Tech Dollars: Technological Innovation and Exchange Rates

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Realistic?

- Empirical evidence indicates a weak or even **positive** correlation between macroeconomic variables and exchange rates. Backus and Smith (1993); Kollmann (1995); Obstfeld and Rogoff (2001); Chahrour et al. (2024)

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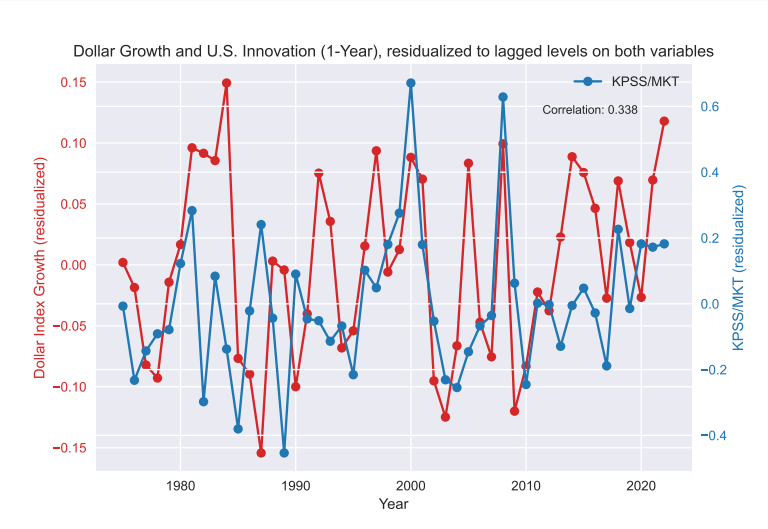
Mechanism: model with creative destruction (Aghion-Howitt) under incomplete markets.

Fact 1: U.S. Innovation and US Dollar



Fact 1: U.S. Innovation and US Dollar

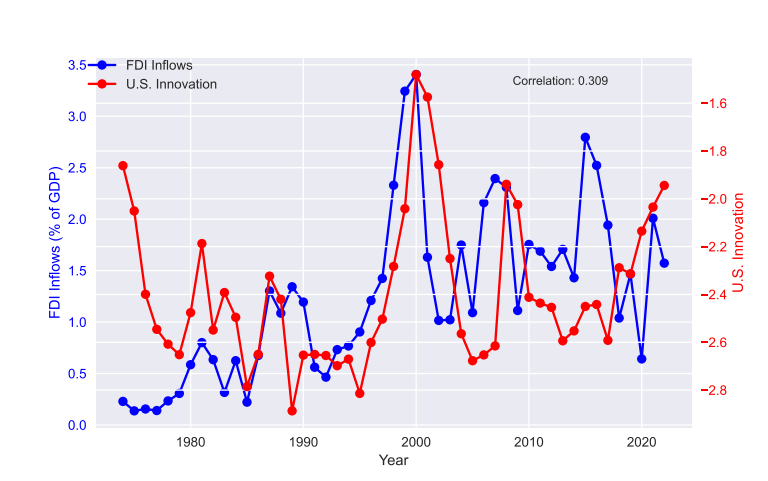
Growth in Real Dollar	Time Series Estimate (EW Dollar Index)				Panel Estimate
	(1)	(2)	(3)	(4)	(5)
KPSS/MKT	0.026**	0.026**	0.036**	0.039**	0.046**
	(0.011)	(0.012)	(0.017)	(0.015)	(0.018)
Lagged Dollar Index	Y	Y		Y	Y
Lagged Output growth		Y	Y	Y	Y
Lagged Innovation			Y	Y	Y
Observations	49	49	49	49	467
R2	0.175	0.175	0.098	0.198	0.226

Sample Period: 1974-2022. U.S. innovation is measured by the total value of patents each year (Kogan et al. (2017)) divided by the total market value. The dollar index is the equal weighted average real value of the US dollar against the group of currencies in our sample. Panel regression

$$\Delta \ln e_{t+1}^{US,f} = \alpha + \beta_1 Inno_{US,t+1} + \beta_2 X_t^{US,f} + \varepsilon_{t+1}$$

Controls X_t include lagged innovation, relative output growth, and lagged dollar index level at t. SEs (in parentheses) are Newey-West.

