e - \rho_{\pi,d})}_{\text{frictionless price } \tilde{p}^*} + \underbrace{\left[\frac{\sum_{i\in\Theta_f} a_{f,i}\lambda_{f,i} + \sum_{i\in\Theta_b} a_{b,i}\lambda_{b,i}}{\sum_{i\in\Theta_f} a_{f,i}\gamma_{f,i} + \sum_{i\in\Theta_b} a_{b,i}\gamma_{b,i}}\right]}_{\text{liquidity premium } lp}$$

- Fundamentals $(\pi^e - \rho_{\pi,d}, \Pi^e - \rho_{\Pi,d})$ orthogonal to liquidity $(\lambda^l_{b,i}, \lambda^s_{b,i}) \perp \lambda_{f,i} \perp \lambda_{h,i}$. Fundamental innovations, ε_π and innovations to liquidity $\varepsilon_f, \varepsilon_h, \varepsilon_b$

CARA-Normal microfoundation

Identification problem

Observe (p, P) that are driven by $\boldsymbol{\varepsilon} = (\varepsilon_h, \varepsilon_f, \varepsilon_b, \varepsilon_\pi)$

We have data $\mathbf{Y} = (Q, P, q, p)'$ on prices and quantities 2 Jan 19 to 10 Feb 23:

- q: net purchases of swaps by PFLDI with $\geq$ 10 year maturity.
- p: daily price zero-coupon RPI inflation swap in long horizon market ($>=$ 10 year).
- Q: net purchases of swaps by hedge funds $\leq$ 3year maturity.
- P: daily price of zero-coupon RPI inflation swap in short horizon market ($<=$ 3 year).

Identification problem

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- Q: net purchases of swaps by hedge funds $\leq$ 3year maturity.
- P: daily price of zero-coupon RPI inflation swap in short horizon market ($<=$ 3 year).

Identification problem: Need to learn about 4x4 matrix $\boldsymbol{\Psi}$.

$$\mathbf{Y} = \boldsymbol{\Psi}\boldsymbol{\varepsilon}$$

Estimation: add dynamics, VAR with 3 lags. Implementation

Three identification strategies

1) Heteroskedasticity: *Fundamental had a higher relative variance on announcement days.*

Formal assumption & Test

- Data shows clear shift in relative variances on those dates (reject null at 0.1% significance level).

Three identification strategies

1) Heteroskedasticity: *Fundamental had a higher relative variance on announcement days.*

2) Granularity. *Size weighted sum of idiosyncratic shocks non-zero in expectation.*

Formal assumption & Test

- Recover residuals from panel factor model

$$\frac{q_{f,i,t}}{a_{f,i,t}} = \boldsymbol{\omega}'_{f,i}\mathbf{F}_{f,t} + \widetilde{\varepsilon}_{f,i,t}, \quad \text{where} \quad \mathbf{F}_{f,t} = (\pi^e - \rho_{\pi,d}, lp_t)' \quad \text{so} \quad \widetilde{\varepsilon}_{f,i,t} = \lambda_{f,i} - \gamma_{f,i} lp_t$$

- Build granular IV, $GIV_{f,t} = \sum_{i \in \Theta_f} a_{f,i,t}\tilde{\varepsilon}_{f,i,t}$. Valid instrument for ε_f as orthogonal by construction and relevant if LLN fails. Equivalent for $GIV_{h,t}$ and $GIV_{b,t}$.

- Pension funds: Pareto parameter 0.13, power law coefficient -0.9. Similar for others.

Three identification strategies

1) Heteroskedasticity: *Fundamental had a higher relative variance on announcement days.*

2) Granularity. *Size weighted sum of idiosyncratic shocks non-zero in expectation.*

3) Timing / sign restrictions. Formal assumption

- *At high frequency, hedge funds respond more to fundamental than banks than pension funds*
- *No spillovers across market desks at high frequency within banks*

$$\begin{pmatrix} \text{short qty} \\ \text{short price} \\ \text{long qty} \\ \text{long price} \end{pmatrix} = \underbrace{\begin{pmatrix} + & 0 & - & + \\ + & 0 & + & + \\ 0 & + & - & - \\ 0 & + & + & + \end{pmatrix}}_{\boldsymbol{\Psi}} \begin{pmatrix} \text{hedge fund demand} \\ \text{pension fund demand} \\ \text{dealer-bank supply} \\ \text{fundamental} \end{pmatrix}$$

Overidentification tests

Correlations of fundamental shock from the three strategies (SR, GIV, Hetero):

$$\begin{bmatrix} 1 & 0.9865 & 0.8038 \\ \cdot & 1 & 0.7320 \\ \cdot & \cdot & 1 \end{bmatrix}$$

- IRFs from strategies 1 & 2 confirm the sign restrictions in strategy 3. Differential reactiveness & desk separation hold in the microdata.

