Exchange Rates and Asset Prices in a Global Demand System

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Determinants of exchange rates and asset prices

- Objective: Estimate a global asset demand system to understand fluctuations in exchange rates, equity markets, and fixed income markets.
  - Asset pricing = Portfolio choice + Market clearing.
  - Match cross-country holdings together with asset prices.

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Two key components of the model:

1. Asset demand curves of global investors.
   - Hold financial assets (short-term debt, long-term debt, and equity) across many countries.
   - Substitute within and across asset classes.
   - Demand depends on expected returns and macro variables.

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   - Hold financial assets (short-term debt, long-term debt, and equity) across many countries.
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   - Demand depends on expected returns and macro variables.
2. Policy.
   - Short-term rates.
   - Debt quantities through fiscal and monetary policy.
   - Foreign exchange reserves: Central banks hold foreign assets.

This paper

- Data on global financial markets for 2002–2017.
  - Exchange rates, asset prices, and macro variables across 36 countries.
  - Cross-country holdings from IMF's Coordinated Portfolio Investment Survey.

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- Applications:
  - Decompose variation in exchange rates and asset prices.
    - Accounting exercise based on the portfolio choice model and market clearing.
  - Interpret events related to the European sovereign debt crisis.
    - Contagion in peripheral countries.
    - Large gap between US and German LT yields after the crisis.
  - Estimate "convenience yield" on US assets.
    - For long-term bonds, equity, and exchange rates.

Data structure

- Annual data for 2002–2017 across 3 asset classes.
  1. Short-term debt.
  2. Long-term debt
  3. Equity.
- Investors: 88 countries and foreign exchange reserves.
  - Reserves: Central bank holdings of foreign assets.
- 36 issuer countries with complete data on asset prices and characteristics.
  - All 22 countries in the MSCI World Index.
  - 14 of 21 countries in the MSCI Emerging Markets Index.
  - Other countries aggregated as "outside asset" for each asset class.
- Define supply as
  - Debt: Total amount held by foreigners.
  - Equity: Total stock market capitalization.

Top ten investors by asset class

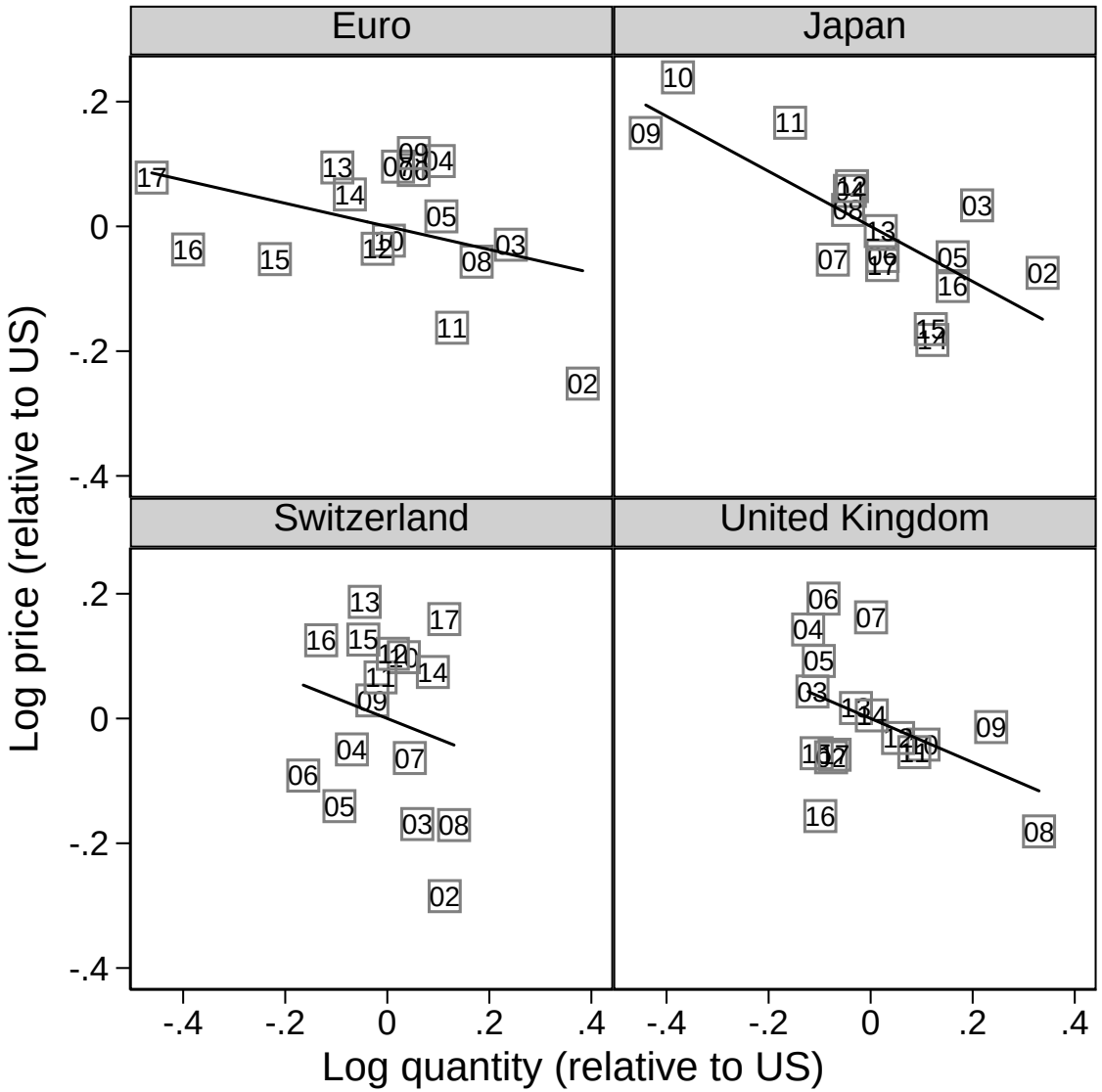
Short-term debt		Long-term debt		Equity	
Investor	Billion US$	Investor	Billion US$	Investor	Billion US$
Reserves	912	Reserves	4,381	United States	32,799
Ireland	527	Japan	2,176	China	8,194
United States	488	United States	2,165	Japan	5,343
Luxembourg	361	Germany	2,002	Hong Kong	4,198
France	215	Luxembourg	1,995	United Kingdom	2,867
Cayman Islands	188	France	1,489	Canada	2,846
United Kingdom	126	Ireland	1,317	France	1,971
Hong Kong	111	United Kingdom	1,038	Luxembourg	1,952
Singapore	84	Netherlands	909	India	1,828
Switzerland	55	Cayman Islands	834	Australia	1,629