Fact 2: U.S. Innovation and Portfolio Flows



U.S. innovation is measured by the log of total value of patents each year (Kogan et al. (2017)) divided by the total market value.

Fact 2: U.S. Innovation and Portfolio Flows

Change in Foreign Institutional ownership	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Firm Innovation	0.182***	0.221***	0.192**	0.138**	0.190***	0.170**	0.159**	0.210***	0.186**
	(0.061)	(0.045)	(0.067)	(0.062)	(0.049)	(0.071)	(0.065)	(0.056)	(0.066)
Innovation Measure:	KPSS	Cites	KPST	KPSS	Cites	KPST	KPSS	Cites	KPST
Firm Controls	No	No	No	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	No	No	No
Industry × Year	No	No	No	No	No	No	YES	YES	YES
Observations	67986	67986	67986	65761	65761	65761	64723	64723	64723
Adj R2	0.788	0.787	0.787	0.795	0.794	0.794	0.796	0.796	0.796
Within R2	0.386	0.384	0.384	0.399	0.398	0.398	0.368	0.367	0.367

The independent variable is the (log) number of important patents (top 20%) granted to firm i in the last year t, according to various innovation measures.

$$\Delta\text{Change in Foreign Institutional ownership}_{i,t,t+1} = \beta \ln(inno)_{i,t,t} + \gamma X_{i,t} + \varepsilon_{i,t}$$

The vector of control $X_{i,t}$ includes foreign institutional ownership at time t, IO_FOR$_{i,t}$, firm and year fixed effects.

Fact 3: U.S. Innovation and Wealth Reallocation

Growth	Between US wealth (relative to foreign)		Within US Inequality (relative to foreign)	
	(1)	(2)	(3)	(4)
KPSS/MKT	0.028*	0.035**	0.011*	0.013**
	(0.015)	(0.015)	(0.006)	(0.006)
Lagged innovation	Y	Y	Y	Y
Lagged output growth	Y	Y	Y	Y
Lagged wealth/inequality ratio		Y		Y
Observations	412	412	486	486
R2	0.033	0.106	0.029	0.106

The dependent variable is the growth of US wealth (or inequality) relative to the wealth (or inequality) of foreign country. Inequality is the 1% percentage share of income. U.S. innovation is the logarithm of the ratio of patent value (KPSS) to total market capitalization.

Model

Model Assumptions

Key Ingredients

1. Creative Destruction: (displacement) shock drives the **productivity of new** vs old firms.
2. Incomplete Markets: investors **cannot trade claims on new firms before they are created.**

Standard Ingredients

1. Home Bias
2. No Arbitrage
3. Free Trade and Capital Flows

   Investors can trade domestic and foreign stocks and bonds—markets are otherwise complete.

Model (reduced form version)

Firm i of cohort s in country $c \in \{H, F\}$ produces cashflows

$$y_{t,s}^{i,c} = a_{t,s}^{i,c} Y_{c,t} \qquad \text{where} \qquad \sum_{s \leq t} \int_{i \in [0,1]} a_{t,s}^{i,c} = 1$$

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New Firms: $$\int_{i \in [0,1]} y_{t,t}^{i,c} = \left(1 - e^{-u_t^c}\right) Y_{c,t}$$

Incumbents: $$a_{t,s}^{i,c} = a_{s,s}^{i,c} \exp\left(-\sum_{n=s+1}^{t} u_n^c\right)$$

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Aggregate output

$$\Delta \ln X_{t+1} = \mu + \varepsilon_{t+1}^c + \delta u_{t+1}^c$$

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Displacement shock increases output and reallocates market share from incumbents to new firms.

