

Exchange Rates and Asset Prices in a Global Demand System

Ralph S.J. Koijen^a Motohiro Yogo^b

^aUniversity of Chicago, Booth School of Business, CEPR, and NBER

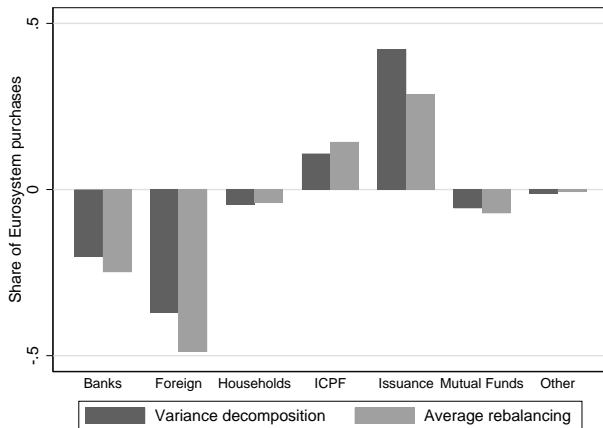
^bPrinceton University and NBER

Research agenda: Demand system asset pricing

- ▶ Important policy questions regarding financial markets and the real economy involve shifts in asset quantities.
 - ▶ E.g., asset purchase programs, growth of ESG mandates, global savings gluts across countries and the wealth distribution.
- ▶ To quantify the impact of demand shocks, we need a model of how investors substitute across asset classes and countries.
- ▶ **Demand system asset pricing:** Asset pricing models that explain prices, fundamentals, and *portfolio holdings* jointly.

The role of global investors: Evidence from the PSPP

- ▶ Who accommodates asset purchases by the Eurosystem from 2015.Q2-2017.Q4?



Source: Kojien, Koulischer, Nguyen, and Yogo (2020, *JFE*, forthcoming)

Why do asset prices and exchange rates move?

- ▶ Asset pricing = Portfolio choice + Market clearing.
 - ▶ Match cross-country holdings together with asset prices.

Why do asset prices and exchange rates move?

- ▶ Asset pricing = Portfolio choice + Market clearing.
 - ▶ Match cross-country holdings together with asset prices.
- ▶ The demand of global investors.
 - ▶ Hold financial assets across asset classes and countries.
 - ▶ Demand depends macroeconomic fundamentals and their expectations (latent demand).
- ▶ The supply of debt and equity by firms.
- ▶ Policy.
 - ▶ Short-term rates.
 - ▶ Debt quantities through fiscal and monetary policy.
 - ▶ Foreign exchange reserves: Central banks hold foreign assets.

Outline

- ▶ 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.
- ▶ A demand system approach to
 - ▶ Decompose variation in exchange rates and asset prices.
 - ▶ Interpret the dynamics in European debt markets during the sovereign debt crisis and thereafter.
 - ▶ Estimate convenience yield on US assets.
- ▶ **In progress:** Use the demand system approach for real-time policy analysis.

Investors, assets, and the definition of supply

- ▶ **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

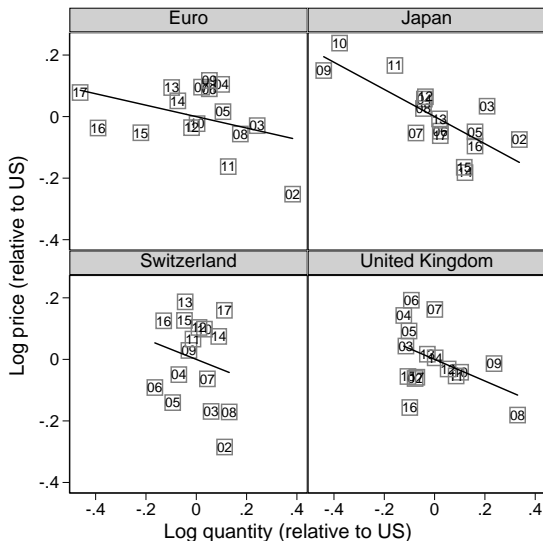
Short-term debt		Long-term debt		Equity	
Investor	Billion US\$	Investor	Billion US\$	Investor	Billion US\$
Reserves	912	Reserves	4,381	United States	32,799
Ireland	527	Japan	2,176	China	8,194
United States	488	United States	2,165	Japan	5,343
Luxembourg	361	Germany	2,002	Hong Kong	4,198
France	215	Luxembourg	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.

