Convenience yields and the foreign demand for US Treasuries

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Convenience yields for US Treasuries

- Special role of US Treasury as global safe asset allows US to fund its debt cheaply (Jiang et al., 2019; Choi et al., 2024)
- Reflected in convenience yield: investors are willing to give up returns to hold Treasuries (Du et al., 2018; Krishnamurthy and Vissing-Jorgensen, 2012)
- US public debt sustainability relies on convenience yield and low demand elasticity, especially by foreigners (Jiang et al., 2022)

Demand for safe assets across sectors

- Empirical evidence
  - Euro area: banks very sensitive to yield, insurance companies and pension funds (ICPF) insensitive (Koijen et al., 2021)
  - Advanced economies: non-banks absorb large portion of new issuances, low yield elasticity for insurers (Fang et al., 2023)
  - US Treasuries: banking sector more responsive to yields than ICPF (Eren et al., 2023)
- Competing explanations for differences in elasticity
  - Risk aversion and risk management practices (Eren et al., 2023)
  - Regulatory framework for mutual funds vs. insurers (Faia et al., 2022)
  - Market making vs. speculative business model (Abbassi et al., 2016; Timmer, 2018)
- In estimated demand systems, sector-specific latent demand explains large fraction of asset price variance (Koijen and Yogo, 2019) $\Longrightarrow$ Role of underlying preferences?

Research question and results

Role of convenience yields and risk aversion in cross-sector differences of foreign demand for US Treasuries and interest rates.

- Theoretical model
  - Mean-variance portfolio choice with sectoral heterogeneity in:
    - Risk aversion
    - Weight of Treasury preferences (convenience yield)
  - Convenience yields reduce sensitivity of demand to mean and variance excess returns and equilibrium excess returns
- Structural parameters and counterfactuals
  - Risk aversion and Treasury preference parameters from 2SLS estimates of model equations on Eurozone data (banks and ICPF)
  - Preferences for Treasuries
    - Reduce yield sensitivity by **9** times for ICPFs, **3** times for banks
    - Explain nearly **all** difference in yield sensitivity between banks and ICPF
    - Reduce Treasury excess returns by **79** basis points

Model: portfolio choice

Sector k investor's choice between US and euro area country j:

$$\max_{s_{US,k}} \mathbb{E}[W_{0,k}] - 0.5\gamma_k \mathbb{V}[W_k] + \psi_k \frac{b_{US,k}^{1-\sigma} - 1}{1-\sigma}$$

$$\text{s.t.} \quad W_k = W_{0,k}(R_j + (R_{US} - R_j)s_{US,k}) + Y_k$$

$$s_{j,k} + s_{US,k} = 1,$$

- Preferences for "specialness" of US Treasuries ▸ Details
  - Weight ψ_k
  - Curvature σ
- Stochastic income Y_k representing business outside sovereign portfolio
- US Treasuries risky because of exchange rate fluctuations in R_{US}, domestic bonds riskless $\Longrightarrow$ Convenience yield **not** safety premium

Model: optimal share and sensitivity

Linearise F.O.C. around $s_{US,k} = \bar{s}$, $\mathbb{E}[R_{US} - R_j] = \bar{e}$, $\mathbb{V}[R_{US} - R_j] = \bar{v}$, and $Cov[R_{US} - R_j, Y_k] = \bar{c}$

Optimal US Treasury portfolio share

$$s_{US,k} = \bar{s} - \gamma_k \frac{W_{0,k}\bar{s}(\mathbb{V}[R_{US} - R_j] - \bar{v}) + Cov[R_{US} - R_j, Y_k] - \bar{c}}{\gamma_k W_{0,k}\bar{v} + \sigma\psi_k W_{0,k}^{-\sigma}\bar{s}^{-\sigma-1}} + \frac{1}{\gamma_k W_{0,k}\bar{v} + \sigma\psi_k W_{0,k}^{-\sigma}\bar{s}^{-\sigma-1}}(\mathbb{E}[R_{US} - R_j] - \bar{e})$$

Sensitivity to Treasury excess returns

Expectation

$$\frac{\partial s_{US,k}}{\partial \mathbb{E}[R_{US} - R_j]} = \frac{1}{\gamma_k W_{0,k}\bar{v} + \sigma\psi_k W_{0,k}^{-\sigma}\bar{s}^{-\sigma-1}}.$$

