

# Exchange Rates and Asset Prices in a Global Demand System

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## References

- ▶ Demand system asset pricing
  - ▶ “A Demand System Approach to Asset Pricing” (with Ralph S.J. Koijen), *Journal of Political Economy*, 2019.
  - ▶ “Inspecting the Mechanism of Quantitative Easing in the Euro Area” (with Ralph S.J. Koijen, François Koulischer, and Benoît Nguyen), 2016.
  - ▶ “Exchange Rates and Asset Prices in a Global Demand System” (with Ralph S. J. Koijen), 2019.

## Data on portfolio holdings

1. SEC Form 13F: Quarterly U.S. stock holdings of institutions managing over \$100m since 1980.
2. Thomson Reuters Ownership and FactSet Ownership: International stock holdings.
3. Thomson Reuters eMAXX: Quarterly bond holdings of institutions (mutual funds and insurance companies) since 2002.
  - ▶ Insurance companies: Schedule D since 1991.
  - ▶ Fed: System Open Market Accounts since 2003.
4. Securities Holdings Statistics: Comprehensive holdings for the euro area since 2014.
5. Household-level data from Statistics Sweden for 1983–2007 (Calvet et al. 2007).
6. Brokerage data for 1991–1996 (Barber and Odean 2000).

## Determinants of exchange rates and asset prices

- ▶ Global investors.
  - ▶ Hold financial assets (short-term debt, long-term debt, and equity) across many countries.
  - ▶ Substitution within and across asset classes.
  - ▶ Demand depends on exchange rates and macro shocks.
- ▶ Policy.
  - ▶ Short-term rates.
  - ▶ Debt quantities through fiscal and monetary policy.
  - ▶ Foreign exchange reserves: Central bank holdings of foreign assets.

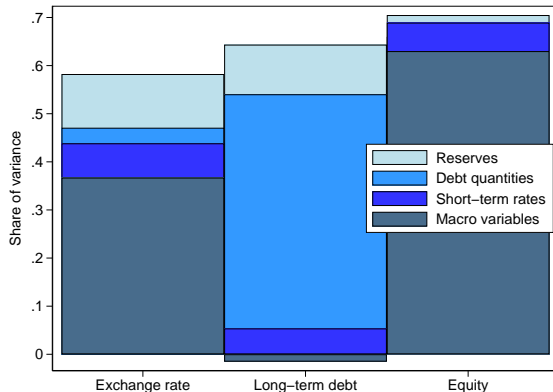
## What we do

- ▶ 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.
- ▶ Asset pricing = Portfolio choice + Market clearing
  - ▶ Match cross-country holdings together with asset prices.
- ▶ A demand system approach to
  - ▶ Decompose variation in exchange rates and asset prices.
  - ▶ Understand events such as global monetary easing and the European debt crisis.

## Summary of findings

### 1. Fundamentals account for

- ▶ 58% of variation in exchange rates.
- ▶ 64% of variation in long-term yields.
- ▶ 70% of variation in book-to-market equity.



## Summary of findings

2. Inelastic demand. Elasticity of
  - ▶ 26 for short-term debt.
  - ▶ 1.9 for long-term debt.
  - ▶ 1.5 for equity.
3. Case study of global monetary easing.
  - ▶ Exchange rate depreciates by 2.6% per 1% decrease in the short-term rate.
  - ▶ A change in debt quantities that decreases the long-term yield by 10bp depreciates the exchange rate by 0.8%.
4. Case study of the European debt crisis. Long-term yield spread between
  - ▶ Germany and the US: Short-term rates (32%) and debt quantities (54%).
  - ▶ Southern euro and Germany: Macro variables (43%) and debt quantities (28%).