- Offshore financial centers: Ireland, Luxembourg, and Cayman Islands.

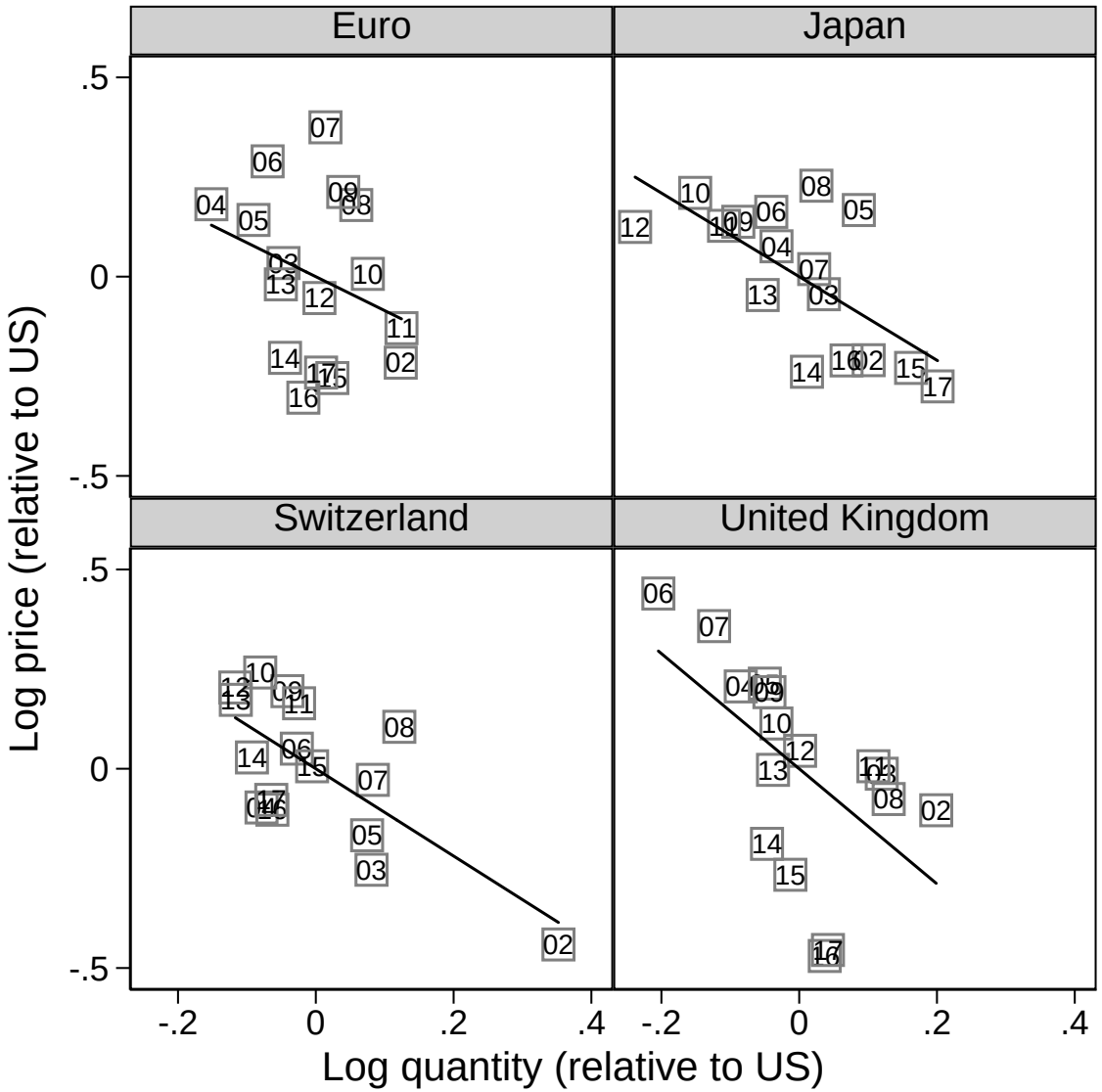
Relative quantities and prices

- Relative log quantity: $q_t(n) - q_t(\text{US})$.
- Relative log price: $p_t(n) + e_t(n) - p_t(\text{US})$.
- Scatter plots suggest inelastic demand for long-term debt and equity.

Relative long-term debt quantity and price



Relative equity quantity and price



Market clearing

- Market clearing for each country n and asset class l:

$$P_t(n,l)E_t(n)Q_t(n,l) = \sum_{i=1}^{I} A_{i,t} w_{i,t}(n,l;\mathbf{P}_t,\mathbf{E}_t)$$

- Supply.
  - $P_t(n,l)$: Market-to-book ratio (or price per unit of face value).
  - $E_t(n)$: Exchange rate in US$ per country n's currency unit.
  - $Q_t(n,l)$: Book (or face) value in country n's currency unit.
- Demand.
  - $A_{i,t}$: Investor i's wealth.
  - $w_{i,t}(n,l)$: Portfolio weight in country n and asset class l.

Demand system asset pricing

- Market clearing is a system of equations.
  1. Short-term debt: 26 countries plus euro area.
  2. Long-term debt: 36 countries.
  3. Equity: 36 countries.
- Conditional on short-term rate (central bank policy), the system determines
  1. 26 exchange rates (relative to US$).
  2. 36 long-term yields.
  3. 36 stock prices.
- A model of portfolio weights that
  - Matches cross-country holdings.
  - Easy to estimate demand elasticities.
  - Flexible substitution within and across asset classes.

Portfolio choice

- Mean-variance portfolio: $\mathbf{w}_i = \Sigma_i^{-1}\mu_i$
  - Heterogeneous beliefs about returns.
- Assumptions:
  1. Covariance matrix has factor structure.
  2. Expected returns and factor loadings depend on characteristics.
- Koijen and Yogo (2019) derive a logit model.

$$\log\left(\frac{w_i(n)}{w_i(0)}\right) = \beta p_i(n) + \gamma' \mathbf{x}_i(n) + \epsilon_i(n)$$

- Nested logit to allow for imperfect substitution across asset classes.

$$w_{i,t}(n,l) = \underbrace{w_{i,t}(n|l)}_{\text{within}}\underbrace{w_{i,t}(l)}_{\text{across}}$$

Two extensions

1. Nested logit to allow for imperfect substitution across asset classes.

$$w_{i,t}(n,l) = \underbrace{w_{i,t}(n|l)}_{\text{within}} \underbrace{w_{i,t}(l)}_{\text{across}}$$

2. Portfolio weights depend on expected returns in own currency unit.
   - Estimate a predictive regression for each asset class:

$$r_{t+1}(n,l) - y_t(\text{US}) = \theta_l p_t(n,l) + \Theta_l(e_t(n) - z_t(n)) + \nu_{t+1}(n,l)$$