Variance

$$\frac{\partial s_{US,k}}{\partial \mathbb{V}[R_{US} - R_j]} = -\frac{\gamma_k W_{0,k}\bar{s}}{\gamma_k W_{0,k}\bar{v} + \sigma\psi_k W_{0,k}^{-\sigma}\bar{s}^{-\sigma-1}}.$$

Model: equilibrium and pricing

Market clearing conditions

$$\sum_k b_{j,k} + b_{j,O} = B_j$$

$$\sum_k b_{US,k} + b_{US,O} = B_{US},$$

$b_{j,k} := s_{j,k} W_{0,k}$ and $b_{US,k} := s_{US,k} W_{0,k}$ sector holdings
$b_{j,O}$ and $b_{US,O}$ holdings by other investors (exogenous)

Equilibrium excess returns, $\tau_k := 1/\gamma_k$ risk tolerance

$$\mathbb{E}[R_{US} - R_j] = \underbrace{\frac{\sum_k \left(\mathbb{V}[R_{US} - R_j] b_{US,k} + Cov\left[R_{US} - R_j, Y_k\right]\right)}{\sum_k \tau_k}}_{\text{Risk premium} := RP}$$

$$\underbrace{-\frac{\sum_k \tau_k \psi_k b_{US,k}^{-\sigma}}{\sum_k \tau_k}}_{\text{Convenience yield} := \phi}$$

Model: excess returns and debt supply

Write $\mathbb{E}[R_{US} - R]$ as a function of B_j (consistency with empirical strategy)

Reaction of excess returns to EA debt supply, accounting for $b_{US,k}$ depending on B_j through $\mathbb{E}[R_{US} - R_j]$

$$\frac{\partial \mathbb{E}[R_{US} - R_j]}{\partial B_j} = \frac{\mathbb{V}[R_{US} - R_j]\left(\frac{\partial b_{j,O}}{\partial B_j} - 1\right)}{\sum_k \tau_k \left(1 - \frac{\sigma \psi_k b_{US,k}^{-\sigma-1}}{\mathbb{V}[R_{US}-R_j]/\tau_k + \sigma \psi_k b_{US,k}^{-\sigma-1}}\right)} < 0.$$

- Lower relative Treasury supply $\implies$ lower excess returns through RP and ϕ
- Treasury preferences amplify fall in excess returns

Estimation: 2SLS sytem

Write linearised model equations as 2SLS system (plus error)

$$\mathbb{E}[R_{US} - R_j] = \iota + \pi B_j + \nu_j \qquad \text{First stage}$$

$$s_{US,k} = \alpha_k + \beta_k \mathbb{E}[R_{US} - R_j] + \varepsilon_{j,k} \text{ for } k = \{B, I\} \qquad \text{Second stage}$$

With $\beta_k > 0$, $\pi < 0$

- $\mathbb{E}[R_{US} - R_j]$ function of B_j in equilibrium $\implies$ Relevance
- $s_{US,k}$ depend on B_j only through $\mathbb{E}[R_{US} - R_j]$ $\implies$ Exogeneity

Estimation: structural parameters

Solve for structural parameters γ_k, ψ_k, σ from estimates of α_k, β_k, π

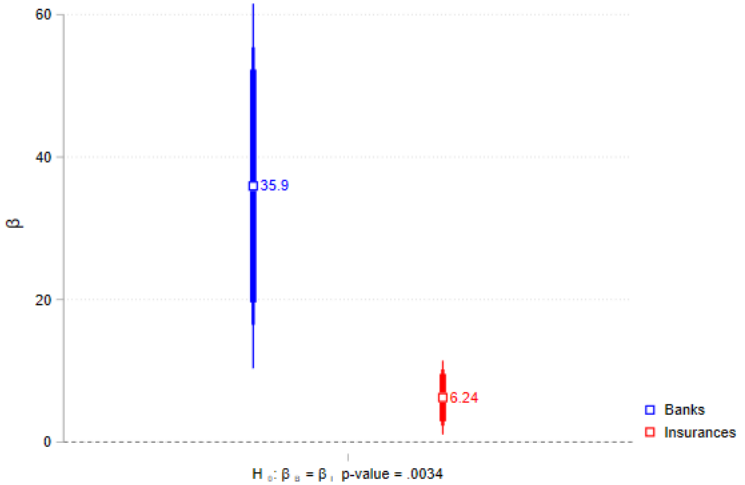
$$\alpha_k = \bar{s} - \gamma_k \frac{W_{0,k} \bar{s} \left(\mathbb{V}\left[R_{US} - R_j\right] - \bar{v} \right) + Cov\left[R_{US} - R_j, Y_k\right] - \bar{c}}{\gamma_k W_{0,k} \bar{v} + \sigma \psi_k W_{0,k}^{-\sigma} \bar{s}^{-\sigma-1}}$$