## 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

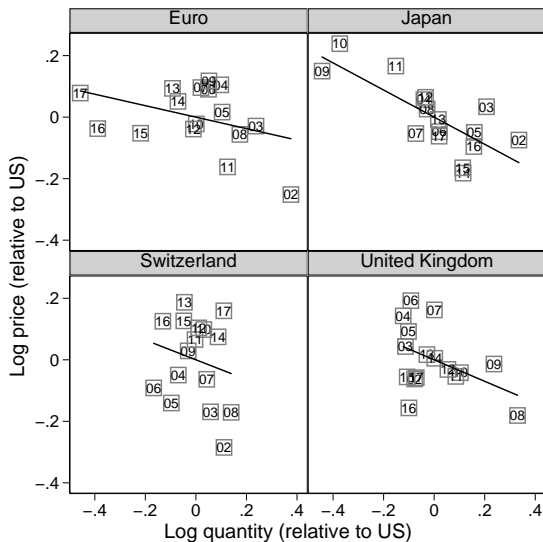
Short-term debt		Long-term debt		Equity	
Investor	Billion US\$	Investor	Billion US\$	Investor	Billion US\$
Reserves	917	Reserves	4,398	United States	32,799
Ireland	527	Japan	2,176	China	8,192
United States	488	United States	2,165	Japan	5,343
Luxembourg	361	Germany	2,002	Hong Kong	4,198
France	215	Luxembourg	1,995	United Kingdom	2,867
Cayman Islands	188	France	1,489	Canada	2,846
United Kingdom	126	Ireland	1,317	France	1,965
Hong Kong	111	United Kingdom	1,038	Luxembourg	1,952
Singapore	84	Netherlands	909	India	1,826
Switzerland	55	Cayman Islands	834	Australia	1,641

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

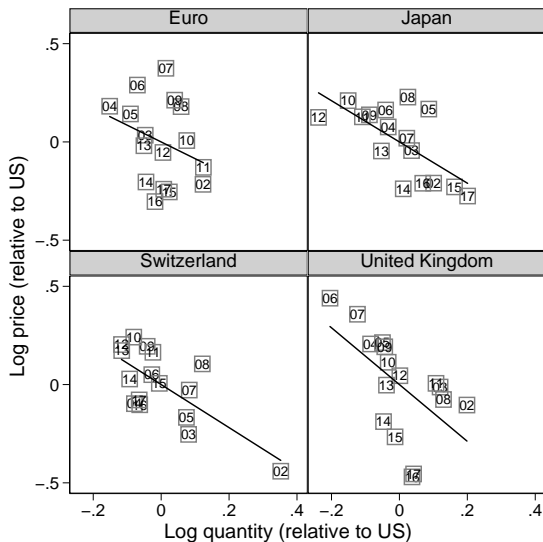
# Facts

1. Inelastic demand for long-term debt.
  - ▶ Relative log quantity:  $q_t(n) - q_t(\text{US})$ .
  - ▶ Relative log price:  $p_t(n) + e_t(n) - p_t(\text{US})$ .
2. Inelastic demand for equity.
3. Predictability of exchange rates and asset returns.

## Fact 1: Relative long-term debt quantity and price



## Fact 2: Relative equity quantity and price



## Fact 3: Predictability of asset returns

Variable	Exchange rate		Short-term debt	Long-term debt	Equity
Interest rate differential	-0.03 (0.79)				
Log real exchange rate		-0.36 (0.08)	-0.31 (0.08)	-0.37 (0.11)	-0.88 (0.30)
Log market-to-book			-7.78 (3.49)	-0.45 (0.13)	-0.29 (0.22)
Observations	375	375	375	540	540

## 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 equity 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.

$$\Sigma_i = \Omega_i \Omega_i' + \text{diag}(\omega_i)$$

2. Expected returns and factor loadings depend on characteristics.

$$\mu_i(n) = \mathbf{y}_i(n)' \Phi_i + \phi_i$$

$$\Omega_i(n) = \mathbf{y}_i(n)' \Psi_i + \psi_i$$

- ▶ Kojien and Yogo (2019) derive a logit model.

$$\frac{w_i(n)}{w_i(0)} = \exp \{ \mathbf{y}_i(n)' \Pi_i \}$$



## Nested logit

- ▶ CAPM is a special case under homogenous beliefs.

$$\mu(n) = \sigma^2 \Omega(n)$$

- ▶ Logit does not allow for imperfect substitution across asset classes.
- ▶ Extend to nested logit.

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

## 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

$$\delta_{i,t}(n, l) = \exp\{\beta_l(p_t(n, l) + \theta_l(e_t(n) - z_t(n))) + \gamma_l' \mathbf{x}_{i,t}(n, l) + \epsilon_{i,t}(n, l)\}$$

- ▶  $p_t(n, l)$ : Log market-to-book.
- ▶  $e_t(n) - z_t(n)$ : Log real exchange rate.
- ▶  $\mathbf{x}_{i,t}(n, l)$ : 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 (Kojien and Yogo 2019).
  - ▶  $\lambda = \mathbf{0}$ : No substitution across asset classes.

