Understanding the Strength of the Dollar

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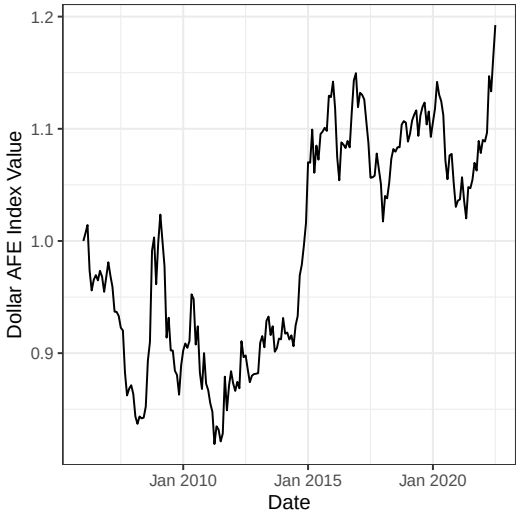
Record Strength of USD versus Advanced Economies

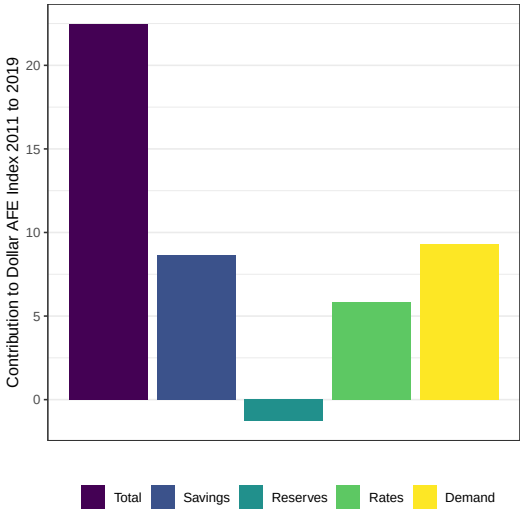


- Dollar strength has consequences for:
  - Global asset prices
  - Global economic conditions
  - Health of the global financial sector
- Diverse set of drivers – how to dis-entangle?
- Focus on 23% appreciation of dollar AFE index from 2011 to 2019

Connecting the Strength of the Dollar to Asset Supply and Demand

- Shifts in demand and supply for assets denominated in different currencies impacts exchange rates
  - An increase in foreigners' demand for dollar assets leads to a capital inflow to the U.S. and a dollar appreciation.
  - Increase in the supply of the dollar short-term debt assets dilutes the supply of dollar assets and leads to a dollar depreciation.
- **This paper:** Employ an empirically plausible demand system for international assets to link shifts in economic primitives to asset demand and the strength of the dollar.
  - Match observed international portfolios.
  - Account for **bilateral** relationships and rich structure of **substitution within and across asset classes**.

Preview of Results



1. Decomposition of Dollar AFE Index 2011 to 2019
   - Savings, Rates, and Demand Shift contributed approximately equally
2. Study heterogeneity in the cross-section of currencies
3. Study hypothetical large-scale shifts in demand for US assets on Dollar
   - What if China were to sell their US holdings?
   - What if the specialness of US assets declined?

An Asset Demand Framework for Decomposing FX

Model Overview

- Model follows Jiang, Richmond, and Zhang (2021)
  - Extends Koijen and Yogo (2020) so that wealth and portfolio returns co-evolve endogenously to study long-run dynamics.
- N countries issuing short-term debt, long-term debt and equity.
- Investors' demand for assets load on asset characteristics
  - Demand can be derived as outcome of optimal portfolio choice when characteristics proxy for loadings on common risk factors.
  - Investors substitute between different countries (USA equity vs. Japan equity) and different asset classes (Debt vs. Equity).
  - Exchange rates respond endogenously to international capital flows (Froot and Ramadorai, 2005; Hau and Rey, 2006)

Demand for Assets Within Classes

We model asset demand using a nested-logit structure:

$$w_{i,t}(n,\ell) = \underbrace{w_{i,t}(n|\ell)}_{\text{within asset class}} \cdot \underbrace{w_{i,t}(\ell)}_{\text{across asset classes}}$$