   - Expected returns in investor i's currency unit:

$$\begin{aligned}\mathbb{E}_t[r_{t+1}(n,l) - \Delta e_{t+1}(i) - y_t(i)] &= \mathbb{E}_t[r_{t+1}(n,l) - r_{t+1}(i,1)] \\ &= \mu_{i,t}(n,l)\end{aligned}$$

Allocation within asset class

- Portfolio weight in country n within asset class l.

$$w_{i,t}(n|l) = \frac{\delta_{i,t}(n,l)}{1 + \sum_{m=0}^{N} \delta_{i,t}(m,l)}$$

where

$$\log(\delta_{i,t}(n,l)) = \beta_l \mu_{i,t}(n,l) + \gamma_l' \mathbf{x}_{i,t}(n,l) + \epsilon_{i,t}(n,l)$$

- $\mathbf{x}_{i,t}(n,l)$: Observed characteristics.
- $\epsilon_{i,t}(n,l)$: Latent demand.

Allocation across asset classes

- Portfolio weight in asset class l.

$$w_{i,t}(l) = \frac{\left(1 + \sum_{m=0}^{N} \delta_{i,t}(m,l)\right)^{\lambda_l} \exp\{\alpha_l + \xi_{i,t}(l)\}}{\sum_{k=1}^{3} \left(1 + \sum_{m=0}^{N} \delta_{i,t}(m,k)\right)^{\lambda_k} \exp\{\alpha_k + \xi_{i,t}(k)\}}$$

- $\xi_{i,t}(l)$: Asset-class latent demand.
- Special cases:
  - $\lambda = \mathbf{1}$: Logit (Koijen and Yogo 2019).
  - $\lambda = \mathbf{0}$: No substitution across asset classes.

Estimation methodology

- Observed characteristics.
  - Macro: Log GDP, log GDP per capita, inflation, equity volatility, and sovereign debt rating.
  - Bilateral: Export/import shares and distance.
  - Dummies: Own country ("home bias"), year, and US issuance interacted with year ("specialness").
- Identification.
  - Asset characteristics and quantities are exogenous (in the spirit of endowment economies).
  - Demand depends directly on own characteristics and indirectly on characteristics of other assets through price.
  - IV: Nonlinear function of all asset characteristics through market clearing.

Estimated demand within asset class

Variable	Short-term debt	Long-term debt	Equity
Expected return	31.53	9.31	4.29
	(5.55)	(0.61)	(0.46)
Log GDP	0.96	0.87	0.80
	(0.04)	(0.01)	(0.01)
Log GDP per capita	1.79	1.42	0.44
	(0.15)	(0.04)	(0.03)
Inflation	-0.51	-0.22	-0.02
	(0.09)	(0.02)	(0.01)
Volatility	-3.78	-1.83	-4.83
	(0.47)	(0.23)	(0.27)
Rating	0.11	0.23	0.08
	(0.02)	(0.02)	(0.01)
Export share	0.35	0.29	0.32
	(0.04)	(0.02)	(0.02)
Import share	-0.03	0.09	0.09
	(0.04)	(0.02)	(0.02)
Distance	-0.20	-0.17	-0.11
	(0.02)	(0.00)	(0.00)
Dummy: Own country			7.21
			(0.13)
Observations	17,293	31,252	30,202
R^2	0.25	0.44	0.66

Estimated demand across asset classes

Variable	Symbol	Estimate
Log outside asset weight:		
Short-term debt	λ_1	0.23
		(0.06)
Long-term debt	λ_2	0.24
		(0.08)
Equity	λ_3	0.50
		(0.03)
Dummy:		
Short-term debt	α_1	-2.21
		(0.25)
Long-term debt	α_2	0.52
		(0.27)
Observations		2,339

Decomposition of exchange rates and asset prices

- Market clearing defines an implicit function for exchange rates and asset prices.

$$\begin{bmatrix} \mathbf{e}_t \\ \mathbf{p}_t(2) \\ \mathbf{p}_t(3) \end{bmatrix} = \mathbf{g}(\mathbf{x}_t, \mathbf{z}_t, \mathbf{O}_t, \mathbf{p}_t(1), \mathbf{Q}_t, \epsilon_t, \xi_t).$$

- Decompose annual changes into:
  1. Macro variables: $\mathbf{x}_t$, $\mathbf{z}_t$, $\mathbf{O}_t$, and $\mathbf{Q}_t(3)$.
  2. Short-term rates: $\mathbf{p}_t(1)$ and $\mathbf{Q}_t(1)$.
  3. Long-term debt quantities: $\mathbf{Q}_t(2)$.
  4. Foreign exchange reserves: Sub-matrix of ϵ_t and ξ_t for foreign exchange reserves only.
  5. Latent demand: Sub-matrix of ϵ_t and ξ_t for investor countries.