## Estimation methodology

- ▶ Price: Single index of log market-to-book and log real exchange rate.
- ▶ 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”), MSCI classification, and year.
- ▶ **Identification**: Short-term rate is exogenous to latent demand conditional on observed characteristics.
  - ▶ Monetary policy shock as an instrument.
- ▶ IV estimation of demand within and across asset classes.

## Estimated demand within asset class

Variable	Short-term debt	Long-term debt	Equity
Log price	-70.43 (8.60)	-1.24 (0.20)	-0.71 (0.39)
Log GDP	0.88 (0.02)	0.80 (0.01)	0.85 (0.01)
Log GDP per capita	0.89 (0.08)	0.77 (0.05)	0.48 (0.04)
Inflation	-0.06 (0.02)	-0.03 (0.01)	0.04 (0.01)
Volatility	-1.84 (0.37)	-0.51 (0.20)	-3.68 (0.50)
Rating	0.03 (0.02)	0.06 (0.01)	0.03 (0.01)
Export share	0.25 (0.03)	0.28 (0.02)	0.30 (0.03)
Import share	0.10 (0.03)	0.13 (0.02)	0.10 (0.03)
Distance	-0.14 (0.01)	-0.13 (0.00)	-0.12 (0.00)
Dummy: Own country			7.12 (0.14)
Observations	17,293	31,252	30,202
$R^2$	0.43	0.49	0.67

## Estimated demand across asset classes

Variable	Symbol	Estimate
Log outside asset weight:		
Short-term debt	$\lambda_1$	0.24 (0.06)
Long-term debt	$\lambda_2$	0.18 (0.08)
Equity	$\lambda_3$	0.45 (0.04)
Dummy:		
Short-term debt	$\alpha_1$	-2.46 (0.25)
Long-term debt	$\alpha_2$	0.44 (0.25)
Observations		2,339

## Decomposition of exchange rates and asset prices

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

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

- ▶ 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 exchange rates and asset prices

Share of variance	Exchange rate	Long-term debt	Equity
Macro variables	0.37 (0.06)	-0.02 (0.09)	0.63 (0.12)
Short-term rates	0.07 (0.04)	0.07 (0.02)	0.06 (0.03)
Debt quantities	0.03 (0.05)	0.49 (0.05)	-0.03 (0.04)
Reserves	0.11 (0.04)	0.10 (0.03)	0.05 (0.02)
Latent demand	0.42 (0.07)	0.36 (0.05)	0.30 (0.12)
North America	0.05 (0.03)	0.04 (0.01)	-0.01 (0.07)
Europe	0.12 (0.04)	0.23 (0.04)	0.13 (0.04)
Pacific	0.03 (0.01)	0.05 (0.01)	0.12 (0.03)
Offshore financial centers	0.21 (0.06)	0.03 (0.02)	-0.02 (0.02)
Emerging markets	0.01 (0.01)	0.01 (0.00)	0.08 (0.04)
Other countries	0.01 (0.00)	0.00 (0.00)	-0.01 (0.01)
Observations	375	540	540



## Variance decomposition of exchange rates

- ▶ Fundamentals account for 58% of variation in exchange rates.
  - ▶ Macro variables: 37%.
  - ▶ Short-term rates: 7%.
  - ▶ Debt quantities: 3%.
  - ▶ Reserves: 11%.
- ▶ Latent demand accounts for 42%.
  - ▶ Offshore financial centers substituting within short-term debt: 25%.
  - ▶ North American investors substituting across asset classes: 8%.
  - ▶ European investors substituting across asset classes: 14%.

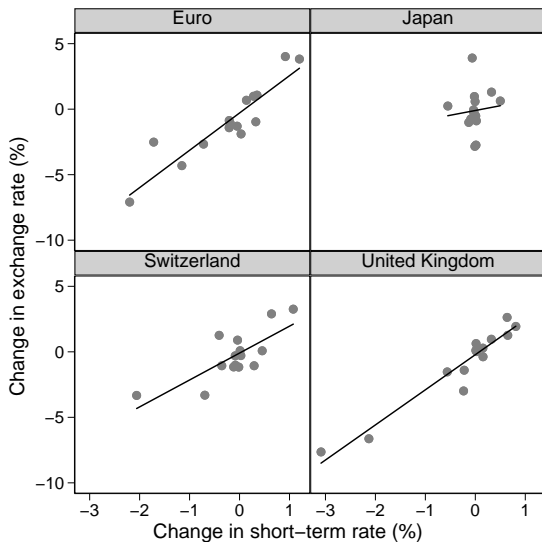
## Intuition

- ▶ In a reduced-form regression, use UK inflation to explain the pound-dollar exchange rate,
- ▶ However, demand system says that inflation of all 36 countries could matter for the pound-dollar exchange rate.
- ▶ Cannot run a regression with 36 regressors!
- ▶ Demand system
  - ▶ Uses only 2 elasticities and parametric restrictions.
  - ▶ Puts importance weights on 36 inflation rates.