$$\beta_k = \frac{1}{\gamma_k W_{0,k} \bar{v} + \sigma \psi_k W_{0,k}^{-\sigma} \bar{s}^{-\sigma-1}} > 0$$

$$\pi = \frac{\bar{v} \left(\frac{\partial b_{j,O}}{\partial B_j} - 1 \right)}{\sum_k \frac{1}{\gamma_k} \left(1 - \frac{\sigma \bar{b}_{US,k}^{-\sigma-1} \psi_k}{\gamma_k \bar{v} + \sigma \psi_k \bar{b}_{US,k}^{-\sigma-1}} \right)} < 0$$

Details

Estimation: yield sensitivities



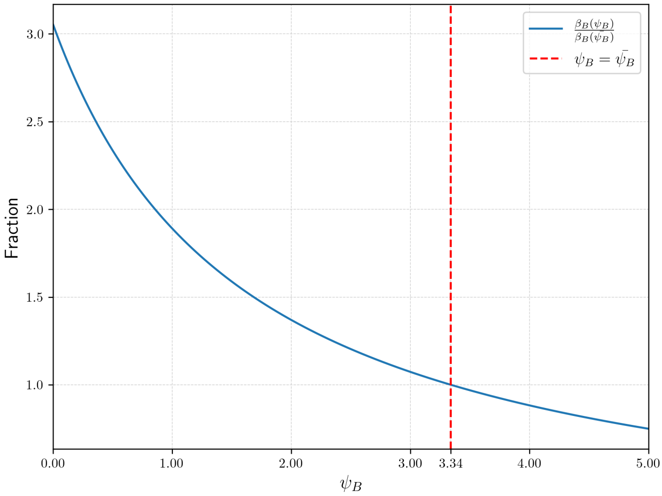
Data Identification Full results

Estimation: structural parameters

Structural parameter	Mean	95% CI lower bound	95% CI upper bound
A. Banks			
γ_B	0.24	0.02	0.2
ψ_B	3.34	1.0	978.64
B. Insurance companies			
γ_I	0.37	0.13	1.0
ψ_I	3.63	0.13	149.34
C. Common parameters			
σ	2.97	0.51	101.0

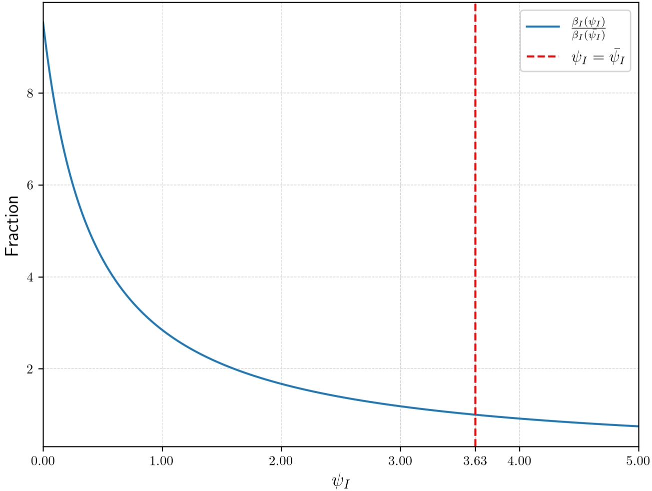
Experiment: banks' sensitivity

How much does banks' sensitivity to mean and variance of Treasury excess returns change as a function of ψ?



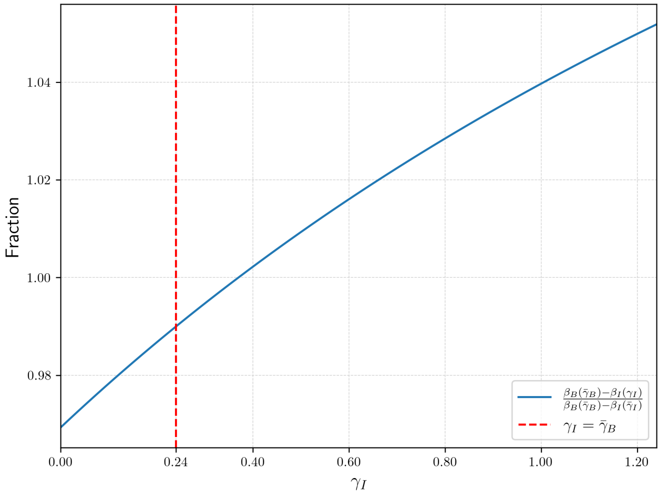
Experiment: ICPF's sensitivity

How much does ICPF's sensitivity to mean and variance of Treasury excess returns change as a function of ψ_I?