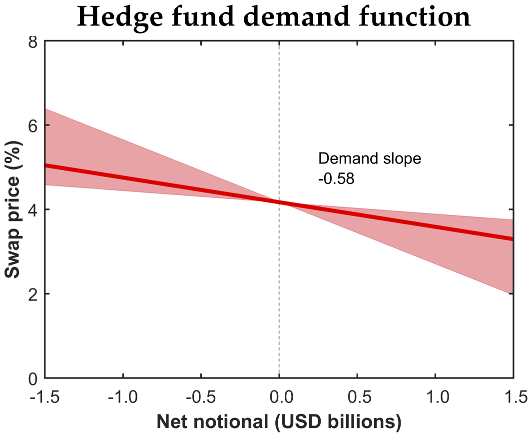
- ε_π from strategies 1 & 3 confirms the exclusion restriction required for the GIV.

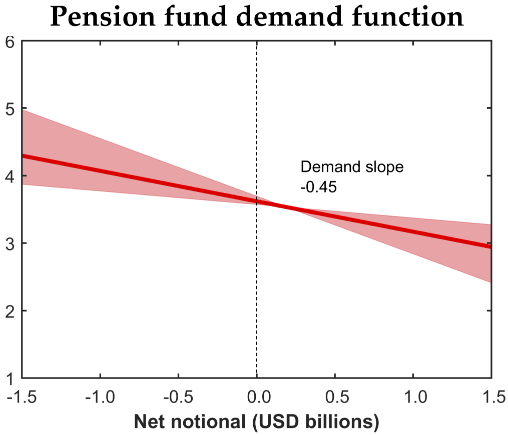
- ε_π from strategies 2 & 3 have higher relative variance on the dates used in strategy 3.

For brevity, results now from strategy 1 (sign restrictions).