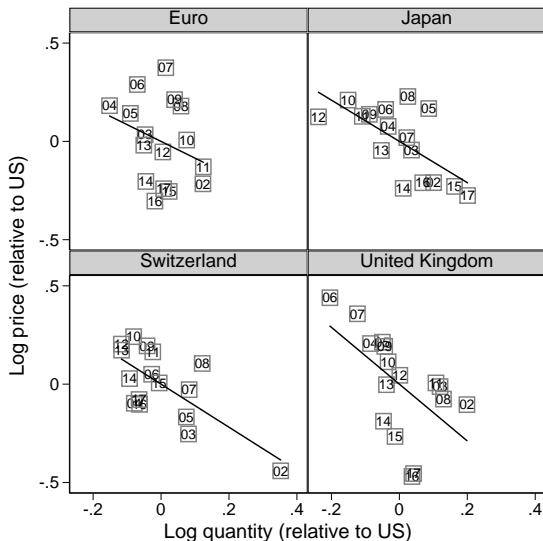
Relative quantities and prices

- ▶ Fiscal and monetary policy affect the supply of debt.
- ▶ Lower supply of long-term debt in the Euro area, relative to the US, implies that
 - ▶ The long-term yield falls.
 - ▶ Exchange rate response depends on the change in short-term debt (e.g. quantitative easing).
- ▶ Analogously, if European firms issue more equity
 - ▶ Equity prices fall.
 - ▶ And/or exchange rate may depreciate.
- ▶ These effects are quantitatively important particularly if demand is inelastic.

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.

Modeling asset demand curves

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

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

Allocation within asset class

- ▶ Portfolio weight in country n within asset class l .

$$w_{i,t}(n|l) = \frac{\delta_{i,t}(n, l)}{D_{i,t}(l)}$$

where $D_{i,t}(l) = 1 + \sum_{m=0}^N \delta_{i,t}(m, l)$ and

$$\begin{aligned} \log(\delta_{i,t}(n, l)) = & \underbrace{\beta_l \mu_{i,t}(n, l)}_{\text{Response to expected returns}} \\ & + \underbrace{\gamma_l' \mathbf{x}_{i,t}(n, l)}_{\text{Response to observable characteristics}} \\ & + \underbrace{\epsilon_{i,t}(n, l)}_{\text{Unobserved demand shocks, latent demand}} \end{aligned}$$

Allocation across asset classes

- ▶ Portfolio weight in asset class l .

$$w_{i,t}(l) = \frac{D_{i,t}(l)^{\lambda_l} \exp\{\alpha_l + \xi_{i,t}(l)\}}{\sum_{k=1}^3 D_{i,t}(k)^{\lambda_k} \exp\{\alpha_k + \xi_{i,t}(k)\}}$$

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

Estimation methodology

- ▶ 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

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

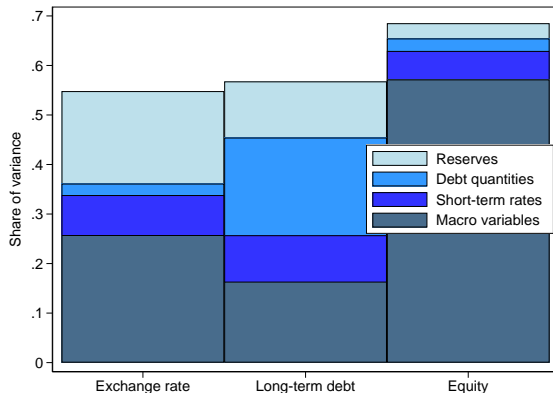
- ▶ The estimates imply imperfect substitution across asset classes.

Decomposition of exchange rates and asset prices

- ▶ Decompose annual changes in exchange rates, long-term yields, and equity prices into
 1. Macro variables (including equity quantities).
 2. Short-term rates (including short-term debt quantities).
 3. Long-term debt quantities.
 4. Reserves.
 5. Latent demand.

Variance decomposition of exchange rates and asset prices

- ▶ Fundamentals account for
 - ▶ 55% of variation in exchange rates.
 - ▶ 57% of variation in long-term yields.
 - ▶ 69% of variation in market-to-book equity.