- Portfolio weight within asset class ℓ:

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

where

$$\delta_{i,t}(n,\ell) = \exp(\beta_\ell \underbrace{\mu_{i,t}(n,\ell)}_{\text{expected return}} + \boldsymbol{\theta}'_\ell \underbrace{\mathbf{x}_{i,t}(n)}_{\text{asset characteristics}} + \underbrace{\kappa_{i,t}(n,\ell)}_{\text{latent demand}})$$

- Expected returns, $\mu_{i,t}(n,\ell)$, computed using a forecasting regression for dollar excess returns and converting to local currency:

$$er_{t+1}(n,\ell) = \phi_\ell \underbrace{pb_t(n,\ell)}_{\text{log price-to-book}} + \psi_\ell \underbrace{rer_t(n)}_{\text{log real FX}} + \chi_{n,\ell} + \nu_{t+1}(n,\ell).$$

Demand Across Asset Classes

- Investor i portfolio weight in in asset class ℓ is:

$$w_{i,t}(\ell) = \frac{(1 + \sum_{k=0}^{N} \delta_{i,t}(n, \ell))^{\lambda_\ell} \exp(\alpha_\ell + \xi_{i,t}(\ell))}{\sum_{m=1}^{3}(1 + \sum_{k=0}^{N} \delta_{i,t}(k, m))^{\lambda_m} \exp(\alpha_m + \xi_{i,t}(m))},$$

- α_l capture asset class fixed effects and $\xi_{i,t}(\ell)$ represent latent demand for unobserved asset class characteristics.

- $\lambda_\ell \in (0, 1)$ govern the elasticity of substitution between asset classes.

AUM Dynamics, Central Banks, and Market Clearing

- *Endogenous* AUM for investor i evolves according to:

$$A_{i,t} = \underbrace{A_{i,t-1} \sum_{\ell=1}^{3} \sum_{n=0}^{N} w_{i,t-1}(\ell) w_{i,t-1}(n|\ell)(1 + R_t(n,\ell))}_{\text{revaluation}} + \underbrace{F_{i,t}}_{\text{net savings}}$$

- In each period, central banks hold an exogenous quantity, $B_{i,t}(n,\ell)$, of country n asset.

- Market clearing in dollars for each asset dictates:

$$PB_t(n,\ell)E_t(n)Q_t(n,\ell) = \underbrace{\sum_{i=1}^{I} A_{i,t} w_{i,t}(\ell) w_{i,t}(n|\ell)}_{\text{private holdings}} + \underbrace{PB_t(n,\ell)E_t(n) \sum_{i=1}^{I} B_{i,t}(n,\ell)}_{\text{official holdings}}.$$

Exchange Rate Determination

- Short-term rates are determined exogenously by monetary policy.
- Market clearing in short-term debt markets determines exchange rates:

$$E_t(n)\left[PB_t(n,1)Q_t(n,1) - PB_t(n,1)\sum_{i=1}^{I} B_{i,t}(n,1)\right] = \sum_{i=1}^{I} A_{i,t}w_{i,t}(1)w_{i,t}(n|1)$$

- If demand for country n short-term debt increases, country n's currency appreciates to clear the short-term debt market.
- Demand for equity and long-term debt also affect exchange rates due to substitution across asset classes.
- Pegged exchange rates are cleared by assuming that the country's central bank maintains the peg by adjusting the supply of short-term debt.

Data, Model Estimation, and Decomposition Strategy

International Portfolio Holdings, Asset Characteristics and Returns

- Combine annual portfolio holdings.
  - CPIS, TIC, SEFER, the FRB balance sheet, SEFER central bank reserves
- Split central bank reserves by region.
  - Using currency composition data. (Iancu et. al 2019)
- Accurately measure returns and net savings.
  - Using TIC flow/position data (Bertaut and Judson)
- Correct for holdings in tax havens.
  - Coppola, Maggiori, Neiman and Schreger (2020)
- Asset characteristics: GDP, GDP per capita, trade centrality, sovereign default probability, trade exposure, log distance and stock market volatility.
- Asset Prices: Market-to-book ratio for equity, 3-month and 10-year govt yields for short- and long-term debt

Sample consists of 35 investor countries including 32 issuer countries from 2011 — 2019.

