# Collateral Demand in Wholesale Funding Markets

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Views are solely those of the authors and not the Bank of England.

# Repo Markets: How they work

Repurchase agreements (repo):

- Borrower sells asset at t & promises to buy it back at t + 1.
- Collateralized lending.
- Lender temporarily owns asset.

Repo serves two functions:

1. Funding demand: Acquiring funding cheaply.
   $\rightarrow$ Collateral valued only as insurance.
2. Collateral demand: Acquiring assets temporarily.
   $\rightarrow$ Usage of collateral valuable, eg to short.

# Repo Markets: Why they matter

Important:

- Key wholesale funding market $\rightarrow$ financial stability.
- Necessary input to a shorting trade $\rightarrow$ asset prices.

Economic interest:

- Organization of market with two functions.

# Question

**Does collateral function complement funding function?**

- What happens to eq'm funding absent collateral demand?
- Does this effect vary over time or in crises?
- Implications for regulation and policy?

# What we do

Our focus: **distribution of collateral demand across firms**.

1. Transaction data of repo against UK gov bonds with firm ids.
   $\rightarrow$ Heterogeneity in repo rates across firms.

2. Equilibrium model of repo.
   $\rightarrow$ Effect of heterogeneous collateral demand across firms.

3. Structurally estimate model.
   $\rightarrow$ Infer & interrogate firm-time-asset collateral demand.
   $\rightarrow$ Counterfactual: remove collateral demand.

# What we find

**Does collateral function complement liquidity function?**

No! Volumes and gains to trade higher absent collateral demand.

- Joint distribution of funding and collateral needs across firms.
- Firms that need funding are also those that value collateral.

# Empirical literature on repo

Duffie (1996); Gorton and Metrick (2012); Copeland, Martin & Walker (2014); Krishnamurthy, Nagel & Orlov (2014); Mancini, Ranaldo & Wrampelmeyer (2016); Boissel, Derrien, Ors & Thesmar (2017); D'Amico, Fan & Kitsul (2018); Ranaldo, Schaffner & Tsatsaronis (2019); Hüser, Lepore & Veraart (2021); Eisenschmidt, Ma & Zhang (2022); Ballensiefen, Ranaldo & Winterberg (2023); Huber (2023).

**Contribution**

1. Structural measurement of collateral demand.
2. Distribution in XS and TS.
3. Equilibrium effects.
4. Negative effect on repo market functioning.

# Empirical literature on repo: Specialness

Duffie (1996); Gorton and Metrick (2012); Copeland, Martin & Walker (2014); Krishnamurthy, Nagel & Orlov (2014); Mancini, Ranaldo & Wrampelmeyer (2016); Boissel, Derrien, Ors & Thesmar (2017); D'Amico, Fan & Kitsul (2018); Ranaldo, Schaffner & Tsatsaronis (2019); Hüser, Lepore & Veraart (2021); Eisenschmidt, Ma & Zhang (2022); Ballensiefen, Ranaldo & Winterberg (2023); Huber (2023).

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# Empirical literature on repo: Structural estimation

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# Empirical Facts

BoE transaction data on $\approx$ universe of repo trading against UK government collateral (gilts) from 2017-23.

Facts on collateral demand:

1. Underlying asset matters for hedge funds, not MMFs.

2. Most repo rates below risk-free rate.
3. Hedge funds charge lower rates to lend.
4. Rates higher when collateral is interchangeable.

Background facts:

- Market power, exogenous networks, interdealer trade, etc.

# Rate Variation: Hedge Fund vs MMF Lending

Table reports $R^2$ in regression of repo rates on FE for firm type.

| Fixed effects | Hedge fund | MMF |
|---|---|---|
| Week-Maturity | 0.50 | 0.31 |
| Week-Maturity-Borrower | 0.56 | 0.98 |
| Week-Maturity-Lender | 0.62 | 0.42 |
| Week-Maturity-Asset | 0.94 | 0.73 |

What about:

1. q?
2. confounding factors?
3. quantification?
4. counterfactuals?

$\rightarrow$ **model**

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# Model: Setup

**Assets & Agents**

- $\mathcal{A}$ assets, indexed by $a$: exchange cash for collateral.
- Return to funding for agent $i \sim N(\nu_i, 1)$.
- Return to collateral for agent $i \sim N(\eta_i^a, \sigma)$.
- Mean-var preferences with risk aversion $\kappa$.

**Trading structure**

- $N_d$ dealers and $N_c$ customers on fixed network $\mathbf{G^a}$.
- Firm $k$ has set $\mathcal{N}_k^a$ as neighbours.
- No customer-customer links.

1. Competitive interdealer market indexed by $D$.
2. Dealer-customer trade, where dealers have market power.

# Model: Setup

**Trading**

- $q_{ij}^a$ borrowing by $i$ from $j$ against $a$.
- $Q_i^a = \sum_{j \in \mathcal{N}_i^a} q_{ij}^a$ total net borrowing by $i$ against $a$.
- $Q_i = \sum_a Q_i^a$ total net borrowing by $i$.
- $r_{ij}^a$ interest rate.
- $\epsilon_{im}^a$ non-pecuniary, relationship-specific benefits.

