# Tech Dollars: Technological Innovation and Exchange Rates*

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**Abstract**

We document a positive link between U.S. innovation, dollar appreciation, and foreign capital inflows. To explain these patterns, we develop a general equilibrium model in which innovation-driven productivity gains accrue disproportionately to entrepreneurs. The calibrated version of the model replicates the joint dynamics of the dollar, equity returns, inequality, output growth, and trade flows, highlighting a new channel between innovation and global capital flows. In our model, foreign investors invest in US technology stocks to share the gains of US innovation; the dollar appreciates not because it is a safe asset but as a claim on US innovation.

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Over the recent decades, many significant innovations have originated in the US. Importantly, periods of significant technological breakthroughs in the U.S.—such as the rise of personal computers in the 1980s, the emergence of internet companies around 2000, and recent advancements in artificial intelligence and large language models—have coincided with times of a strong dollar. Is this positive correlation consistent with existing theories? Not really: models of exchange rates that assume complete markets suggest that innovation-driven booms should lower marginal utility and lead to real exchange rate depreciation. If markets are complete, good news for the U.S. implies wealth transfers to the rest of the world (insurance) and a weaker dollar. Yet this prediction is at odds with the data: empirical evidence shows a weak, sometimes even positive, correlation between output or consumption growth and exchange rates (Backus and Smith, 1993).

In this paper, we begin by documenting a strong positive correlation between US innovation and the growth of the real dollar index. Then, we provide a theoretical model that rationalizes this positive comovement. The key assumption in the model is that markets are incomplete: a significant fraction of the gains from innovation accrue to innovators (entrepreneurs) or other workers that are key in the production of innovation. Hence, these gains cannot be fully appropriated by investing in the shares of US firms and therefore cannot be fully shared globally. Importantly, this is a different type of incompleteness than existing models which feature essentially segmented asset markets (for instance, Itskhoki and Mukhin, 2021; Kekre and Lenel, 2024a). Home investors can invest in foreign stocks and bonds without any frictions in our model.

In our model, increases in the rate of US innovation lead to an increase in the US share of global wealth and an increase in US output and consumption growth. Importantly, despite the increase in consumption, the average marginal utility for US households also increases because most US households are left behind while a few prosper—a mechanism similar to Constantinides and Duffie (1996).[1] As a result, the real exchange rate appreciates. Overall, the model is consistent with the joint dynamics of exchange rates, wealth shares, output and consumption growth, income inequality, and stock returns. Importantly, the model generates a novel mechanism for holding dollars: investing in the shares of US innovative firms. Consistent with this prediction, we show that US innovation is associated with an increase in foreign capital inflows at both the aggregate and firm levels.

We begin by analyzing the empirical relationship between real dollar appreciation and U.S. innovation—measured using the approach of Kogan, Papanikolaou, Seru, and Stoffman (2017). Focusing on the post-Bretton Woods era, we document a robust positive correlation: a one-standard-

[1] The increase in marginal utility in response to innovation shocks is also present in Papanikolaou (2011); Gârleanu, Panageas, Papanikolaou, and Yu (2016); Kogan, Papanikolaou, and Stoffman (2020); Huang, Kogan, and Papanikolaou (2023). Kogan et al. (2020) build a general equilibrium model with capital embodied technology shocks in which benefits of innovation are distributed asymmetrically across the economy. They show that the resulting displacement risk can lead to increased demand for insurance (an increase in the stochastic discount factor) and can help rationalize certain cross-sectional features of asset returns. Gârleanu et al. (2016) embed a reduced-form of this mechanism in a standard endowment model and study its implications for the equity risk premium. Huang et al. (2023) examine this mechanism in a multi-region model of a monetary union and study its implications for regional inflation dynamics.

deviation rise in innovation is associated with approximately a 3 to 4 percent appreciation in the real exchange rate. Furthermore, our measure of innovation strongly correlates with U.S. productivity growth, as captured by utilization-adjusted total factor productivity (TFP) from Fernald (2014). From the perspective of complete markets, this positive correlation presents a puzzle: if high innovation in the US represents favorable states for US households, the US would transfer wealth to the rest of the world, leading to a depreciation of the real exchange rate and a reduction in US relative wealth.