Variance decomposition of exchange rates and asset prices

Variable	Exchange rate	Long-term debt	Equity
Macro variables	0.26	0.16	0.57
	(0.07)	(0.09)	(0.08)
Short-term rates	0.08	0.09	0.06
	(0.05)	(0.03)	(0.07)
Debt quantities	0.02	0.20	0.03
	(0.01)	(0.02)	(0.00)
Reserves	0.19	0.11	0.03
	(0.04)	(0.03)	(0.01)
Latent demand	0.45	0.43	0.31
	(0.04)	(0.06)	(0.06)
North America	0.08	0.05	0.06
	(0.02)	(0.01)	(0.04)
Europe	0.08	0.28	0.13
	(0.02)	(0.03)	(0.03)
Pacific	0.03	0.04	0.11
	(0.01)	(0.01)	(0.04)
Offshore financial centers	0.25	0.05	-0.01
	(0.02)	(0.02)	(0.01)
Emerging markets	0.01	0.01	0.03
	(0.00)	(0.00)	(0.03)
Other countries	0.01	0.00	0.00
	(0.00)	(0.00)	(0.01)
Observations	375	540	540

Variance decomposition of exchange rates

- Fundamentals account for 55% of variation in exchange rates.
  - Macro variables: 26%.
  - Short-term rates: 8%.
  - Debt quantities: 2%.
  - Reserves: 19%.
- Latent demand accounts for 45%.

	Within asset class			Across
Investor	Short-term debt	Long-term debt	Equity	asset classes
Total	0.28	0.03	-0.03	0.17
North America	0.01	0.00	-0.01	0.08
Europe	-0.02	0.03	-0.01	0.08
Pacific	0.01	0.01	0.00	0.01
Offshore financial centers	0.26	-0.02	0.00	0.00
Emerging markets	0.01	0.01	-0.01	0.00
Other countries	0.01	0.00	0.00	0.00