US External Assets and Liabilities

2011				2019			
Assets		**Liabilities**		**Assets**		**Liabilities**	
Long-Term Debt							
Canada	261	Federal Reserve	2,379	Canada	379	Federal Reserve	3,271
United Kingdom	257	China Central Bank	1,776	United Kingdom	355	European Union	2,756
Australia	142	European Union	1,429	France	151	China Central Bank	1,904
France	73	Japan	1,216	Japan	145	Japan	1,622
Germany	72	United Kingdom	493	Australia	135	United Kingdom	596
All Other	423	All Other	1,643	All Other	627	All Other	2,572
Equity							
United Kingdom	511	European Union	946	China	1,030	European Union	2,401
Japan	396	United Kingdom	411	United Kingdom	982	United Kingdom	1,058
Canada	314	Canada	368	Japan	915	Canada	949
China	290	Japan	300	Canada	563	Japan	591
Switzerland	226	China	174	France	490	Norway	331
All Other	1,208	All Other	726	All Other	2,363	All Other	1,771
Total	**4,477**	**Total**	**12,413**	**Total**	**8,540**	**Total**	**20,422**

Estimating the Demand Equations

- The nested-logit structure yields two linear estimation equations.
- Demand within each asset class ℓ:

$$\log\left(\frac{w_{i,t}(n,\ell)}{w_{i,t}(0,\ell)}\right) = \beta_\ell \mu_{i,t}(n,\ell) + \boldsymbol{\theta}'_\ell \mathbf{x}_{i,t}(n) + \kappa_{i,t}(n,\ell).$$

- Demand across asset classes:

$$\log\left(\frac{w_{i,t}(\ell)}{w_{i,t}(3)}\right) = -\lambda_\ell \log\left(w_{i,t}(0|\ell)\right) + \lambda_3 \log\left(w_{i,t}(0|3)\right) + \alpha_\ell + \xi_{i,t}(\ell).$$

- Construct $\mu_{i,t}(n,\ell)$ a function of prices and real exchange rates. Details
- **Endogeneity concern**: high weight, high price, and low expected return due to high latent demand

Use structural model to construct instruments for expected returns

- **Exogeneity assumption**: Characteristics, supply, and holdings of outside assets are uncorrelated with latent demand.
- Approach:
  1. Use characteristics alone to predict portfolio weights.
  2. Using structural model to exchange rates and prices implied by predicted portfolio weights.
  3. Estimate within asset-class equation using IV.
- **Intuition:** higher asset prices for countries which are closer to others, have lower supply, or tend to be held by large investors.
- Instruments are a non-linear function of *all* countries' exogenous characteristics as is common in the IO literature
- Results robust to instrumenting supply and AUM, as well as to endogenizing GDP

IV Details

Demand Estimation Results

	ST Debt (1)	LT Debt (2)	Equity (3)
E[Excess Return]	43.67***	7.04	10.29**
	(13.42)	(5.63)	(3.71)
Log GDP	2.34***	1.95***	2.13***
	(0.35)	(0.20)	(0.33)
Centrality	-0.04	-0.08	0.02
	(0.09)	(0.06)	(0.10)
Own Country	7.34***	5.76***	5.38***
	(0.00)	(0.77)	(1.07)
Indicator: USA Issuance	1.86**	2.31***	0.86
	(0.66)	(0.57)	(0.59)
Observations	17,393	20,087	20,142
F-test (1st stage)	28.7	39.0	166.7

- First stage is strong.
- Investors exhibit downward sloping demand curves.
- Short-term debt is most substitutable across countries.
- Preference for investing in larger, wealthier and closer countries.
- λ_ℓ estimates are between 0 and 1, which implies some substitution as asset class values vary.