We next present evidence consistent with imperfect international risk-sharing of innovation shocks. Specifically, we show that higher U.S. innovation is associated with an increase in the relative wealth of U.S. households compared to the rest of the world, as well as rising income inequality within the U.S. Additionally, innovation shocks coincide with significant foreign capital inflows at both aggregate and firm levels. Aggregate measures reveal a clear positive correlation between U.S. innovation and inflows of foreign direct investment and portfolio equity to the US. At the firm level, we find that U.S. companies experiencing an innovation shock—measured by the grant of valuable or significant new patents—subsequently attract greater foreign institutional ownership.

Our goal is to rationalize these patterns in a simple model. To clarify the economic mechanism, we start with a set of minimal ingredients: a two-country endowment economy with log utility and home-bias in consumption. In addition to standard aggregate endowment shocks, each country experiences displacement shocks designed to capture key aspects of creative destruction. To keep the exposition simple, we model the process of creative destruction in reduced form following Gârleanu et al. (2016): economic growth arises partly from new, innovative projects (firms) that potentially displace incumbents. We show how our reduced form assumptions can be micro-founded using a more elaborate quality ladder model in the style of Aghion and Howitt (1992) in which creative destruction has an aggregate (systematic) component. Crucially, markets are incomplete: new projects are not owned by existing shareholders but rather randomly allocated to a small subset of agents. Households cannot trade away their future claims to these potential innovations. Thus, shocks that increase the relative profitability of new firms redistribute wealth from incumbent owners to new entrepreneurs, amplifying consumption inequality, increasing marginal utility and the relative price of the home currency.

Our theoretical model delivers a number of predictions that are consistent with the data. First, it sheds new light on the Backus and Smith (1993) puzzle, specifically the weak correlation between exchange rates and relative consumption and output growth. In our model, bilateral exchange rate growth depends not only on the relative consumption growth between home and foreign countries but also crucially on shifts in their relative wealth. Increases in innovation in the home country lead to real exchange rate appreciation and increased value of domestic assets and the country's aggregate wealth. This prediction is consistent with the findings of Dahlquist, Heyerdahl Larsen, Pavlova, and Penasse (2023): increases in a country's relative wealth coincide systematically with real exchange rate appreciation. Moreover, once we account for changes in relative wealth, the correlation between exchange rate movements and standard macroeconomic fundamentals turns negative and statistically significant—precisely as standard complete-market logic would suggest.

Second, a positive innovation shock in the model leads to an increase in income inequality, a prediction that is consistent with the evidence in Aghion, Akcigit, Bergeaud, Blundell, and Hemous (2018). As a result, our model implies a positive correlation between exchange rates and changes in relative income inequality between the home and foreign country. This prediction is consistent with the findings in Kocherlakota and Pistaferri (2008). Replicating their analysis in our sample of eleven countries covering the post-Bretton Woods era, we find a positive and economically significant correlation between changes in bilateral exchange rates and changes in relative income inequality. For instance, focusing on the coefficients from the pooled regression, a one-standard-deviation increase in income inequality in a foreign country relative to the United States is associated with a 1.7 log point appreciation of its currency relative to the US dollar.

Third, the model suggests a direct proxy for the displacement shock that follows the logic in Gârleanu et al. (2016). In particular, the difference between the aggregate market capitalization growth and the returns from holding the market portfolio is related to the realizations of the displacement shock in the model. This gap emerges because market investors must continuously liquidate existing positions to finance purchases of shares in new, entering firms, ensuring the portfolio remains self-financing. More broadly, this gap also reflects equity issuance by incumbent firms—either to fund new projects or to compensate innovators with equity grants—which effectively dilutes the claims of existing shareholders and reallocates ownership. Consequently, as new firms enter the market, returns on the market portfolio consistently lag behind aggregate market capitalization growth. Using this insight, we construct an empirical displacement shock measure for the U.S. and find that it is positively correlated with the appreciation of the real US dollar. Notably, periods characterized by significant innovation and the entry of new firms (projects) systematically coincide with real dollar appreciation.