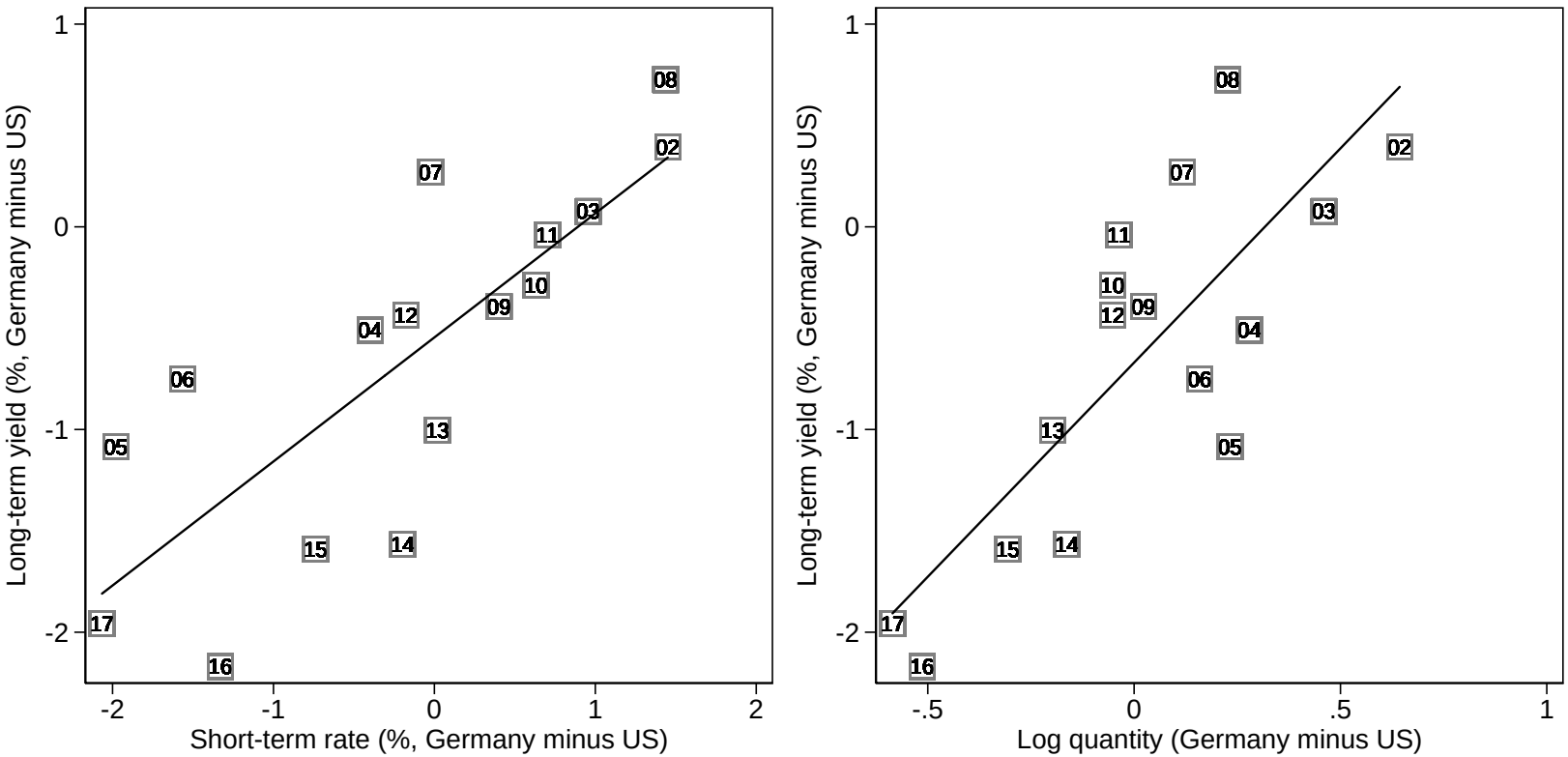
European sovereign debt crisis

- What explains the long-term yield spread between
  - Germany and the US?
  - Southern euro and Germany?
- Decompose annual changes into