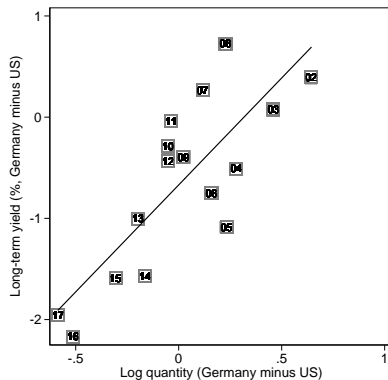
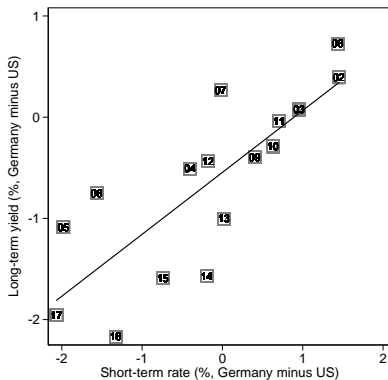
Interpreting asset markets: European sovereign debt

- ▶ What explains the long-term yield spread between
 - ▶ Germany and the US.
 - ▶ Southern European countries and Germany.
- ▶ Decompose annual changes into
 1. Macro variables (including equity quantities).
 2. Short-term rates (including short-term debt quantities).
 3. Long-term debt quantities.
 4. Reserves.
 5. Latent demand.

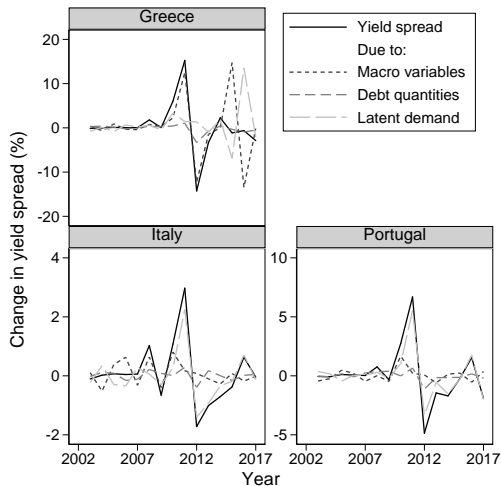
Variance decomposition of long-term yield spreads

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

Long-term yield spread between Germany and the US



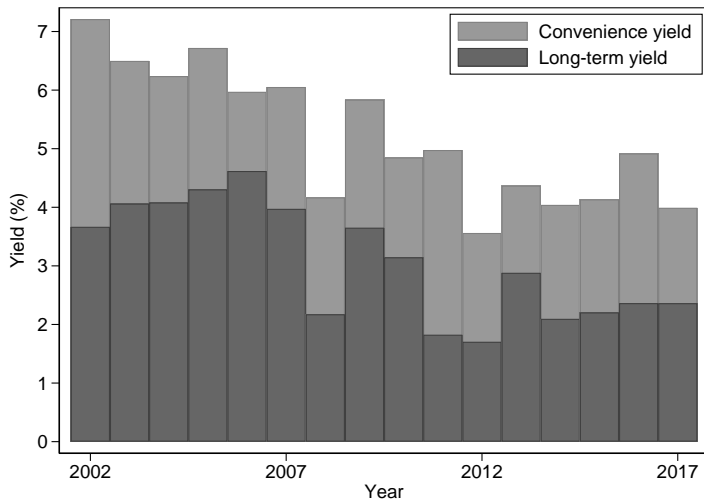
Change in the long-term yield spread between southern euro countries and Germany



Convenience yield on US long-term debt

- ▶ 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.

US long-term yield and its convenience yield



In progress: Monetary policy evaluation in real time

- ▶ In response to the COVID-19 crisis, central banks all over the world implemented asset purchase programs.
- ▶ Predicting the joint impact by relying on past event-study estimates may be suboptimal.
 - ▶ Current fundamentals and ownership structure are different.
 - ▶ Event studies measure the policy shock of a single central bank at high frequencies, not the low-frequency impact when multiple central banks act.
- ▶ In Koijen and Yogo (2019, *JPE*), we show that one can predict returns by predicting demand.

In progress: Monetary policy evaluation in real time

- ▶ Demand system approach to predicting policy impact:
 - ▶ Calibrate holdings, prices, and fundamentals to their pre-announcement values.
 - ▶ Feed in the monetary policy shocks and compute counterfactual prices.
 - ▶ In doing so, we can use predictions of characteristics (e.g., volatility) and asset quantities (e.g., fiscal policy), as so far as available, to sharpen the estimates.

Main takeaways

- ▶ Demand system asset pricing (DSAP) provides a novel way to interpret asset markets.
- ▶ 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.

	Exchange	Long-term	
Share of variance	rate	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

- ▶ By predicting the demand response, DSAP provides a new framework to predict the impact of policy interventions on markets.

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.

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

Variance decomposition of exchange rates by latent demand

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

List of issuer countries

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

Regressions of changes in exchange rates and asset prices

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