We then explore the ability of our mechanism to quantitatively account for these empirical patterns. To this end, we introduce some additional elements: we allow for recursive preferences over relative consumption and relax the assumption of extreme inequality—a positive measure of households receives new projects and some of these projects accrue to firms so all investors could appropriate a fraction of these gains. In addition, we allow for the distribution of the displacement shock to vary over time. Though these modifications are not needed to qualitatively explain the key patterns in the data, they help the model deliver realistic quantitative predictions.

Our model successfully replicates the joint dynamics of innovation, exchange rates, consumption growth, and capital flows, while generating low and relatively smooth risk-free rates. Importantly, our model quantitatively reproduces the three key 'anomalies' in the exchange rate literature: the volatility puzzle of Brandt, Cochrane, and Santa-Clara (2006), the Backus and Smith (1993) correlation puzzle, and the violation of the uncovered interest rate parity (UIP). The key to replicating the failure of the UIP is the time-varying distribution of the displacement shock. To ensure that the magnitudes of displacement shocks are realistic, we discipline the distribution of the displacement shock using the moments of income inequality in the data.

Last, we explore the implications of our model for the joint dynamics of exchange rates and stock returns. In the extended model, a fraction of the gains from innovation accrue to stock market investors. Introducing some degree of ex-ante firm heterogeneity—some firms are more likely to innovate than other firms, and hence have higher valuations—leads to new testable implications. Specifically, an appreciation of the home currency is associated with higher stock returns for these high-growth firms relative to low-growth firms in the home country, and most importantly, higher relative returns of high-growth firms relative to low-growth firms in the foreign country (a difference in differences). We conclude our analysis by verifying this implication is indeed consistent with the data.

Our work contributes to several strands of the literature. Over the last several decades, a voluminous literature has studied the determination of exchange rates in two-country equilibrium models.[2] Similar to most of these models, our model requires a high degree of home bias in household preferences to generate sufficiently volatile exchange rates given the high level of correlation in consumption growth across countries. Our key innovation relative to these papers, however, is that exchange rates are pro-cyclical in our model, since increases in technological innovation are positively correlated with future growth in consumption, productivity and output.

In this regard, our work is highly complementary to the findings of Chahrour, Cormun, De Leo, Guerrón-Quintana, and Valchev (2024), who document a correlation between the dollar exchange rate and subsequent movements in total factor productivity. Specifically, Chahrour et al. (2024) identify a shock to future TFP growth in the US using VARs, and show that this shock leads to an appreciation of the dollar over the short run. These patterns are hard to reconcile with models with complete markets (for example Colacito and Croce, 2013), in which positive news on future productivity would lead to lower marginal utility of US investors and therefore to a depreciation of the dollar. By contrast, our model is both qualitatively, but also quantitatively, consistent with this pattern: a positive innovation shock in the US leads to both higher productivity and output growth in the US, but also to an appreciation of the dollar.

More broadly, our work addresses the 'exchange rate disconnect' puzzle—the persistently weak correlation between exchange rates and fundamentals.[3] While this puzzle has motivated various models featuring segmented or incomplete asset markets, our mechanism is distinct.[4] Existing models

[2]See, for example, Alvarez, Atkeson, and Kehoe (2002, 2007, 2009); Pavlova and Rigobon (2007, 2008, 2010, 2011); Verdelhan (2010); Colacito and Croce (2011, 2013); Colacito, Croce, Gavazzoni, and Ready (2018); Gavazzoni and Santacreu (2020); Liu and Shaliastovich (2022); Kekre and Lenel (2024b).