**Payoff to firm $i$**

$$\underbrace{\nu_i Q_i - \frac{\kappa}{2} Q_i^2}_{\text{Funding}} \underbrace{- \sum_a \eta_i^a Q_i^a - \sum_a \frac{\kappa}{2} \sigma (Q_i^a)^2}_{\text{Collateral demand}} \underbrace{- \sum_a \sum_{m \in \mathcal{N}_i^a} q_{im}^a (r_{im}^a + \epsilon_{im}^a)}_{\text{Transaction terms}}$$

# First order condition

Customer $j$, with respect to quantity $q_{ij}^a$:

$$\underbrace{-\nu_j + \kappa Q_j}_{\text{-}j\text{'s MB from cash}} \quad \underbrace{+\eta_j^a + \kappa\sigma Q_j^a}_{j\text{'s MB from collateral}} \quad +r_{ij}^a = 0$$

Dealer $i$, with respect to quantity $q_{ij}^a$:

$$\underbrace{\nu_i - \kappa Q_i}_{i\text{'s MB from cash}} \quad \underbrace{-(\eta_i^a + \kappa\sigma Q_i^a)}_{\text{-}i\text{'s MB from collateral}} \quad \underbrace{-\kappa \sum_l q_{ij}^l - \kappa\sigma q_{ij}^a}_{\text{Price effect}} - \epsilon_{ij}^a - r_{ij}^a = 0$$

# Equilibrium

Solution:

- Linear FOCs where network link exists, given $\mathbf{G}$.

Equilibrium quantity $q_{ij}^a$ depends on:

- Relative counterparty characteristics: $v_i, v_j$ and $\eta_i^a, \eta_j^a$.
- Network: counterparties' counterparties' characteristics, etc.

Effect of collateral demand on gains to trade ($\eta_i^a = 0, \forall i$):

- Correlation between funding and collateral demand across $i$.
- Therefore an empirical question. Example

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# Estimation: Setting

Task is to recover as flexibly as possible

- funding demand $\nu_{it}$;
- collateral demand $\eta^a_{it}$;
- risk $\sigma$; and
- risk aversion $\kappa$;

from

- observed quantities $q^a_{ijt}$; and
- observed rates $r^a_{ijt}$.

# Estimation: Overview

Model: Dealer $i$ FOC with respect to $q^a_{ijt}$:

$$r^a_{ijt} = \underbrace{\nu_{it} - \kappa Q_{it}}_{i\text{'s MB from cash}} \underbrace{-(\eta^a_{it} + \kappa\sigma Q^a_{it})}_{-i\text{'s MB from collateral}} \underbrace{-\kappa \sum_l q^l_{ijt} - \kappa\sigma q^a_{ijt}}_{\text{Price effect}} - \epsilon^a_{ijt}$$

Two step estimation:

1. Infer $(\kappa, \sigma)$ from variation across $j$, within $i - t$.
2. Given these estimates, infer $(\nu_{it}, \eta^a_{it})$ from variation across $a$.

Challenges:

- Simultaneity: Gilt prices and trading patterns by firm as IV.
- Level identification: $\eta^a_{it} = 0$ when $a$ is "general collateral".

Details

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# Results

Variation across firms:

1. Variation across type: banks and HF have high $\eta$.
2. Positive correlation across firms between $\eta$ and $\nu$.

Variation across time:

3. Funding demand tracks central bank rate.
4. Level and dispersion in collateral demand track volatility.

Implication:

- Collateral demand bad for funding, particularly in stress?

Hedging Correlation Vol

# Variation in Funding & Collateral Demand

Most variation across firms, not across assets:

| Fixed Effects | Funding demand | Collateral demand |
|---|---|---|
| Time $t$ | 0.96 | 0.07 |
| Firm $i$ | 0.14 | 0.49 |
| Asset $a$ | | 0.05 |
| Firm-Asset $ia$ | | 0.58 |
| Firm-Time $it$ | | 0.85 |
| Asset-Time $at$ | | 0.19 |