Decomposition Approach

- Exogenous variables: Savings, issuances, reserves, rates, demand
- Endogenous variables: Wealth, portfolio weights, prices, exchange rates
- Set the exogenous variables to $t-1$ values.
  - Implies no change in endogenous variables.
- Restore exogenous variables and recompute endogenous variables at each step:
  - Step 1: Restore change in savings $F_{i,t}$ and asset issuance $Q_t(n,\ell)$
  - Step 2: Additionally restore the central bank holdings $B_{i,t}(n,\ell)$
  - Step 3: Additionally restore short rates $pb(n,1)$
  - Step 4: Additionally restore the demand parameters $\mathbf{x}_{i,t}(k)$, $\kappa_{i,t}(k,\ell)$, $\xi_{i,t}(\ell)$
- Difference in the log of the implied dollar index between the $(j-1)$-th and j-th steps:

$$\Delta_{j,t} = \log\left(USD_t^j / USD_t^{j-1}\right).$$

- Report the incremental contribution of each step across all years:

$$\overline{\Delta}_j = \sum_j \Delta_{j,t}.$$

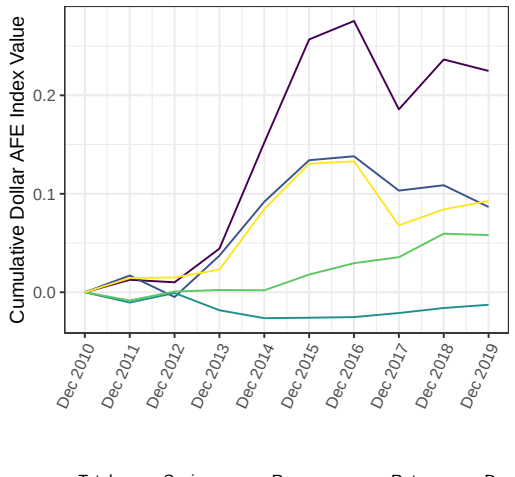
Additional Details

Understanding the Strength of the Dollar

Savings, Rates, and Demand Shifts Drove Dollar Appreciation

	AFE	EUR	CAN	JPN	GBR	CHE
Savings and Issuances						
Total Savings	8.7	9.2	9.3	9.5	5.9	9.3
Monetary Policies (Reserves)						
Total Reserves	-1.3	-0.1	-2.1	-3.1	-0.4	-1.4
Monetary Policies (Rates)						
Total Rates	5.8	9.8	0.5	5.2	2.4	8.4
Demand Shifts						
Total Demand	9.3	-1.3	18.9	17.7	8.8	-12.5
Total	**22.5**	**17.6**	**26.6**	**29.3**	**16.7**	**3.8**

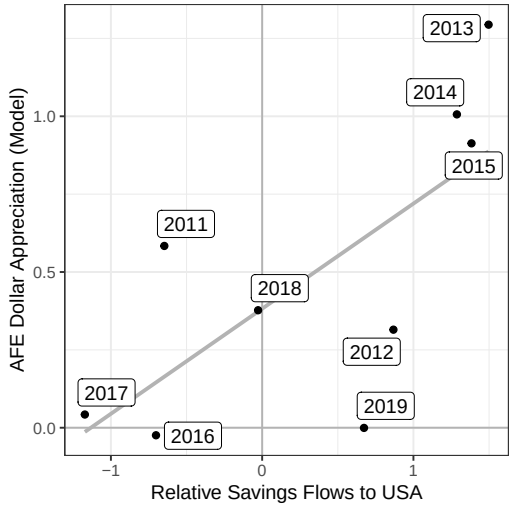
- Savings and issuances, rates, and demand contributed approximately equal
- Reserves played a minor role



Inspecting the Savings Channel

	AFE	EUR	CAN	JPN	GBR	CHE
Savings and Issuances						
DM Savings	4.2	4.5	5.2	4.4	1.1	5.1
EM Savings	4.5	4.7	4.1	5.0	4.8	4.2
Total Savings	8.7	9.2	9.3	9.5	5.9	9.3
Total	**22.5**	**17.6**	**26.6**	**29.3**	**16.7**	**3.8**