Competitive Equilibrium

Equilibrium can be described as a central planner's problem:

$$\max \mathrm{E}_0 \left[\sum_{t=0}^{\infty} \hat{\beta}^t \left(u(C_t^H) + \lambda_t \, u(C_t^F) \right) \right]$$

Here, λ_t is the ratio of Pareto-Negishi weights (constant if markets are complete)

Simplest version: log utility, entrepreneurs are measure zero

$$\begin{aligned} \Delta \ln e_{t+1} &= \Delta \ln C_{t+1}^F - \Delta \ln C_{t+1}^H + \underbrace{\Delta \ln W_{H,t+1} - \Delta \ln W_{F,t+1}}_{-\Delta \lambda_{t+1}} \\ &= \Delta \ln C_{t+1}^F - \Delta \ln C_{t+1}^H + \ln b_{F,t+1} - \underbrace{\ln b_{H,t+1}}_{\substack{\text{change in} \\ \text{wealth share} \\ \text{non-entrepreneurs}}} . \end{aligned}$$

Intuition

Assume extreme home bias. Growth in **average marginal utility** (Equilibrium SDF) in country c

$$\frac{M^c_{t+1}}{M^c_t} = \beta \left(\frac{Y_{c,t+1}}{Y_{c,t}} \right)^{-1} \left(\underbrace{(1-\pi)\, e^{u^c_{t+1}}}_{\text{non-entrepreneurs}} + \underbrace{\pi \left(\frac{1 - e^{-u^c_{t+1}}}{\pi} \right)^{-1}}_{\text{entrepreneurs}} \right).$$

$$= \beta \left(\frac{Y_{c,t+1}}{Y_{c,t}} \right)^{-1} e^{u^c_{t+1}} \qquad \text{as} \quad \pi \to 0$$

Exchange rate is equal to ratio of country SDFs.

Key Moments: Model vs Data

	Data	Model		
		Median	5%	95%
B. Asset Prices				
Risk-free rate, mean	0.016	0.022	-0.029	0.030
Risk-free rate, volatility	0.031	0.012	0.004	0.055
Excess stock returns, mean	0.037	0.032	0.007	0.136
Excess stock returns, volatility	0.252	0.140	0.061	0.338
Exchange rate, volatility	0.115	0.075	0.032	0.214
C. Comovement of Key Variables				
i. Univariate Regression Slopes				
Consumption growth and wealth growth	0.008	0.010	0.001	0.094
Output growth and wealth growth	0.005	0.003	-0.005	0.008
Exchange rate growth and inequality growth	0.017	0.039	-0.012	0.124
US displacement shocks and US wealth ratio growth	0.053	0.034	-0.113	0.166
ii. Bivariate Regression Slopes				
Exchange rate and				
—relative consumption growth	-0.020	-0.016	-0.065	-0.006
—relative wealth growth	0.107	0.086	0.034	0.267
Exchange rate and				
—relative output growth	-0.016	-0.012	-0.019	-0.003
—relative wealth growth	0.103	0.077	0.032	0.218
D. Other				
Uncovered interest parity slope	-0.215	-0.204	-4.641	1.917
Dollar index growth and US displacement (correlation)	0.350	0.340	-0.680	0.744

Implications

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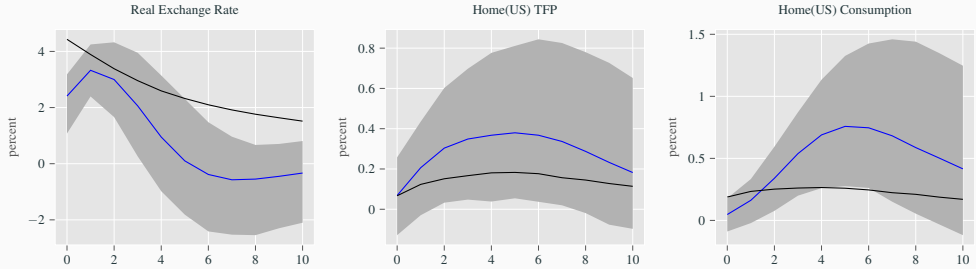
New Predictions:

- US Innovation positively correlated with US dollar (Fact 1)
- Motive for holding US dollars: investing in shares of innovative firms (Fact 2)
- US Innovation increases US inequality and the share of US wealth (Fact 3)

Calibrated model resolves existing exchange rate puzzles:

- Cyclicality puzzle: Backus and Smith (1993)
- UIP puzzle: Fama (1984)
- Volatility puzzle: Brandt et al. (2006)
- U.S. productivity shocks affect exchange rates movement: Chahrour et al. (2024).