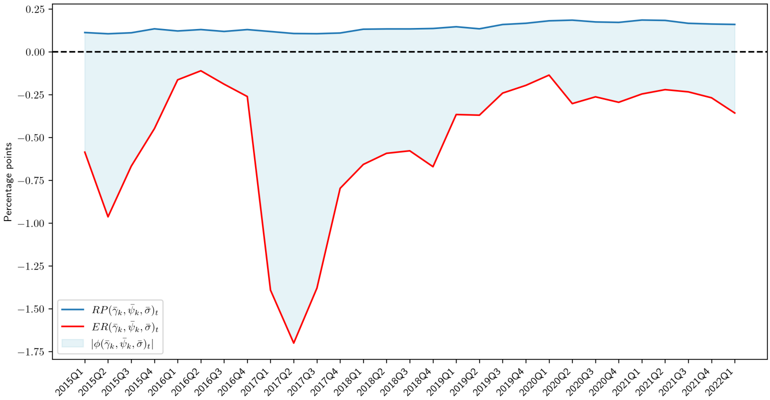
Experiment: cross-sector difference in sensitivity

How much of the difference in cross-sector yield sensitivity can be explained by Treasury preferences?



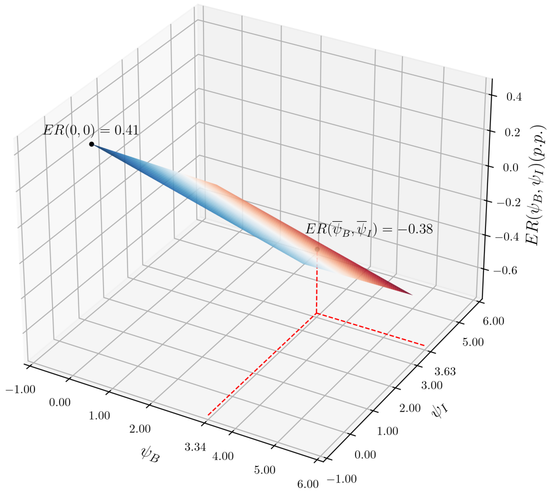
Experiment: excess return decomposition

How much do the convenience yield ϕ and risk premium RP components contribute to excess returns over time?



Experiment: Treasury preferences and excess returns

How sensitive are excess returns to Treasury preference parameters ψ_k?



Closing remarks

- Results
  - Treasury preferences...
    - reduce sensitivity to mean and variance of excess returns and equilibrium excess returns
    - explain virtually all the difference in cross-sector demand sensitivity
  - Excess returns very sensitive to Treasury preferences $\implies$ Fragile funding advantage of US government
- Next steps
  - Global data with multiple sectors (Arslanalp and Tsuda, 2012; Fang et al., 2023)
  - Exchange rate risk hedging
  - Sensitivity to curvature parameter σ

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Convenience yield preferences derivation

Utility function over wealth and US Treasury holdings

$$U(W_k, b_{US,k}) = -e^{-\gamma_k\left(W_k + \psi_k \frac{b_{US,k}^{1-\sigma}-1}{1-\sigma}\right)}$$

Desirable properties:

$$U'(b_{US,k}) = \gamma_k \psi_k b_{US,k}^{-\sigma} e^{-\gamma_k\left(W_k + \psi_k \frac{b_{US,k}^{1-\sigma}-1}{1-\sigma}\right)} > 0$$

$$U''(b_{US,k}) = -\gamma_k \psi_k b_{US,k}^{-2\sigma} \left(\gamma_k \psi_k + \sigma b_{US,k}^{\sigma-1}\right) e^{-\gamma_k\left(W_k + \psi_k \frac{b_{US,k}^{1-\sigma}-1}{1-\sigma}\right)} < 0.$$

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Convenience yield preferences derivation

Assuming $W_k \sim \left(\mu_W, \sigma_W^2\right)$, write expected utility as

$$\mathbb{E}\left[U(W_k, b_{US,k})\right] = \int_{-\infty}^{\infty} -e^{-\gamma_k\left(W_k + \psi_k \frac{b_{US,k}^{1-\sigma}-1}{1-\sigma}\right)} \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{W_k-\mu_W}{2\sigma_{W_k}^2}} dW_k$$