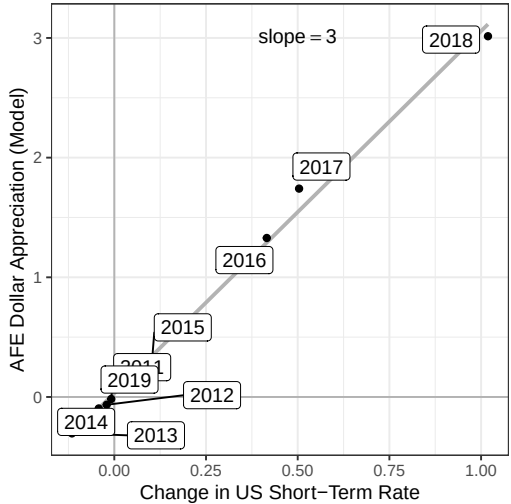
- Foreign investors tend to allocate a large share of their wealth to U.S. assets
  - Savings tend to appreciate dollar
- Figure plots relative flows to U.S. based upon time $t-1$ portfolio weights.
- Savings tended to flow to US and GBR.
- Greatest savings flows into the U.S. occurred mostly in 2013—2015.



Inspecting the Rates Channel

	AFE	EUR	CAN	JPN	GBR	CHE
Monetary Policies (Rates)						
US Rates	6.0	5.7	7.0	5.3	5.0	5.7
EM/DM Rates	-0.1	4.1	-6.6	-0.1	-2.7	2.7
Total Rates	5.8	9.8	0.5	5.2	2.4	8.4
Total	**22.5**	**17.6**	**26.6**	**29.3**	**16.7**	**3.8**

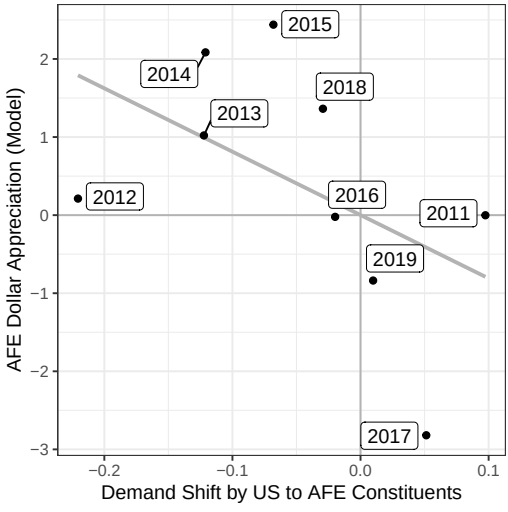
- Higher rates made U.S. assets attractive
- Increases in U.S. short-term rate from 2016 to 2018 are associated with the most dollar appreciation.
- Consistent with high-frequency identification (Curcuru et al. 2017).
- ECB and the Swiss CBs eased.
- Canadian and the British CBs tightened.



Inspecting the Demand Channel (US Shifts from Foreign)

	AFE	EUR	CAN	JPN	GBR	CHE
Demand Shifts						
DM Demand	8.1	-2.3	18.2	16.3	6.9	-13.9
EM Demand	1.1	1.0	0.8	1.4	1.9	1.5
Total Demand	9.3	-1.3	18.9	17.7	8.8	-12.5
Total	**22.5**	**17.6**	**26.6**	**29.3**	**16.7**	**3.8**

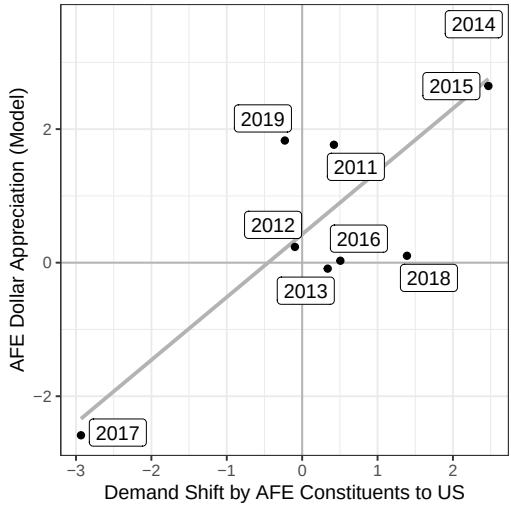
- Plot shifts in U.S. demand for developed countries' assets against model-implied dollar appreciation.
- Weaker U.S. demand for foreign assets leads a depreciation of foreign currencies and therefore an appreciation of the dollar
- Largest demand shifts in 2012-2015.