Dollar is positively correlated with (future) US TFP growth

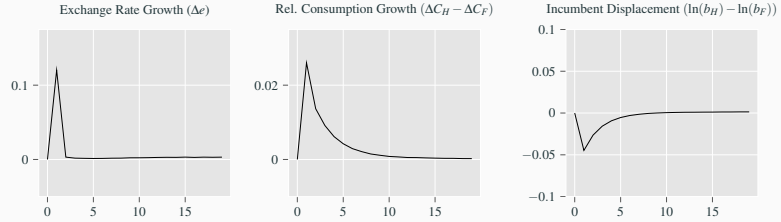


Note: Figure replicates the VAR analysis in Chahrour et al. (2024) in simulated data from the model. The first figure plots the extracted 'FX shock', the second figure plots the response of productivity (output) in the US and the third figure plots the response of US consumption. The black line plots the median impulse response in simulated data. The blue line represents the impulse responses to the main exchange rate shock in the data along with 90% confidence intervals.

Backus-Smith Puzzle

Innovation shock leads to both an **output boom** and **an appreciation of the exchange rate**.

Response to Displacement Shock: News about **current** innovation



Forward Premium (UIP) Puzzle

Model replicates the failure of UIP

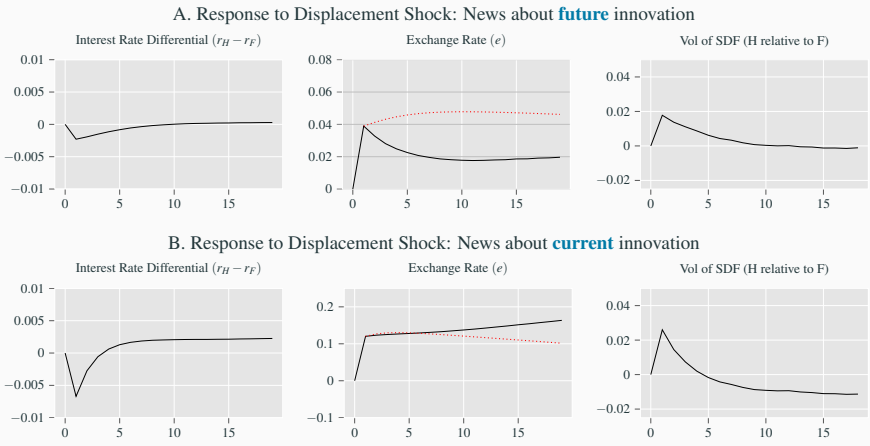
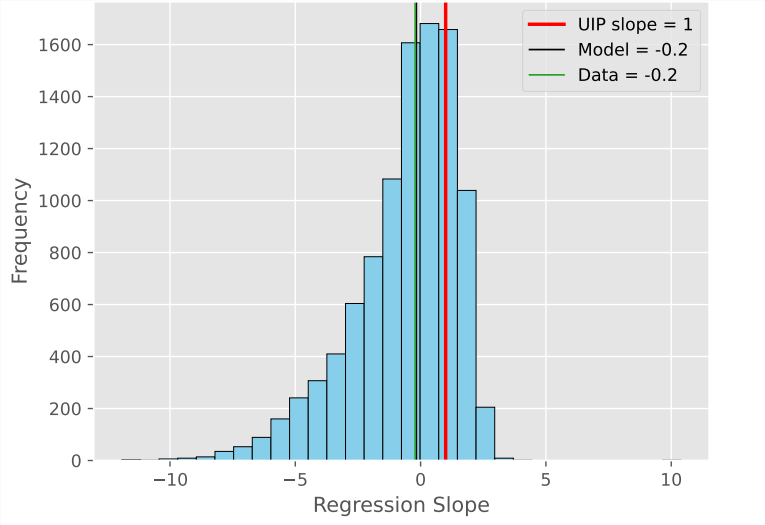


Figure plots the model's impulse response to Displacement Shock (u). Black = Model, Red = If UIP were to hold

Model-Implied UIP Slopes



Dollars and Equity flows

Positive correlation between equity flows and exchange rate (Fact 2)

- Innovation at home ↑
- Foreign investors buy shares of new firms ↑
- Home receives net capital inflows.