Collecting terms that depend on W_k

$$\mathbb{E}\left[U(W_k, b_{US,k})\right] =$$

$$e^{-\gamma_k\left(\mu_W - \frac{\gamma_k}{2}\sigma_{W_k}^2 + \psi_k \frac{b_{US,k}^{1-\sigma}-1}{1-\sigma}\right)} \underbrace{\int_{-\infty}^{\infty} \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{\left(W_k-\mu_W+\gamma_k\sigma_{W_k}^2\right)^2}{2\sigma_{W_k}^2}} dW_k}_{=1}$$

So

$$\max_{b_{US}} \mathbb{E}\left[U(W_k, b_{US,k})\right] = \max_{b_{US,k}} \mu_W - \frac{\gamma_k}{2}\sigma_{W_k}^2 + \psi_k \frac{b_{US,k}^{1-\sigma}-1}{1-\sigma}$$

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Structural parameters details

To recover structural parameters, need estimates for

- $\mathbb{V}[R_{US} - R_j]$ and $Cov[R_{US} - R_j, Y_k] \implies$ Sample counterparts
- $\frac{\partial b_{j,O}}{\partial B_j} \implies$ Estimate absorption regression
- $W_{0,k}, \bar{B}, \bar{b}^B, \bar{b}^O \implies$ Sample average

Approximation points: $\bar{e} = 0$, $\bar{c} = 0$, $\bar{v} = 1$, and $\bar{s} = 0.5$

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Structural parameters details

Estimate the fraction of EA debt absorbed by sector x, including ECB

$$b_{j,k,t} = \zeta_j + \zeta_t + \theta_k B_{j,t} + \upsilon_{j,k,t}$$

Proxy $\frac{\partial b^{j,O}}{\partial B_j}$ with $\hat{\theta}_O$

	(1)	(2)	(3)	(4)
$b_{j,B,t}$	0.19***	0.19***	0.02	0.04**
	(0.01)	(0.01)	(0.02)	(0.02)
$b_{j,I,t}$	0.22***	0.22***	0.16***	0.18***
	(0.01)	(0.01)	(0.02)	(0.01)
$b_{j,PSPP,t}$	0.19***	0.18***	0.63***	0.57***
	(0.01)	(0.01)	(0.05)	(0.04)
$b_{j,O,t}$	0.41***	0.41***	0.19***	0.20***
	(0.01)	(0.01)	(0.05)	(0.04)
Time fixed effects	No	Yes	No	Yes
Country fixed effects	No	No	Yes	Yes

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Estimation: data and specification

- Holdings of country j and US government bonds by EA banks and ICPF in quarter t
- Available from 2013 Q1 to 2022 Q1 on ECB SHSS database
- PSPP holdings of country j government debt in quarter t from 2015Q1

$$er_{j,t} = \iota_j + \iota_t - \pi PSPP_{j,t} + \lambda' \mathbf{V_{j,t}} + \kappa' \mathbf{W_{j,t}} + \nu_{j,t} \qquad \text{First stage}$$

$$s_{US,j,k,t} = \alpha_{k,j} + \alpha_{k,t} + \beta_k er_{j,t} + \delta'_k \mathbf{V_{j,t}} + \eta'_k \mathbf{W_{j,t}} + \varepsilon_{j,k,t} \qquad \text{Second stage}$$

- $\mathbb{E}[R_{US} - R_j]$ proxied by $er_{j,t}$: US - country j yield adjusted for forward premium and CDS rates, controlling for factors $\mathbf{V_{j,t}}$ and $\mathbf{W_{i,t}}$ (Koijen et al., 2021)
- $\mathbf{V_{j,t}}$: changes in country j bond prices
- $\mathbf{W_{j,t}}$: CPI inflation, real GDP growth, Debt/GDP ratio

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Summary statistics

	N	Mean	SD	Min	P25	P50	P75	Max
A. Portfolio shares								
$s_{US,B,t}$	442	71.2	26.8	14.8	50.9	80.9	95.3	99.1
$s_{US,I,t}$	425	48.96	33.19	2.59	16.71	46.82	80.59	98.83
B. Financial variables								
$er_{j,t}$	463	-0.26	0.64	-5.21	-0.49	-0.16	0.08	0.77
$\phi_{j,t}$	387	-0.25	0.24	-2.04	-0.35	-0.25	-0.15	1.65
$\Delta BI_{j,t}$	371	0.20	4.39	-10.69	-1.89	0.42	3.10	14.09
$\Delta BI_{US,t}$	371	0.5	2.4	-4.7	-0.5	0.6	1.5	7.2
$\Delta e_t^{EUR/USD}$	463	0.4	3.9	-5.6	-1.8	0.1	2.5	13.7
C. Macroeconomic variables								
$Debt/GDP_{j,t}$	372	87.1	30.0	36.3	62.3	83.3	108.4	158.9
$\Delta CPI_{i,t}$	372	1.4	1.9	-2.2	0.2	1.1	2.0	11.7
$\Delta GDP_{i,t}$	343	0.6	3.5	-17.6	0.2	0.5	0.9	21.4