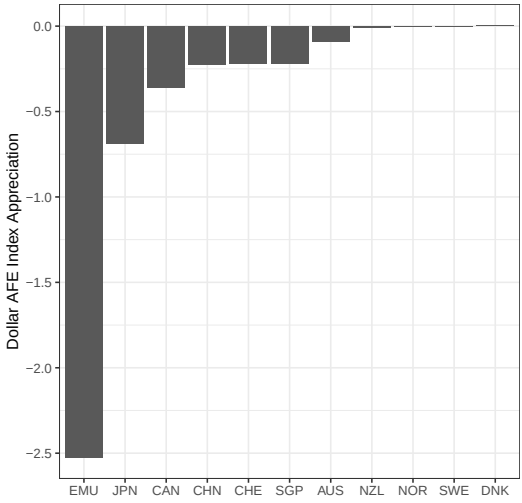
Inspecting the Demand Channel (Foreign Shifts to US)

	AFE	EUR	CAN	JPN	GBR	CHE
Demand Shifts						
DM Demand	8.1	-2.3	18.2	16.3	6.9	-13.9
EM Demand	1.1	1.0	0.8	1.4	1.9	1.5
Total Demand	9.3	-1.3	18.9	17.7	8.8	-12.5
Total	**22.5**	**17.6**	**26.6**	**29.3**	**16.7**	**3.8**

- Plot shifts in the developed countries' demand for U.S. assets against model-implied dollar appreciations.
- Stronger foreign demand for U.S. assets leads to a dollar appreciation.
- Largest shift in the foreign demand towards U.S. assets occurred in 2014 and 2015.

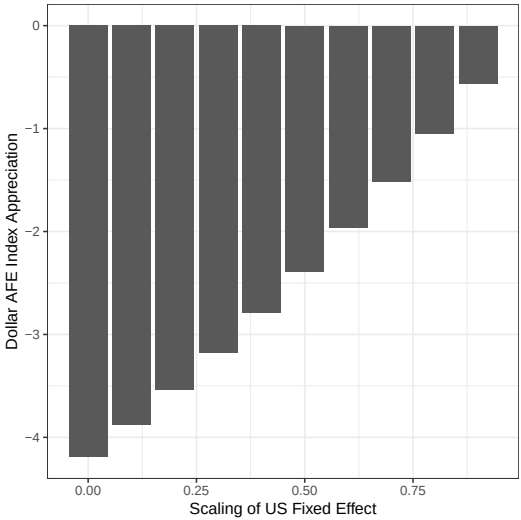


What if a region unilaterally sells their US asset holdings?



- Highlights which countries' holdings matter for the value of the dollar.
- Assume central bank liquidates US reserves and distributes the wealth to domestic investors.
- Domestic investors' demand set to zero for US assets.
- When any one country unilaterally sells U.S. assets, other countries are willing to absorb the excess supply of dollar assets at a minor price discount.
- As the EMU sells their U.S. assets, other countries increase their positions in the U.S. assets by 10% to 30%.

What is the specialness of US assets decreased?



- Scale the U.S. asset dummy in investors' demand curves down towards zero.
- Hold other demand parameters fixed.
- When the specialness of U.S. issued assets is completely removed the dollar AFE index depreciates by over 4%.

Conclusion

- We use a portfolio-based demand system to decompose the dollar's appreciation since 2011.
- We show this appreciation can be explained approximately equally by increases in global savings, relatively high U.S. monetary policy rates, and shifts in investor demand.
- We use asset demand system to understand the impact of potential demand shifts on the dollar.