4. The financial market

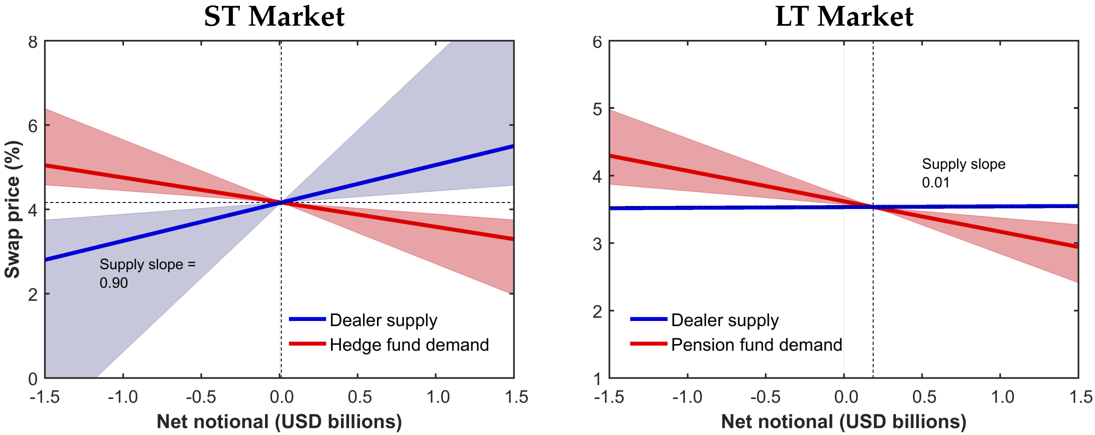
Slope of demand functions: similar





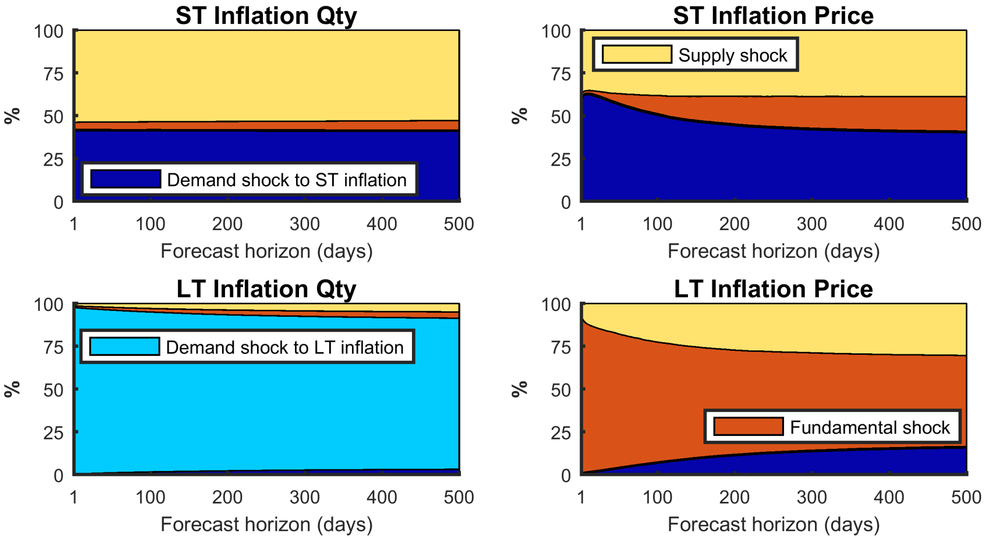
IRFs

R1: Slope of supply function horizontal in long market



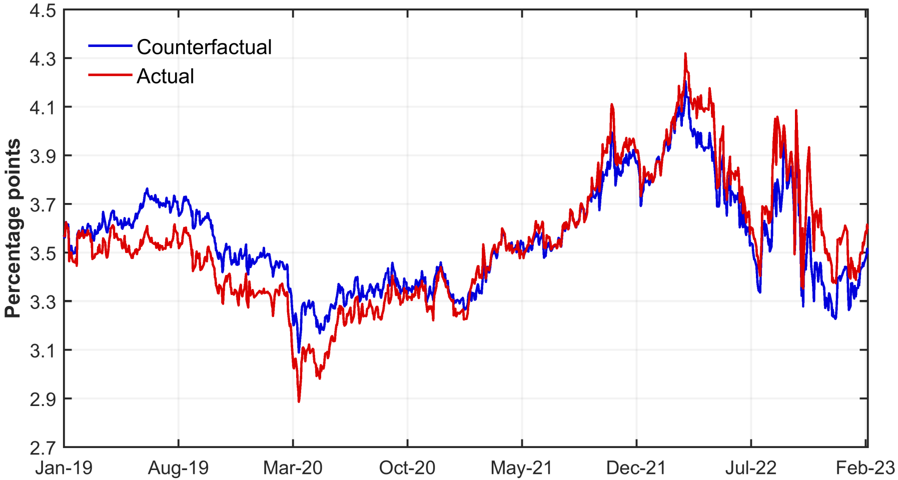
IRFs

R2: LT prices reflect fundamentals, ST prices liquidity



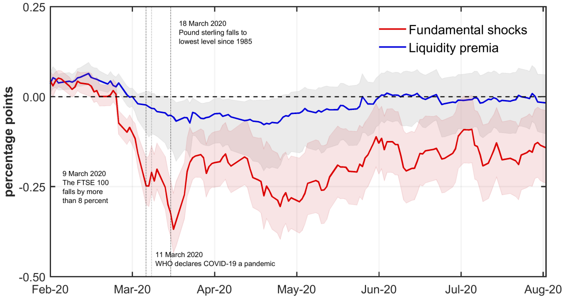
5. The macro inferences for inflation

R3: LONG PRICES OVERSTATE MOVEMENTS IN FUNDAMENTALS

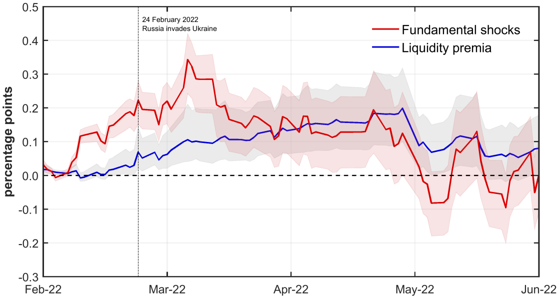


Historical decomposition: COVID and Ukraine

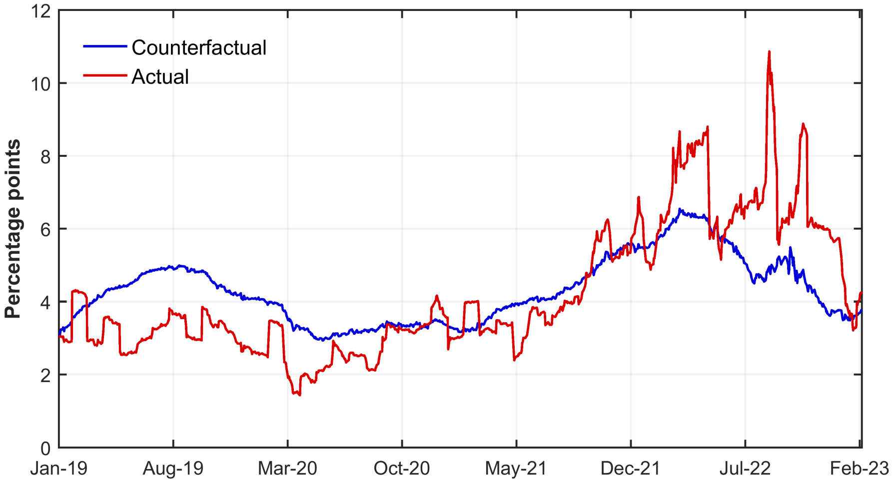
Covid period



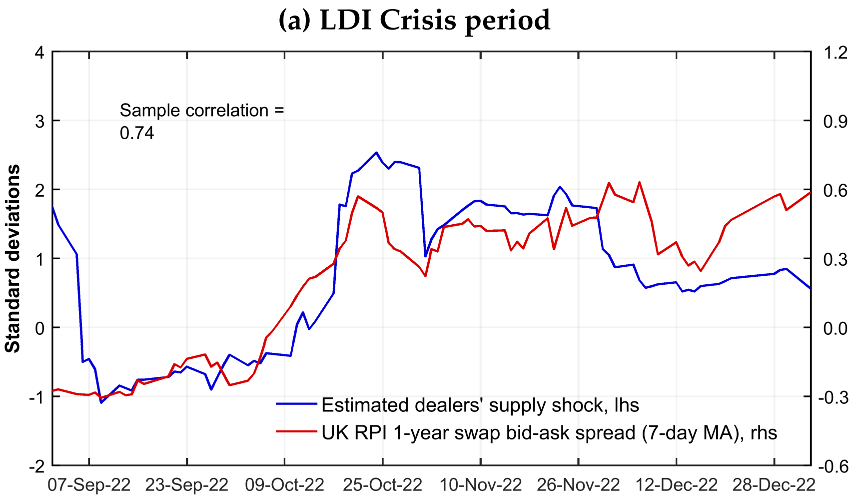
Ukraine invasion



R4: ST prices still have lower-frequency information

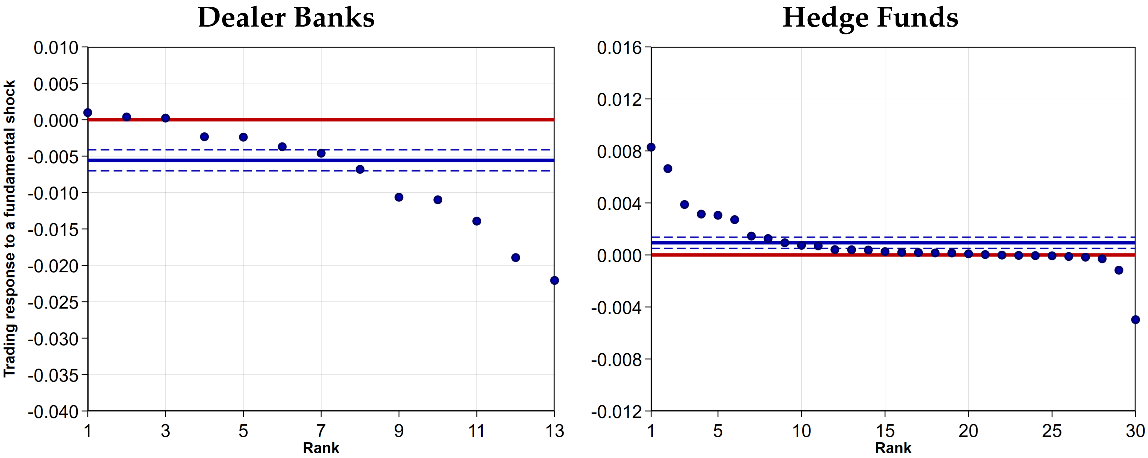


Comparisons with market bid-ask spreads



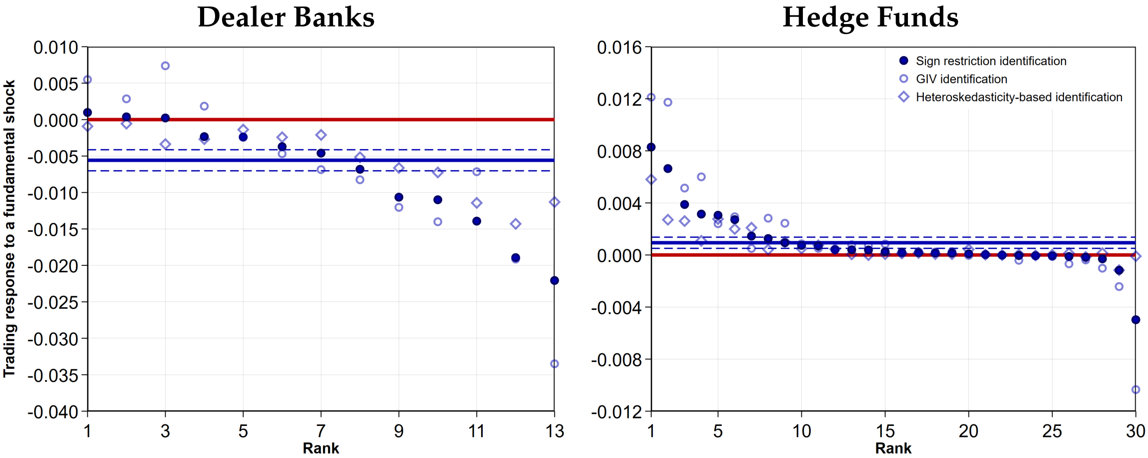