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Estimation: identification strategy

- B_j valid instrument for $\mathbb{E}[R_{US} - R_j]$ in the model
- In the data, debt levels likely endogenous with portfolio choice

Exploit structure of Public Sector Purchase Programme (PSPP) by the ECB (Koijen et al., 2021). Country allocation depends on:

- ECB capital key $\implies$ function of GDP and population, revised every 5 years
- Maturity structure of outstanding debt $\implies$ function of evolution of relative market and PSPP maturities

Cross-country variation in B_j exogenous once controlling for overall PSPP size via time FE

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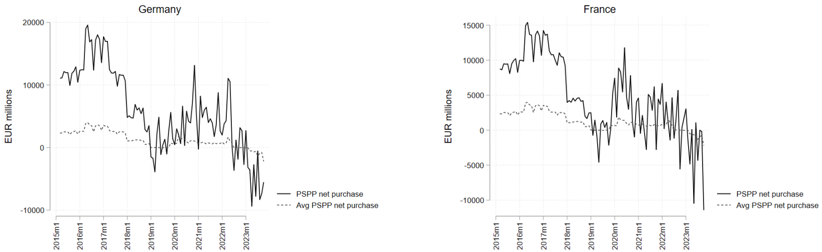
Estimation: identification strategy



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Estimation: first stage

	(1)	(2)	(3)
$PSPP_{j,t}$	0.75***	1.37***	1.47***
	(0.10)	(0.16)	(0.30)
$\Delta BI_{j,t}$	-0.01*	-0.01*	-0.01
	(0.01)	(0.01)	(0.01)
$\Delta BI_{US,t}$	0.02**		
	(0.01)		
$\Delta e_t^{EUR/USD}$	-0.00		
	(0.00)		
N	309	309	309
F stat	58.71	70.63	23.86
Macro controls	Yes	Yes	Yes
Time fixed effects	No	Yes	Yes
Country fixed effects	No	No	Yes

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Estimation: second stage banks

	OLS			2SLS		
	(1)	(2)	(3)	(4)	(5)	(6)
$er_{j,t}$	-7.44	-15.20*	4.75**	22.86	-3.43	35.94***
	(6.98)	(8.79)	(2.32)	(24.19)	(25.08)	(9.94)
$\Delta BI_{j,t}$	0.01	0.89	-0.22	0.32	1.05	0.03
	(0.82)	(1.37)	(0.17)	(0.88)	(1.33)	(0.23)
$\Delta BI_{US,t}$	0.34			-0.47		
	(1.09)			(1.28)		
$\Delta e_t^{EUR/USD}$	0.19			0.35		
	(0.74)			(0.75)		
N	309	309	309	309	309	309
Macro controls	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	No	Yes	Yes	No	Yes	Yes
Country fixed effects	No	No	Yes	No	No	Yes
Underid test p-value				0.00	0.00	0.00
Weak id test stat				58.71	70.63	23.86

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Estimation: second stage ICPF

	OLS			2SLS		
	(1)	(2)	(3)	(4)	(5)	(6)
$er_{j,t}$	-2.46	-4.99*	-0.45*	17.75***	10.03	6.24***
	(1.97)	(2.56)	(0.24)	(6.25)	(6.73)	(2.02)
$\Delta BI_{j,t}$	0.74	2.14	-0.17	1.72	3.15*	0.10
	(0.92)	(1.59)	(0.14)	(1.15)	(1.69)	(0.24)
$\Delta BI_{US,t}$	0.16			-2.56		
	(1.26)			(1.72)		
$\Delta e_t^{EUR/USD}$	0.49			0.98		
	(0.79)			(0.92)		
N	307	307	307	307	307	307
Macro controls	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	No	Yes	Yes	No	Yes	Yes
Country fixed effects	No	No	Yes	No	No	Yes
Underid test p-value				0.00	0.00	0.00
Weak id test stat				58.21	69.86	23.65

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