  1. Macro variables (including equity quantities).
  2. Short-term rates.
  3. Debt quantities.
  4. Reserves.
  5. Latent demand.

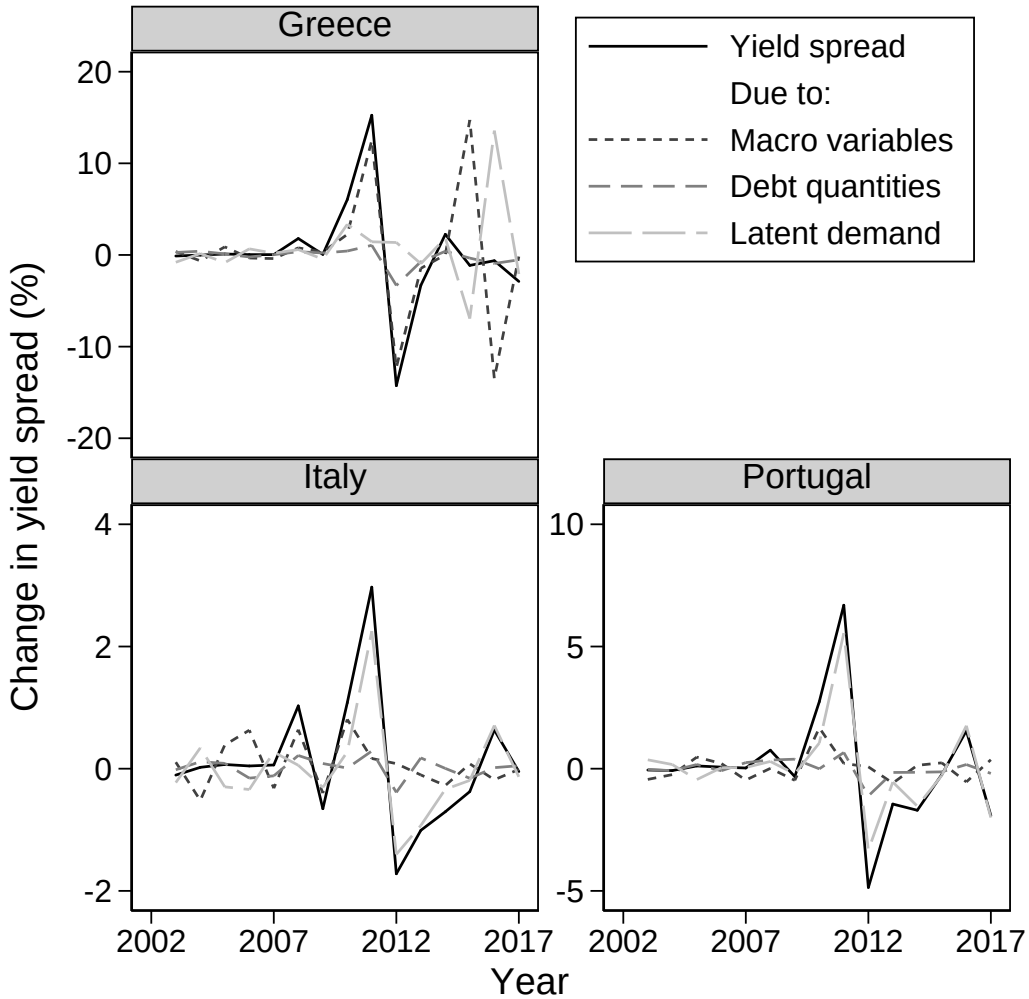
Variance decomposition of long-term yield spreads