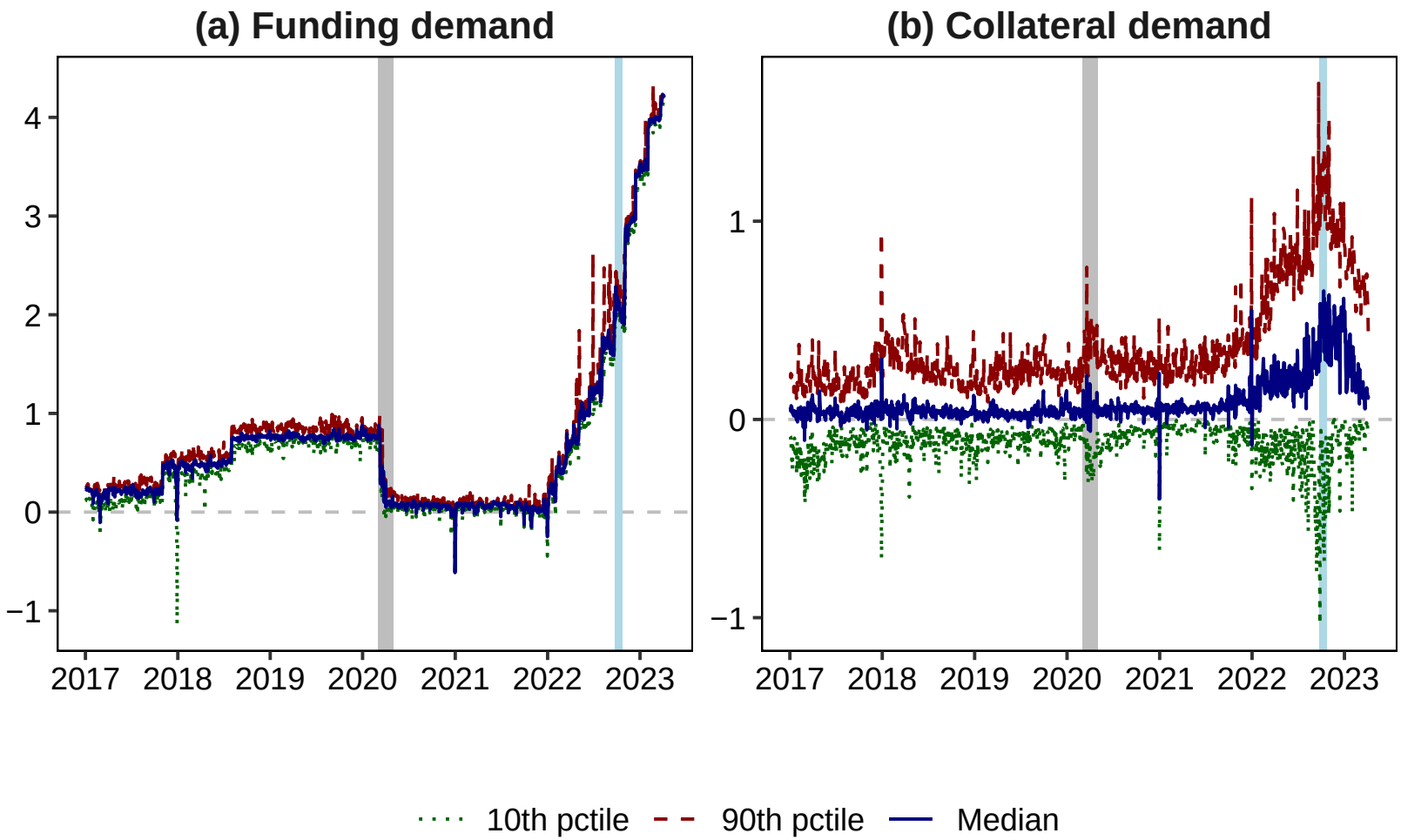
# Variation across firm types

| | Funding demand $\nu_{it}$ (1) | Collateral demand $\eta^a_{it}$ (2) |
|---|---|---|
| Bank | 0.68*** | 0.13*** |
| | (0.007) | (0.0007) |
| Dealer | 0.81*** | 0.23*** |
| | (0.006) | (0.0004) |
| Fund | 0.84*** | 0.07*** |
| | (0.005) | (0.001) |
| Hedge Fund | 0.70*** | 0.11*** |
| | (0.004) | (0.0007) |
| MMF | 0.61*** | 0.05*** |
| | (0.01) | (0.003) |
| Other | 0.77*** | 0.13*** |
| | (0.008) | (0.002) |
| PFLDI | 0.71*** | -0.08*** |
| | (0.006) | (0.001) |
| $R^2$ | 0.005 | 0.05 |
| Observations | 167,037 | 1,490,509 |

# Correlation between funding and collateral demand

| | Collateral demand $\eta^a_{it}$ | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Funding demand $\nu_{it}$ | $0.20^{***}$ | $0.95^{***}$ | $0.12^{***}$ |
| | (0.0003) | (0.001) | (0.02) |
| $R^2$ | 0.22 | 0.74 | 0.57 |
| Observations | 1,563,051 | 1,563,051 | 1,563,051 |
| Day FEs | | Yes | |
| Firm FEs | | | Yes |

# Variation over time



# Results

Variation across firms:

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2. Positive correlation across firms between $\eta$ and $\nu$.

Variation across time:

3. Funding demand tracks central bank rate.
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Implication:

- Collateral demand bad for funding, particularly in stress?

Hedging Correlation Vol

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# Counterfactual: Removing Collateral Demand

Removing collateral demand:

- Set $\eta_{it}^{a} = 0$ for all $a, i, t$.
- Collateral equally useful for everyone only as insurance.

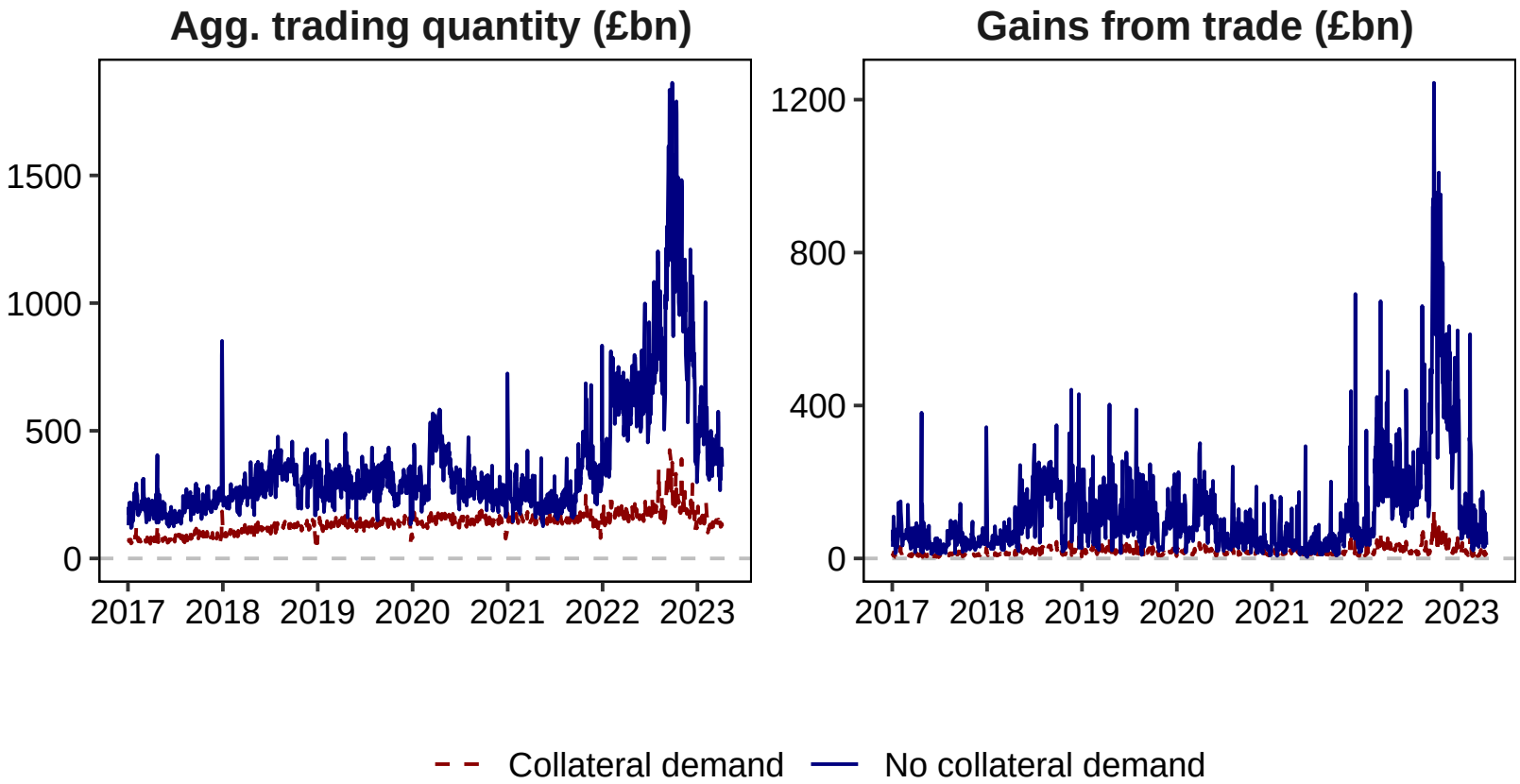
Effect, relative to baseline:

- Volumes and gains to trade higher, particularly in stress.

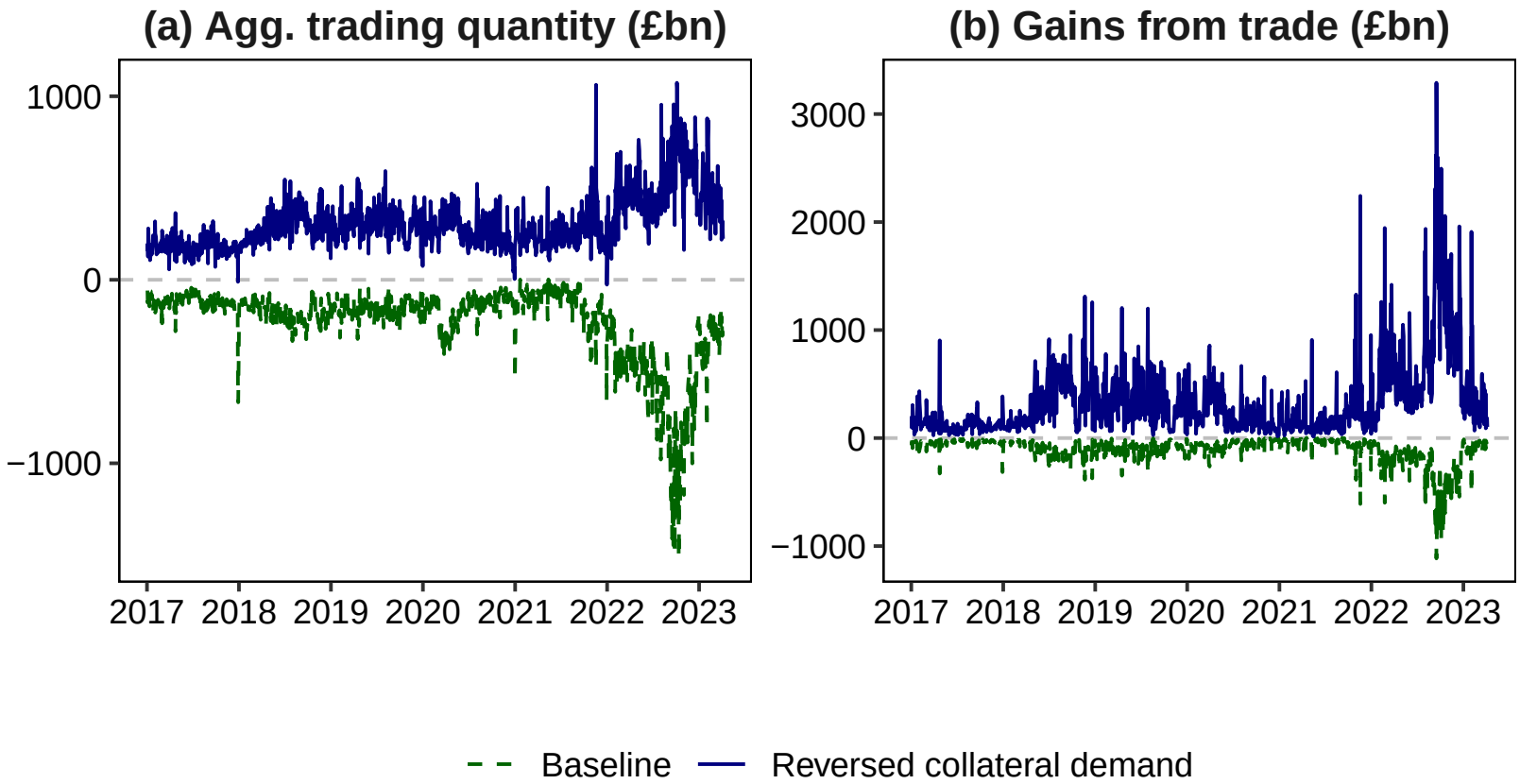
Extension, wrt correlation:

- Rearrange $\eta_{it}^{a}$ across $i$ to reverse correlation.
- Undertake same counterfactual removing collateral demand.
- Effect reversed: this is about correlation.