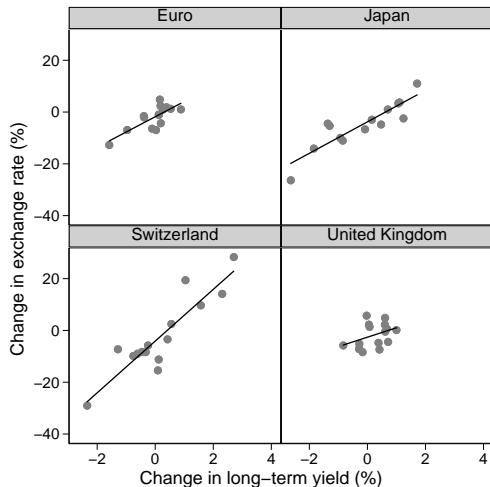
## Case study 1: Global monetary easing

- ▶ Monetary policy could affect exchange rates.
  1. Decreasing the short-term rate depreciates the exchange rate.
  2. Decreasing the debt quantity lowers the long-term yield and depreciates the exchange rate.
- ▶ Simple correlations between changes in short-term rates and exchange rates are confounded by other shocks.
- ▶ Use the demand system to isolate the impact of monetary policy.

## How exchange rates relate to short-term rates



# How long-term yields and exchange rates relate to debt quantities



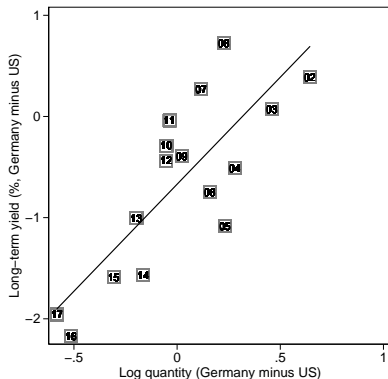
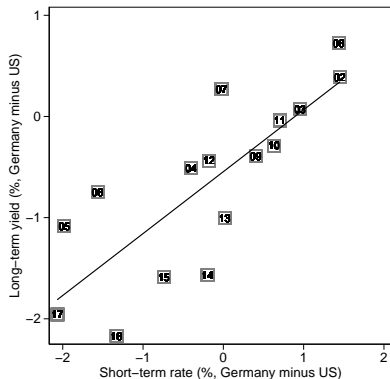
## Case study 2: European debt crisis

- ▶ 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

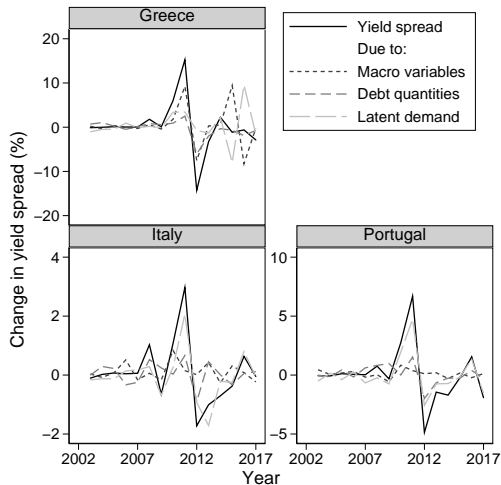
Share of variance	Germany – US	Southern euro – Germany
Macro variables	-0.14 (0.18)	0.43 (0.09)
Short-term rates	0.32 (0.11)	0.00 (0.00)
Debt quantities	0.54 (0.17)	0.28 (0.06)
Reserves	0.13 (0.33)	0.02 (0.01)
Latent demand	0.14 (0.14)	0.28 (0.09)
North America	-0.05 (0.06)	0.01 (0.00)
Europe	0.14 (0.14)	0.20 (0.07)
Pacific	0.05 (0.04)	0.00 (0.00)
Offshore financial centers	-0.01 (0.11)	0.06 (0.02)
Emerging markets	-0.02 (0.02)	0.00 (0.00)
Other countries	0.02 (0.02)	0.00 (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



## Summary

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

	Exchange rate	Long-term debt	Equity
Share of variance			
Short-term rates	0.07	0.07	0.06
Debt quantities		0.49	
Reserves	0.11	0.10	0.05

## Future work

- ▶ 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.
  - ▶ Understand the factor structure in returns across countries and asset classes.
  - ▶ Develop a framework for monetary policy evaluation (both conventional and unconventional) in real time.