Variable	Germany — US	Southern euro — Germany
Macro variables	-0.02	0.64
	(0.24)	(0.13)
Short-term rates	0.53	0.00
	(0.16)	(0.00)
Debt quantities	0.15	0.14
	(0.06)	(0.04)
Reserves	0.20	0.04
	(0.20)	(0.03)
Latent demand	0.14	0.19
	(0.12)	(0.12)
North America	-0.02	0.01
	(0.03)	(0.01)
Europe	0.04	0.13
	(0.07)	(0.08)
Pacific	0.02	0.01
	(0.05)	(0.00)
Offshore financial centers	0.07	0.04
	(0.10)	(0.02)
Emerging markets	0.00	0.00
	(0.01)	(0.00)
Other countries	0.01	-0.01
	(0.01)	(0.01)
Observations	15	45

Long-term yield spread between Germany and the US



Change in the long-term yield spread between southern euro countries and Germany



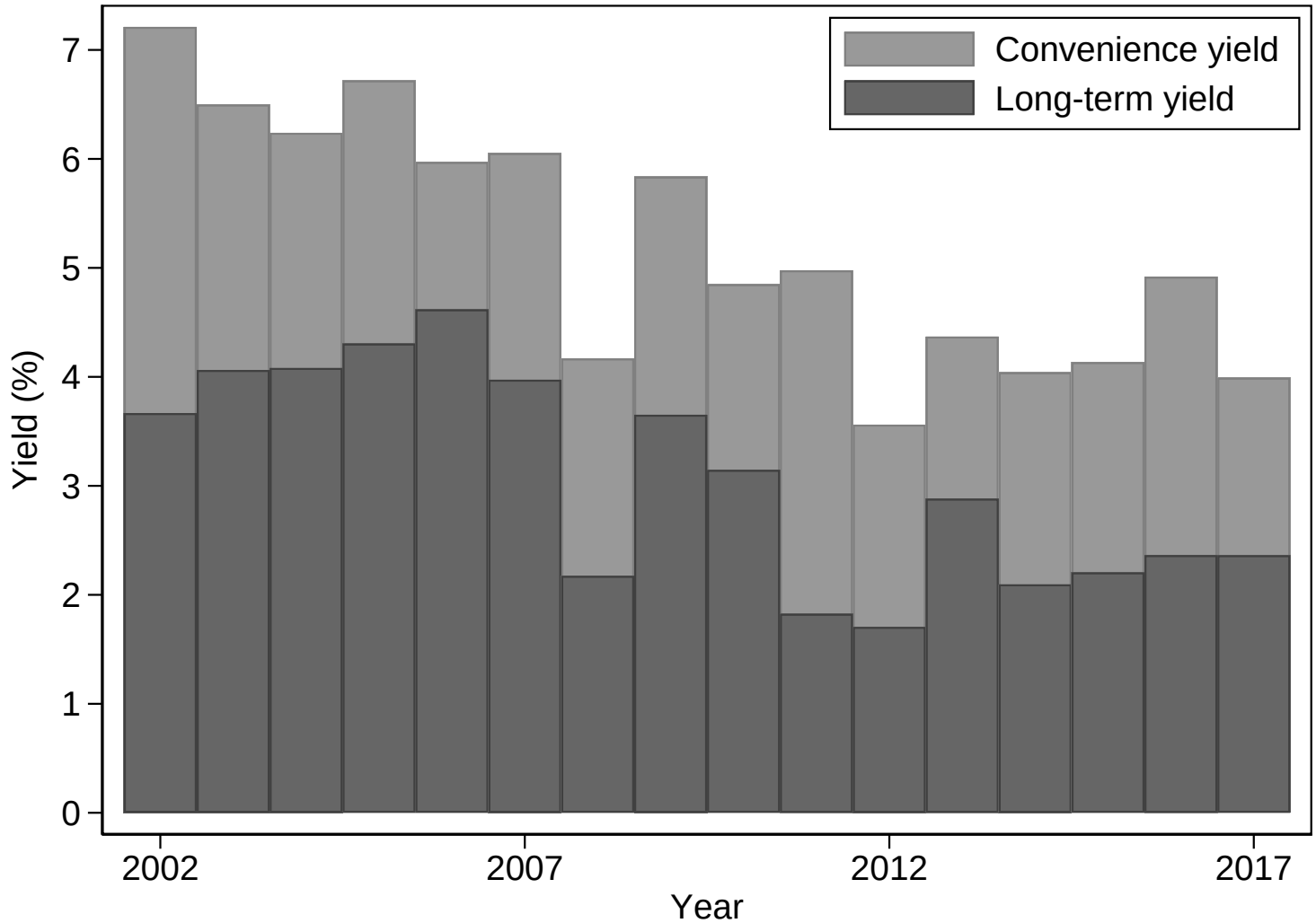
Convenience yield on US assets

- Special status of the US dollar as reserve currency.
- In the demand system, fixed effects for US issuance interacted with year.
- Estimate the convenience yield on the US dollar, long-term debt, and equity.

Average convenience yield on US assets

Investor	Exchange rate	Long-term debt	Equity
Total	1.28	2.15	1.70
	(0.40)	(0.14)	(0.15)
Reserves	0.06	0.48	-0.07
	(0.14)	(0.02)	(0.01)
North America	0.04	0.02	0.21
	(0.00)	(0.00)	(0.02)
Europe	0.35	0.51	0.69
	(0.06)	(0.03)	(0.04)
Pacific	0.41	0.52	0.37
	(0.06)	(0.05)	(0.03)
Offshore financial centers	0.33	0.53	0.38
	(0.15)	(0.05)	(0.05)
Emerging markets	0.07	0.05	0.09
	(0.01)	(0.01)	(0.02)
Other countries	0.03	0.04	0.03
	(0.01)	(0.00)	(0.00)

US long-term yield and its convenience yield



Summary

- Significant substitution effects across asset classes.
  - Must study exchange rates, long-term yields, and stock prices jointly.
- Policy important for exchange rates and asset prices.