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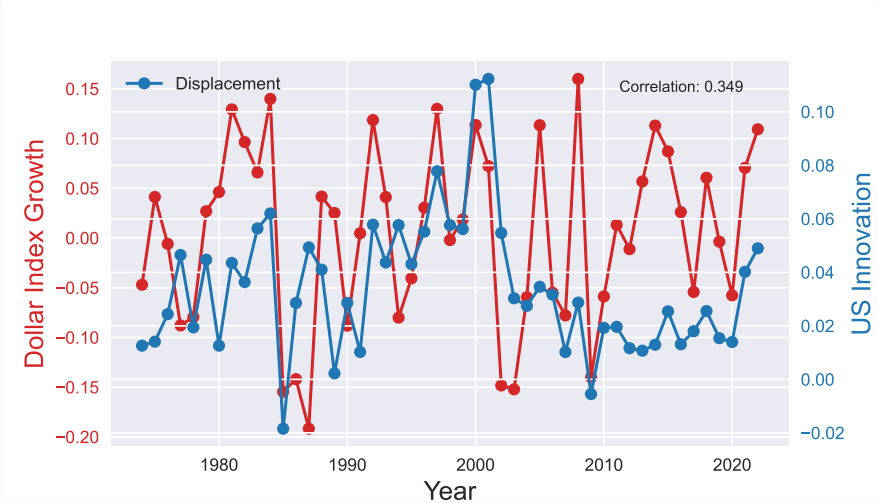
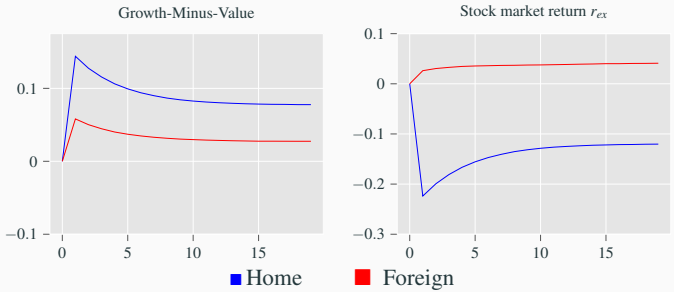
Model Prediction: the gap between the returns on a portfolio invested in incumbent firms and the growth in aggregate market capitalization negatively correlated with US dollar.

The real dollar index and displacement shock



Stock Returns: High- vs Low-Growth Firms

Response to Displacement Shock: News about **current** innovation



News about future US innovation increases motive for holding US innovative firms

Model Prediction: the gap between the returns on a portfolio invested in high-growth vs low-growth (value) stocks positively correlated with exchange rates.

Real Exchange Rates and Returns of Growth vs Value Stocks

Growth in real exchange rates	Panel Estimates		
	(1)	(2)	(3)
GmV return	-0.008**	-0.008**	-0.008**
	(0.003)	(0.003)	(0.003)
Time Fixed Effects	Y	Y	Y
Lagged real exchange rates	Y	Y	Y
Lagged output growth		Y	Y
Lagged consumption growth			Y
Observations	430	430	430
R2	0.602	0.603	0.605

Evidence: Higher relative returns of local high-growth stocks (relative to value) are positively correlated with local exchange rates.

Conclusion

- A quantitative GE model that targets the joint dynamics of exchange rates, innovation, consumption, wealth changes, stock returns and trade flows.
- **Idea:** Due to incomplete markets, innovation leads to wealth reallocation and an increase in marginal utility for local investors, which leads to an appreciation of the local currency.
- Local and foreign investors hold high-growth (technology) stocks to hedge displacement risk.
- Novel mechanism for holding dollars: **investing in the shares of U.S. innovative firms.**

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