# Counterfactual: Quantities & GTT



# Role of Correlation



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# Regulation

Problem: banks cannot simultaneously manage risk and funding.

- Banks need to be long on bonds to fund themselves...
- ... when they want to reduce inventory risk.

Implications for regulation/policy?

- Uncovered short-selling.
- Central bank repo accepting other collateral.
- Central bank collateral swap facilities.
- Monetary policy.

# Conclusion

- Collateral demand is a key driver of repo outcomes.
- Effect depends on joint distribution with funding demand.
- Finding: dual repo functions do not always combine well.

# Conclusion

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- Effect depends on joint distribution with funding demand.
- Finding: dual repo functions do not always combine well.

**Thank you!**

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# Annexes

# Background facts

Trade details:

- Mostly short maturity.
- Fully or over collateralized, no default.

Trade structure:

- Network sparse & broadly fixed. Details
- Dealers earn a spread. Dealer spreads
- D-D trade mostly on platforms, D-C trade OTC.

Firm types:

- MMFs uniquely lend, do not use collateral. Details
- Hedge funds borrow & lend, and may use to short.
- Different firms borrow against different gilts. Wallet variation

# Net lending by sector

| | Trade Share (%) | Daily net lending (%) | Daily net lending (£bn) |
|---|---|---|---|
| Dealer | 66.1 | -3.8 | -4.6 |
| Bank | 11.7 | -31.4 | -7.5 |
| Hedge Fund | 10.3 | -0.2 | -0.4 |
| Fund | 4.2 | 62.5 | 5.2 |
| MMF | 2.9 | 97.4 | 6.2 |
| PFLDI | 2.8 | 18.9 | 0.9 |
| Other | 2.0 | 0.6 | 0.5 |

# Additional facts

1. Fewer than 2% of counterparty pairs have non-zero trade in the whole sample.

2. Over 95% of transactions after January 2022 onwards were between traders who had traded together before January 2022.

Back

# Repo rate variation

| Fixed effects | R-squared |
|---|---|
| *Deal characteristics* | |
| Week | 0.37 |
| Week-Asset | 0.86 |
| Week-Maturity | 0.42 |
| Week-Asset-Maturity | 0.90 |
| *Trader characteristics* | |
| Week-Borrower | 0.51 |
| Week-Lender | 0.45 |
| Week-Borrower-Lender | 0.59 |

Rate variation

# Dealer spreads

| | Repo rate (%) | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Dealer lending | $0.155^{***}$ | $0.149^{***}$ | $0.092^{***}$ |
| | (0.007) | (0.002) | (0.0006) |
| $R^2$ | 0.23 | 0.35 | 0.81 |
| Observations | 1,003,270 | 1,003,270 | 1,003,270 |
| Week FEs | Yes | | |
| Week-Dealer FEs | | Yes | |
| Week-Dealer-Asset FEs | | | Yes |

# Repo Rates & Collateralization Type

| | Repo rate (%) | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| General Collateral | 0.09*** | 0.09*** | 0.09*** | 0.10*** |
| | (0.006) | (0.01) | (0.003) | (0.004) |
| $R^2$ | 0.30 | 0.20 | 0.55 | 0.43 |
| Observations | 6,095,617 | 6,095,617 | 6,095,617 | 6,095,617 |
| Week FEs | Yes | | | |
| Borrower-Lender FEs | | Yes | | |
| Borrower-Week FEs | | | Yes | |
| Lender-Week FEs | | | | Yes |

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# Rates for hedge funds vs MMFs

| | Repo rate (%) | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Lender: Hedge fund | -0.06*** | -0.08*** | -0.003*** | -0.002** |
| | (0.006) | (0.003) | (0.001) | (0.001) |
| $R^2$ | 0.38 | 0.58 | 0.94 | 0.97 |
| Observations | 371,649 | 371,649 | 371,649 | 371,649 |
| Week FEs | Yes | | | |
| Borrower-Week FEs | | Yes | | |
| Borrower-Asset-Week FEs | | | Yes | |
| Asset-Mat-Borr-Week FEs | | | | Yes |

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# Model: Simplified example

One dealer $i$, one customer $j$, one asset:

- $\Delta\nu \equiv \nu_i - \nu_j$, $\Delta\eta \equiv \eta_i - \eta_j$.
- Equilibrium net borrowing by $i$:

$$q_{ij} = \frac{\Delta\nu - \Delta\eta}{3\kappa(1+\sigma)}$$

- Equilibrium trading volume:

$$\mid q_{ij} \mid = \frac{\mid \Delta\nu - \Delta\eta \mid}{3\kappa(1+\sigma)}$$

- Gains to trade:

$$GTT = \frac{2(\Delta\nu - \Delta\eta)^2}{9\kappa(1+\sigma)}$$

# Model: Simplified example

One dealer $i$, one customer $j$, one asset:

- $\Delta\nu \equiv \nu_i - \nu_j$, $\Delta\eta \equiv \rho\bar{\eta}\Delta\nu$.
  - $\rho \in [-1\ 1]$: correlation btw liquidity and collateral demand.
  - $\bar{\eta} \in [0\ 1]$: magnitude of collateral demand.

- Effect of collateral demand on GTT depends on correlation $\rho$:

$$\frac{dGTT}{d\bar{\eta}} \begin{cases} > 0, & \text{if } \rho < 0 \\ < 0, & \text{otherwise} \end{cases}$$

- Effect of collateral demand therefore an empirical question.