[3]See, for instance Meese and Rogoff (1983); Obstfeld and Rogoff (2001).

[4]An incomplete list includes Bacchetta and Van Wincoop (2006); Hau and Rey (2006); Farhi and Werning (2014); Itskhoki and Mukhin (2021); Lustig and Verdelhan (2019); Greenwood, Hanson, Stein, and Sunderam (2020);

typically assume exogenous capital flow shocks that are orthogonal to fundamentals, and study their implications for exchange rates under imperfect risk sharing (e.g., Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021). By contrast, our model's market incompleteness arises endogenously from imperfect risk-sharing of agents' endowment shocks. Capital flows are endogenously determined in equilibrium.

Our model generates a positive correlation between capital inflows and currency appreciation, consistent with the findings of Hau and Rey (2006). In the model, a positive innovation shock in the home country is associated with the creation of new firms (projects) which are initially owned by a small subset of households (entrepreneurs). Entrepreneurs sell their shares to diversify their holdings and foreign investors buy some of these shares to rebalance their portfolio as the share of the home country in the world market portfolio increases. The net effect is that the home country experiences net capital inflows and its currency appreciates.

A key implication of our framework is that both home and foreign investors invest in high-growth stocks during the early stages of innovation booms to appropriate some of the gains of future innovation waves in the home country. This 'fear of missing out' increases the value of growth stock prices early in the innovation cycle, as investors respond to elevated—but potentially noisy—expectations about future growth, leading to low average returns in the future. However, once a true wave of innovation is realized, returns on growth stocks rise significantly. Consistent with this mechanism, we document a positive cross-sectional association between growth-minus-value portfolio returns and countries' exchange rates.

Our work also connects to the voluminous literature that aims to rationalize the failure of uncovered interest parity (UIP) in the data (Fama, 1984). Overall, the literature suggests that the UIP puzzle can be explained either by time variation in higher-order moments of the stochastic discount factor or by cross-country differences in economic environments.[5] More recently, Hassan, Mertens, and Wang (2024) argue that the puzzle is still unresolved, as many of these existing models imply a counterfactually high predictability of exchange rates by interest rate differentials. Their critique does not apply to our work: the UIP fails to hold in our model even as exchange rates are essentially unpredictable by interest rate differentials.

Our work contributes to the growing body of literature that studies the special role of dollar assets in international markets. Previous studies have focused on the US's role as a global insurance provider and its exorbitant privilege, the convenience yield of holding US assets, and more recently the impact of US fiscal policy.[6] Our work offers a novel perspective: a key motive for investors to hold dollars is to invest in innovative technology firms in the US. Thus, part of the strong demand

Gourinchas, Ray, and Vayanos (2020); Camanho, Hau, and Rey (2020); Fang and Liu (2021); Fang (2021); Fukui, Nakamura, and Steinsson (2023); Jiang, Krishnamurthy, and Lustig (2023); Kekre and Lenel (2024a).

[5] See, for instance, Backus, Foresi, and Telmer (2001); Verdelhan (2010); Martin (2011); Hassan (2013); Colacito and Croce (2013); Ready, Roussanov, and Ward (2017); Colacito et al. (2018); Richmond (2019); Wiriadinata (2021).

[6] See, for example, Gourinchas and Rey (2007a,b); Gourinchas, Rey, and Govillot (2010); Atkeson, Heathcote, and Perri (2022); Dahlquist et al. (2023); Sauzet (2023); Jiang, Krishnamurthy, and Lustig (2021); Jiang, Krishnamurthy, Lustig, and Sun (2021); Atkeson et al. (2022).

for dollar assets is driven by the increased rates of technological innovation in the US relative to the rest of the world.