Appendix

Details on Estimating Expected Returns

Run a forecasting regression for dollar denominated excess returns:

$$er_{t+1}(n,\ell) = \phi_\ell \underbrace{pb_t(n,\ell)}_{\text{log price-to-book}} + \psi_\ell \underbrace{rer_t(n)}_{\text{log real FX}} + \chi_{n,\ell} + \nu_{t+1}(n,\ell)$$

	DebtLong (1)	DebtShort (2)	Equity (3)
Log market-to-book	-0.37***	-8.33***	-0.11***
	(0.05)	(1.22)	(0.04)
Log real exchange rate	-0.42***	-0.35***	-0.80***
	(0.06)	(0.03)	(0.09)
Observations	576	576	576
R^2	0.30	0.28	0.16
Country fixed effects	✓	✓	✓

Construct expected return in currency i by subtracting $er_{t+1}(i,1)$.

Decomposition Exercise Details

$$\text{AUM:} \quad A_{i,t} = A_{i,t-1} \sum_{\ell=1}^{3} \sum_{k=0}^{N} w_{i,t-1}(\ell) w_{i,t-1}(k|\ell)(1 + R_t(k,\ell)) + F_{i,t}$$

$$\text{Mkt Clearing:} \quad PB_t(n,\ell) Q_t(n,\ell) = \sum_{i=1}^{I} \frac{A_{i,t}}{E_t(n)} w_{i,t}(\ell) w_{i,t}(n|\ell) + PB_t(n,\ell) \sum_{i=1}^{I} B_{i,t}(n,\ell)$$

$$\text{Asset Demand:} \quad w_{i,t}(n|\ell) = \frac{\exp(\beta_\ell \mu_{i,t}(n,\ell) + \boldsymbol{\theta}_\ell' \mathbf{x}_{i,t}(n) + \kappa_{i,t}(n,\ell))}{1 + \sum_{k=1}^{N} \exp(\beta_\ell \mu_{i,t}(k,\ell) + \boldsymbol{\theta}_\ell' \mathbf{x}_{i,t}(k) + \kappa_{i,t}(k,\ell))}$$

- Exogenous variables in black, endogenous variables in red.
- Step 1: Set the exogenous variables to $t-1$ values, endogenous variables stay constant
- Step 2: Restore change in savings $F_{i,t}$ and asset issuance $Q_t(n,\ell)$
- Step 3: Additionally restore the central bank holdings $B_{i,t}(n,\ell)$ and policy
- Step 4: Additionally restore the demand parameters $\mathbf{x}_{i,t}(k)$, $\kappa_{i,t}(k,\ell)$, $\xi_{i,t}(\ell)$

Back

IV Details (1)

- Get predicted values, $\hat{\delta}_{i,t}(n,\ell)$, from:

$$\log\left(\frac{w_{i,t}(n,\ell)}{w_{i,t}(0,\ell)}\right) = \boldsymbol{\theta}'_\ell \mathbf{x}_{i,t}(n) + \kappa_{i,t}(n,\ell)$$

  using population, distance, investor fixed effects and own country dummy.

- Construct instruments for cross-asset estimation:

$$\hat{w}_{i,t}(0|\ell) = \frac{1}{1+\sum_{n=0}^{N}\hat{\delta}_{i,t}(n,\ell)}.$$

- Estimate $\hat{\lambda}$s with instruments and estimation equation:

$$\log\left(\frac{w_{i,t}(\ell)}{w_{i,t}(3)}\right) = -\lambda_\ell \log\left(w_{i,t}(0|\ell)\right) + \lambda_3 \log\left(w_{i,t}(0|3)\right) + \alpha_\ell + \xi_{i,t}(\ell).$$

IV Details (2)

- Calculate country-level predicted weights:

$$\hat{w}_{i,t}(n,\ell) = \frac{\hat{\delta}_{i,t}(n,\ell)}{1+\sum_{k=0}^{N}\hat{\delta}_{i,t}(n,\ell)} \frac{\left(1+\sum_{n=0}^{N}\hat{\delta}_{i,t}(n,\ell)\right)^{\hat{\lambda}_\ell}\exp\left(\hat{\alpha_\ell}\right)}{\sum_{k=0}\left(\left(1+\sum_{n=0}^{N}\hat{\delta}_{i,t}(n,k)\right)^{\hat{\lambda}_k}\exp\left(\hat{\alpha_k}\right)\right)}.$$