Back

# Estimation: Step 1

Estimating equation:

$$r^a_{ijt} = \delta^a_{it} - \left[\kappa \sum_l q^l_{ijt} + \kappa\sigma\, q^a_{ijt}\right] \mathbb{1}_{ij} + \epsilon^a_{ijt}$$

where $\mathbb{1}_{ij} = 1$ if $i$ has market power wrt $j$.

Identification:

- Challenge: standard joint determination of $q$ and $r$.
- Different $j$ trade different $a$ (exogenous "wallet").
- Change in price of gilt $a$ exogenous to $\epsilon^a_{ijt}$.
- Shift-share IV: lag wallet shares, interact with price.

Estimation Details

# Estimation: Step 2

Model:

$$\delta_{it}^{a} = \nu_{it} - \kappa Q_{it} - \eta_{it}^{a} - \kappa\sigma \sum_{m} q_{imt}^{a}$$

Second step estimation:

$$\hat{\delta}_{it}^{a} + \hat{\kappa}\hat{\sigma} \sum_{m} q_{imt}^{a} + \hat{\kappa} Q_{it} = \nu_{it} - \eta_{it}^{a}$$

- Decompose network-adjusted average interest rates for $i$.
- Level identification from following assumption:

$$\eta_{it}^{GC} = 0 \quad \forall i, t$$

# Instruments: Details

Instruments:

$$z_{1,jt} = \sum_{a \in \omega_j} s^a_{jt} \times \text{price}^a_t$$

$$z^a_{2,jt} = z_{1,jt} - s^a_{jt} \times \text{price}^a_t$$

First stage:

$$q^a_{ijt} = \alpha^a_{it} + \beta_1 z_{1,jt} + \beta_2 z^a_{2,jt} + e^a_{ijt}$$

$$\sum_l q^l_{ijt} = \alpha^a_{it} + \beta_3 z_{1,jt} + \beta_4 z^a_{2,jt} + e^a_{ijt}$$

Second stage:

$$r^a_{ijt} = \delta^a_{it} - \left[\kappa \sum_l q^l_{ijt} + \kappa\sigma q^a_{ijt}\right] \mathbb{1}_{ij} + \epsilon^a_{ijt}$$

Back

# Estimates: risk & risk aversion

| | Repo rate $r^a_{ijt}$ (%) | |
|---|---|---|
| | OLS | 2SLS |
| | (1) | (2) |
| $\sum_l q^l_{ijt}$ | -0.01*** | -0.02*** |
| | (0.0009) | (0.002) |
| $q^a_{ijt}$ | -0.12*** | -0.18*** |
| | (0.002) | (0.003) |
| Wald (1st stage), $\sum_l q^l_{ijt}$ | | 6,377.2 |
| Wald (1st stage), $q^a_{ijt}$ | | 2,170.8 |
| $R^2$ | 0.996 | 0.997 |
| Within $R^2$ | 0.027 | 0.037 |
| Observations | 599,384 | 527,295 |
| Firm-asset-day FEs | Yes | Yes |
| Firm-counterparty FEs | Yes | Yes |

First Stage Back

# First Stage

| | $q^a_{ijt}$ OLS (1) | $\sum_l q^l_{ijt}$ 2SLS (2) |
|---|---|---|
| $z_{1,jt}$ | -0.0114*** | -0.0072*** |
| | (0.0002) | (0.0002) |
| $z^a_{2,jt}$ | 0.0116*** | 0.0009*** |
| | (0.0002) | (0.0002) |
| $R^2$ | 0.80069 | 0.86838 |
| F-test | 535.18 | 878.98 |
| Observations | 527,295 | 527,295 |
| Firm-asset-week FEs | Yes | Yes |
| Firm-counterparty FEs | Yes | Yes |

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# Collateral Demand & Asset Prices

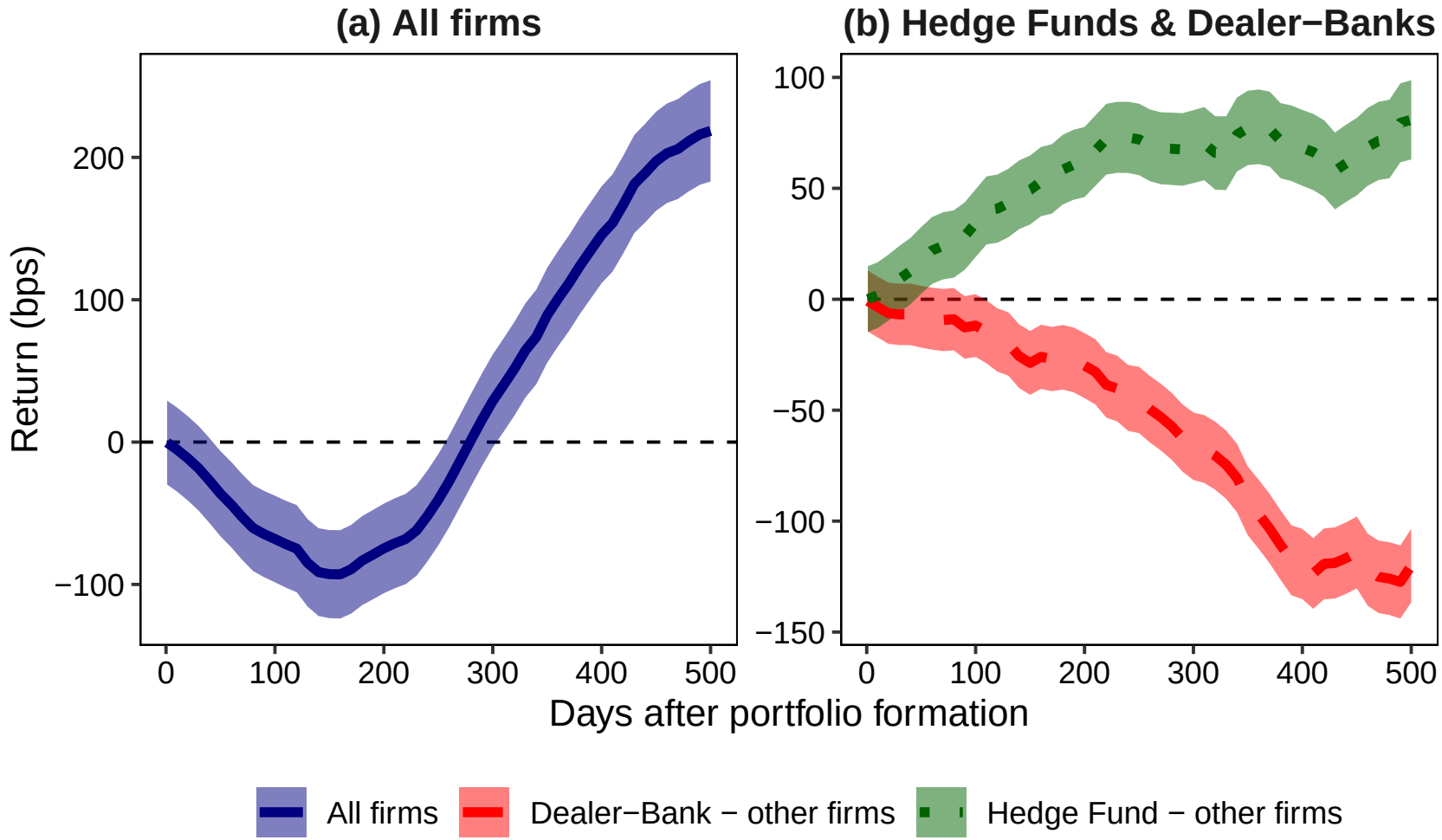
Questions:

- Why do banks have collateral demand?
- Does collateral demand predict future bond prices?
- Is collateral demand about hedging or speculation?

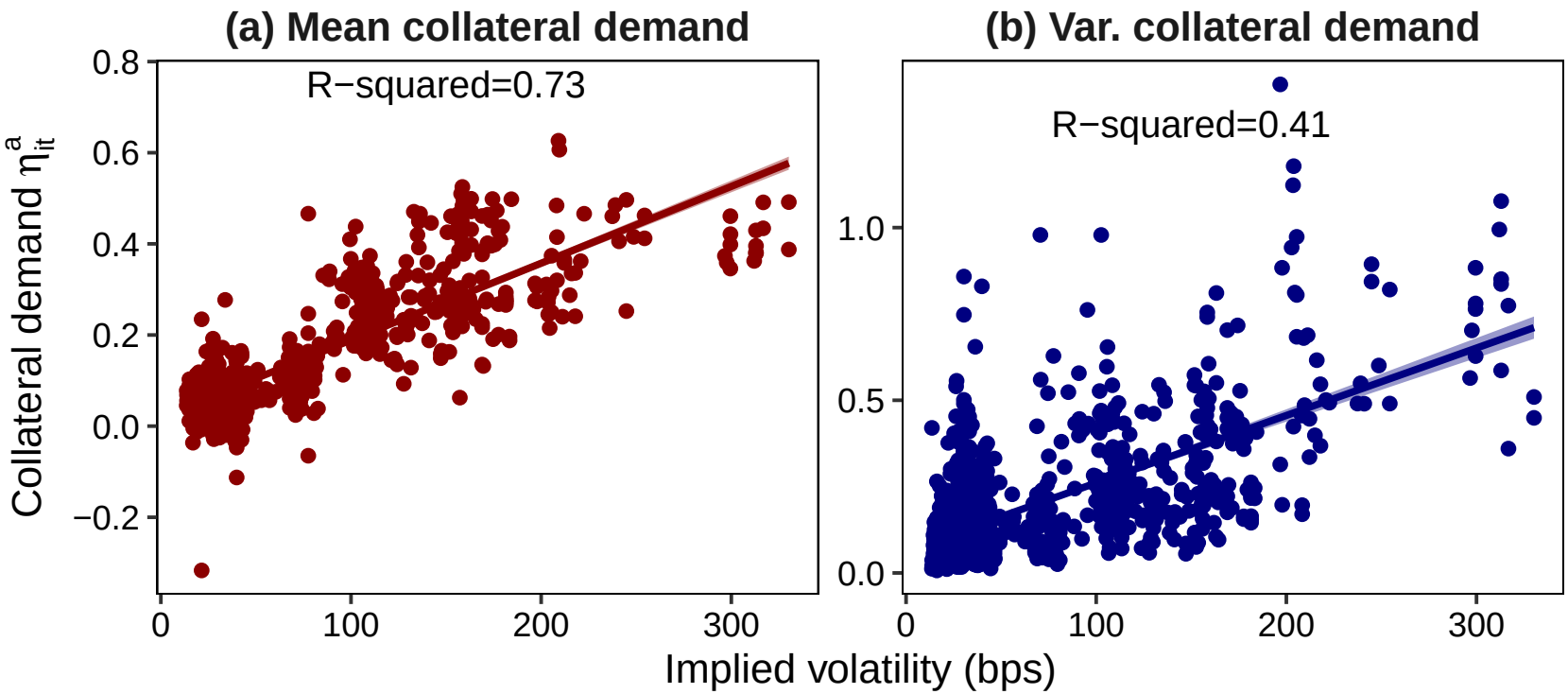
Approach:

- Go short (long) on bonds with high (low) collateral demand.