6. Disagreement and expectations

R5: Relative price impact disperse and driven by few



LT market

Relative price impact consistent across identification



LT market

Markets versus surveys

- Focus on dealers in ST market

- **Trading behaviour**, regress quantity traded by an institution on our identified fundamental ε_t^{π}

$$\frac{Q_{b,i,t}}{a_{b,i,t}} = \beta_{b,i}\varepsilon_t^{\pi} + \text{residual}_{b,i,t}$$

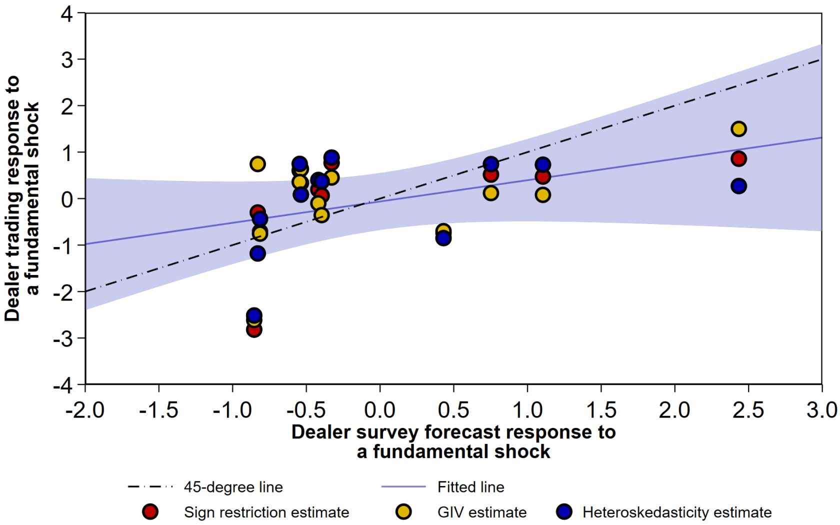
  $\beta_{b,i}$ are negative, consistent with assumption 3a. Differential response, to either subjective expectations or risk premia.

- **Agent's expectations** Bloomberg monthly panel of forecasts for inflation, $\hat{\Pi}^e_{b,i}$

$$\Delta\hat{\Pi}^e_{b,i,t} = \mu_{b,i}\Delta P_t^* + \text{residual}_{b,i,t},$$

  $\mu_{b,i}$ measures disagreement about subjective expectations.

R6: MATCH BETWEEN MARKETS AND SURVEYS



7. Conclusions

Conclusions

1) Facts: At short horizons, hedge funds and dealers alternate between negative and positive net positions. At long horizons, dealers provide inflation protection to pension funds.

2) Propose three separate identification strategies that exploit information/variability in daily frequency, concentration across institutions, and time series.

3) At short horizon, supply curve is steep, liquidity shocks drive prices; at long horizons, supply curve is flat, fundamentals account for 80% of price variation.

4) New measure of expected inflation cleaned of liquidity frictions reacts less to key shocks, is more anchored.

5) Risk-neutral expectations inferred from market positions match with subjective expectations inferred from survey answers.