Demand System Asset Pricing
Application to International Finance

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Based on

▶ Ralph S.J. Koijen and Motohiro Yogo (2019), "Exchange Rates and Asset Prices in a Global Demand System".

Determinants of exchange rates and asset prices

- ▶ 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 exchange rates and macro shocks.
- ▶ Policy.
    - ▶ Short-term rates.
    - ▶ Debt quantities through fiscal and monetary policy.
    - ▶ Foreign exchange reserves: Central banks hold foreign assets.

Demand system asset pricing

- ▶ 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.
  - ▶ Interpret events such as the European debt crisis.
  - ▶ Estimate convenience yield on US assets.

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

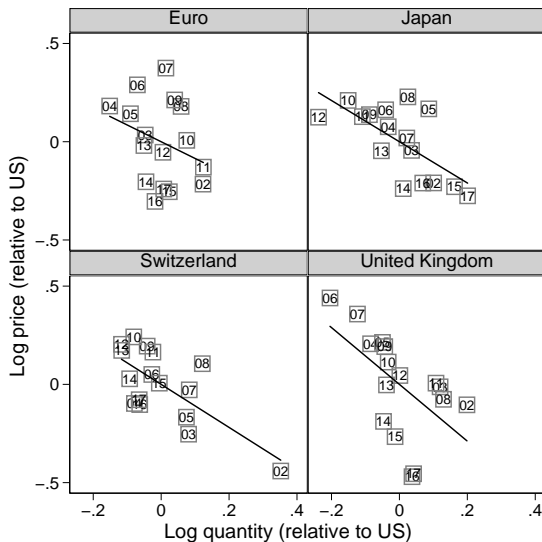▶ Offshore financial centers: Ireland, Luxembourg, and Cayman Islands.

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
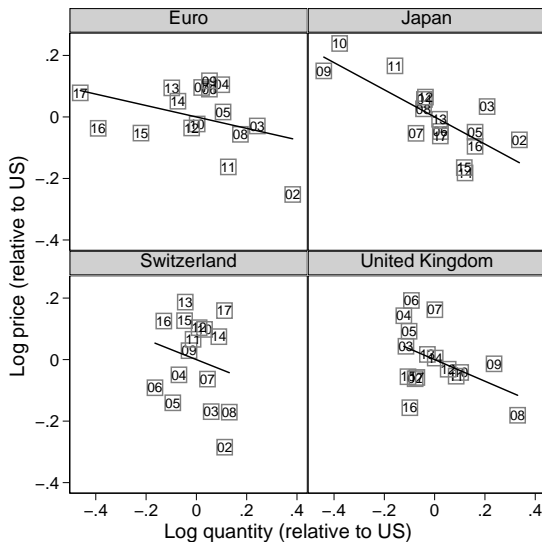
Relative equity quantity and price

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.

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

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:

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

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.
    - ▶ Recall Instrument Version 1 from Lecture Note 4. Nonlinear function of all asset characteristics through market clearing.
    - ▶ Restrictions from portfolio theory allows us to identify from cross-sectional variation.
    - ▶ In practice, we can get strong instruments from only size of investors, amounts outstanding, and physical distance.

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.

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

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.

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

▶ 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

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%.
  ▶ Offshore financial centers substituting within short-term debt:
    26%.
  ▶ North American investors substituting across asset classes: 8%.
  ▶ European investors substituting across asset classes: 8%.

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

| 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

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.

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
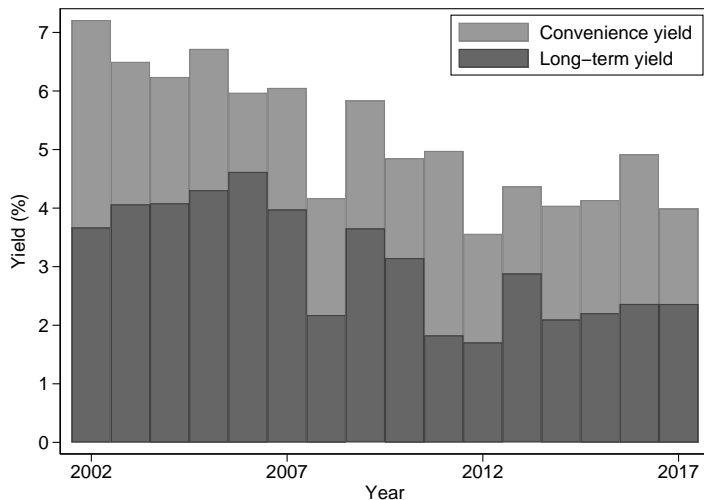
Summary

- ▶ 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