# 3. Collateral Demand & Asset Prices



# Volatility & Collateral Demand

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# Sector heterogeneity

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# Rates for general collateral

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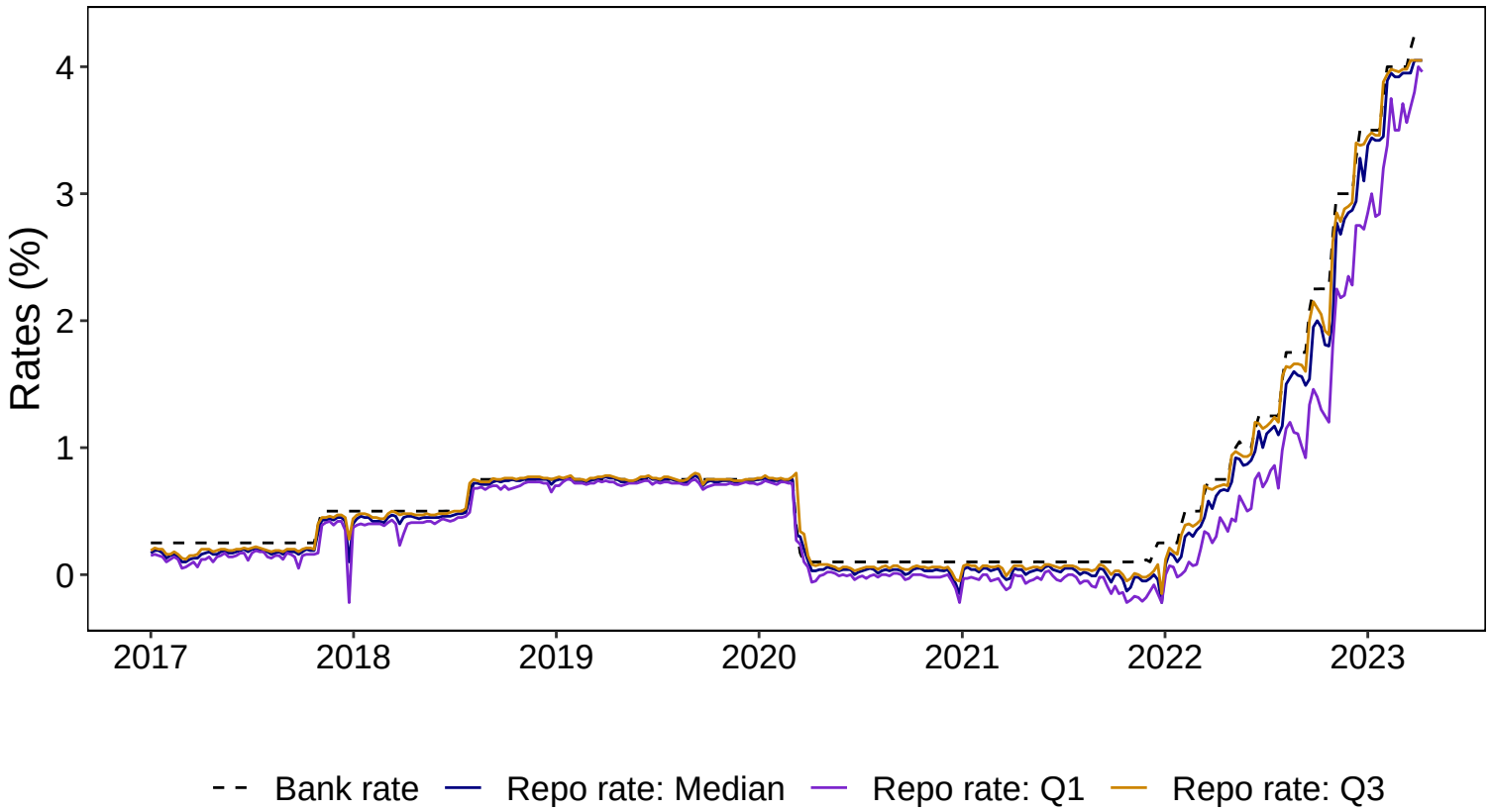
| Week-Dealer-Asset FEs | | | Yes |

# Rates through time on dealer repo lending



# Regression Results

| | Repo rate $r^a_{ijt}$ (%) | |
|---|---|---|
| | OLS | 2SLS |
| | (1) | (2) |
| $\sum_l q^l_{ijt}$ | -0.01*** | -0.02*** |
| | (0.0009) | (0.002) |
| $q^a_{ijt}$ | -0.12*** | -0.18*** |
| | (0.002) | (0.003) |
| Wald (1st stage), $\sum_l q^l_{ijt}$ | | 6,377.2 |
| Wald (1st stage), $q^a_{ijt}$ | | 2,170.8 |
| $R^2$ | 0.996 | 0.997 |
| Within $R^2$ | 0.027 | 0.037 |
| Observations | 599,384 | 527,295 |
| Firm-asset-day FEs | Yes | Yes |
| Firm-counterparty FEs | Yes | Yes |

# Regression Results: First Stage

| | $q^a_{ijt}$ | $\sum_l q^l_{ijt}$ |
|---|---|---|
| | OLS | 2SLS |
| | (1) | (2) |
| $z_{1,jt}$ | -0.0114*** | -0.0072*** |
| | (0.0002) | (0.0002) |
| $z^a_{2,jt}$ | 0.0116*** | 0.0009*** |
| | (0.0002) | (0.0002) |
| $R^2$ | 0.80069 | 0.86838 |
| F-test | 535.18 | 878.98 |
| Observations | 527,295 | 527,295 |
| Firm-asset-week FEs | Yes | Yes |
| Firm-counterparty FEs | Yes | Yes |

# Implied volatility