Share of variance	Exchange rate	Long-term debt	Equity
Short-term rates	0.08	0.09	0.06
Debt quantities	0.02	0.20	0.03
Reserves	0.19	0.11	0.03

Future work

- Implications for international macro models.
  - Asset demand shocks unrelated to fundamentals: Blanchard, Giavazzi, and Sa (2005), Gabaix and Maggiori (2015), Itskhoki and Mukhin (2017).
  - Latent demand can be estimated from cross-country holdings.
  - Variance decompositions could be used as calibration targets.
- Next steps.
  - Develop a framework for monetary policy evaluation (both conventional and unconventional) in real time.
  - Add dynamics and endogenize the macro variables.
  - Use global demand system to explore questions related to fiscal capacity.

Estimating equations

- Substitution within asset class.

$$\log\left(\frac{w_{i,t}(n|l)}{w_{i,t}(0|l)}\right) = \beta_l \mu_{i,t}(n,l) + \gamma_l' \mathbf{x}_{i,t}(n,l) + \epsilon_{i,t}(n,l)$$

- Substitution across asset classes.

$$\log\left(\frac{w_{i,t}(l)}{w_{i,t}(3)}\right) = -\lambda_l \log(w_{i,t}(0|l)) + \lambda_3 \log(w_{i,t}(0|3)) + \alpha_l + \xi_{i,t}(l)$$

Regressions of changes in exchange rates and asset prices

Variable	Exchange rate	Long-term debt	Equity
Log GDP	0.73	-0.01	-0.11
	(0.05)	(0.03)	(0.04)
Log GDP per capita	-0.21	-0.08	0.02
	(0.07)	(0.06)	(0.06)
Inflation	0.02	0.17	0.14
	(0.05)	(0.06)	(0.07)
Volatility	-0.16	-0.05	-0.65
	(0.05)	(0.05)	(0.05)
Rating	0.03	-0.22	0.02
	(0.05)	(0.08)	(0.03)
Export share	0.28	0.15	0.03
	(0.13)	(0.11)	(0.12)
Import share	-0.38	-0.18	-0.23
	(0.14)	(0.12)	(0.12)
Relative CPI	0.07	0.05	0.13
	(0.06)	(0.05)	(0.05)
Asset quantity	-0.21	0.53	0.03
	(0.05)	(0.06)	(0.05)
Observations	509	539	539
R^2	0.44	0.46	0.55