- Instruments for exchange rates clear short-term debt markets at predicted weights
- Instruments for long-term bond prices and stock prices clear their markets at predicted weights and exchange rates

IV Details (3)

- The following equation allows estimation of within asset class:

$$\log\left(\frac{w_{i,t}(n,\ell)}{w_{i,t}(0,\ell)}\right) = \beta_\ell \mu_{i,t}(n,\ell) + \boldsymbol{\theta}'_\ell \mathbf{x}_{i,t}(n) + \kappa_{i,t}(n,\ell).$$

- Use instruments for exchange rates and prices to instrument for expected returns.

Back

IV Details (Robustness)

1. Instrument for asset supply using issuer country population.
2. Instrument outside asset holdings using investor country population.
3. Instrument both supply and outside asset holdings.
4. Use GDP instead of population to build exogenous weights.
5. Relax exogeneity of GDP by modeling GDP as a function of prices:

$$\log GDP_t(n) = \alpha_t + \beta_2 pb_t(n,2) + \beta_3 pb_t(n,3) + \nu_t(n)$$

- Estimate this equation using instrumented prices constructed using population, etc.
- Extract residuals and instrument GDP in main estimation with "GDP shocks"
- Procedure builds on Koijen, Richmond, and Yogo (2020).

Different Estimation Variants

	Estimation Variation					
	Baseline	(1)	(2)	(3)	(4)	(5)
Short-Term Debt	43.7	41.8	45.4	43.8	29.0	74.4
	(13.4)	(19.8)	(18.4)	(37.4)	(10.7)	(35.6)
Long-Term Debt	7.0	14.4	11.9	0.5	3.2	9.2
	(5.6)	(14.3)	(5.7)	(9.4)	(4.6)	(5.8)
Equity	10.3	1.5	5.3	9.4	5.0	18.7
	(3.7)	(2.3)	(3.7)	(3.0)	(2.0)	(7.3)

1. Instrument for asset supply using issuer country population.
2. Instrument outside asset holdings using investor country population.
3. Instrument both supply and outside asset holdings.
4. Use GDP instead of population to build exogenous weights.
5. Relax exogeneity of GDP by modeling GDP as a function of prices

Robustness to Different Estimates

	Estimation Variation					
	Baseline	(1)	(2)	(3)	(4)	(5)
Trend Decomposition						
Savings and Issuances						
DM Savings	4.2	4.3	4.2	2.5	3.5	3.7
EM Savings	4.5	4.4	4.4	4.1	4.4	3.7
Total Savings	8.7	8.7	8.6	6.6	8.0	7.5
Monetary Policies (Reserves)						
US Reserves	-1.2	-1.5	-1.4	-0.9	-1.2	-1.1
DM Reserves	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1
EM Reserves	0.1	0.1	0.1	0.1	0.2	0.0
Total Reserves	-1.3	-1.6	-1.5	-1.0	-1.2	-1.2
Monetary Policies (Rates)						
US Rates	6.0	6.2	6.3	5.4	4.9	7.2
EM/DM Rates	-0.1	0.2	0.1	-0.2	-0.1	0.2
Total Rates	5.8	6.4	6.4	5.2	4.8	7.3
Demand Shifts						
DM Demand	8.1	8.0	7.9	10.3	9.9	6.8
EM Demand	1.1	1.0	1.1	1.5	1.0	2.1
Total Demand	9.3	9.0	8.9	11.8	10.9	8.9
Total	**22.5**	**22.5**	**22.5**	**22.5**	**22.5**	**22.5**

1. Instrument for asset supply using issuer country population.
2. Instrument outside asset holdings using investor country population.
3. Instrument both supply and outside asset holdings.
4. Use GDP instead of population to build exogenous weights.
5. Relax exogeneity of GDP by modeling GDP as a function of prices