## Estimation equations

- ▶ Substitution within asset class.

$$\log \left( \frac{w_{i,t}(n|l)}{w_{i,t}(0|l)} \right) = \beta_l \underbrace{(p_t(n, l) + \theta_l(e_t(n) - z_t(n)))}_{\text{log price}} + \gamma_l' \mathbf{x}_{i,t}(n, l) + \epsilon_{i,t}(n, l)$$

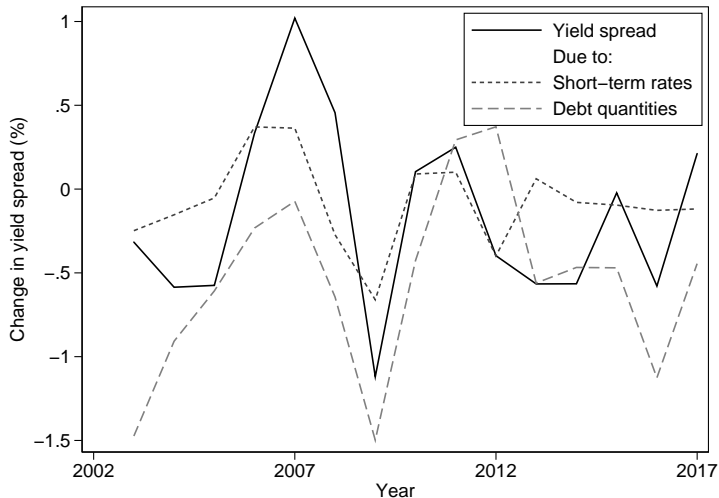
- ▶ Substitution across asset classes.

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

## Variance decomposition of exchange rates by latent demand

Share of variance	Within asset class			Across
	Short-term debt	Long-term debt	Equity	asset classes
Latent demand	0.21 (0.08)	0.01 (0.03)	-0.01 (0.03)	0.21 (0.06)
North America	-0.04 (0.06)	0.00 (0.00)	0.01 (0.01)	0.08 (0.05)
Europe	-0.03 (0.07)	0.01 (0.01)	0.00 (0.01)	0.14 (0.06)
Pacific	0.01 (0.04)	-0.01 (0.01)	0.01 (0.00)	0.01 (0.04)
Offshore financial centers	0.25 (0.09)	-0.01 (0.01)	0.00 (0.00)	-0.03 (0.05)
Emerging markets	0.02 (0.01)	0.02 (0.02)	-0.02 (0.02)	0.00 (0.00)
Other countries	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)

# Change in the long-term yield spread between Germany and the US



## List of issuer countries

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Country	Country
<i>Developed markets: North America</i>	<i>Developed markets: Pacific</i>
Canada	Australia
United States	Hong Kong
<i>Developed markets: Europe</i>	Japan
Austria	New Zealand
Belgium	Singapore
Denmark	<i>Emerging markets</i>
Finland	China
France	Colombia
Germany	Czech Republic
Israel	Greece
Italy	Hungary
Netherlands	India
Norway	Malaysia
Portugal	Mexico
Spain	Philippines
Sweden	Poland
Switzerland	Russia
United Kingdom	South Africa
	South Korea
	Thailand

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## Regressions of changes in exchange rates and asset prices

Variable	Exchange rate	Long-term debt	Equity
Log GDP	0.54 (0.07)	-0.02 (0.05)	-0.11 (0.05)
Log GDP per capita	-0.22 (0.08)	0.01 (0.06)	0.00 (0.00)
Inflation	-0.02 (0.06)	-0.30 (0.09)	0.13 (0.07)
Volatility	-0.35 (0.08)	0.13 (0.05)	-0.67 (0.05)
Rating	-0.02 (0.03)	0.33 (0.10)	0.02 (0.03)
Export share	0.08 (0.12)	-0.05 (0.12)	0.04 (0.10)
Import share	-0.10 (0.13)	0.21 (0.14)	-0.24 (0.12)
Observations	509	539	539
$R^2$	0.35	0.24	0.53