At a first glance level, our mechanism appears related to the Balassa (1964); Samuelson (1964) effect. The traditional Balassa-Samuelson logic posits that productivity gains in the tradable sector lead to real exchange rate appreciation, as higher wages in the tradable goods sector spill over to the non-tradable sector, which leads to an increase in the price of non-tradable goods and hence the real exchange rates. Subsequent work also pointed out that workers experiencing a positive wealth shock due to higher wages will also increase their demand for non-tradable goods, which also leads to an increase in the price of non-tradables and the real exchange rate (see Froot and Rogoff, 1995, for a review). Our mechanism is related, but distinct: technological innovation leads to an increase in consumption and wealth, but it also leads to an increase in within-country inequality and therefore to an increase in marginal utility through the Constantinides and Duffie (1996) effect. Absence of arbitrage and complete international financial markets implies that the exchange rate appreciates.

# 1 Dollar Exchange Rates and US Innovation

We begin by documenting a set of stylized facts regarding the joint dynamics of US innovation, the real exchange rate, capital flows, and the distribution of income and wealth. Below, we briefly discuss the sources of main variables in our analysis. Appendix A contains additional details.

## 1.1 Data Sources

Our sample consists of a combination of G-10 currency countries and G-7 countries. Specifically, it includes Australia, Canada, Germany, Japan, Norway, New Zealand, Sweden, Switzerland, United Kingdom, France, Italy and the United States. We take the domestic country to be the United States and define the exchange rate as the units of foreign currency per dollar. The sample period covers the post-Bretton Woods era (1974 to 2022).

We obtain end-of-year nominal exchange rates from the IMF. The real exchange rate is calculated by adjusting nominal exchange rates by the relative CPI index of the corresponding country. We calculate the growth of the real dollar index as the equal-weighted average of the log growth rates of the real dollar exchange rates against the currencies in our sample. The level of the dollar index is obtained by accumulating these growth rates over the past years.

We obtain data on consumption, GDP, and net exports from the World Development Indicators published by the World Bank. We use household final consumption expenditure for consumption series, and the difference between the indices of export of goods and imports of goods and services as our net export series. Both consumption and GDP are real. We measure income inequality using the top 1% income share and obtain data on the top income share from the World Inequality Database. The World Inequality Database also provides each country's total net wealth (code =

mnweal) in local currency. To convert each country's wealth into US dollars, we multiply the total net wealth by the corresponding exchange rate.

We measure the annual US innovation level as the log of the ratio of the total economic value of patents (Kogan et al., 2017) each year to the total stock market capitalization at the end of the year. Data on aggregate foreign direct investment and portfolio equity flows are obtained from the World Bank. The interest rate data come from Global Financial Data. Real interest rates are constructed using three-month T-bill yields from the Global Financial Data, adjusting for realized inflation using annual changes in CPI. Data on equity index returns (MSCI series) are obtained from Datastream.

## 1.2 Innovation and the US Dollar

We begin by documenting a positive correlation between US innovation and contemporaneous growth of the real dollar exchange rate. We estimate the following specification

$$\Delta \log e_{t+1}^{USD} = \alpha + \beta \, Inno_{US,t+1} + c \, \mathbf{Z}_t + \varepsilon_{t+1} \tag{1}$$

The dependent variable is the growth in the (log) dollar index level from $t$ to $t+1$. The independent variable is the US innovation at year $t+1$. Depending on the specification, we include the lagged dollar index level, lagged US innovation, or both as control variables. We also control for lagged US output growth. Standard errors are calculated using the Newey-West procedure, with a bandwidth of one year.

Table 1 reports the estimates from (1). We see an economically and statistically significant positive correlation between the level of US innovation and the growth of the US dollar index. This suggests that technological booms coincide with a stronger dollar, contrary to what standard models predict under complete risk-sharing. A one-standard-deviation increase in US innovation is associated with approximately 3 to 4 log points of exchange rate appreciation at the annual level. Figure 1 plots the innovations in the series of real dollar index growth and US innovation, orthogonalized with respect to lagged US innovation and the lagged dollar index. The specification corresponds to column (3) in Table 1. Examining the figure, we observe that, first, the two series are highly correlated, and, second, during periods of significant innovation, such as the internet boom around the 2000s and the AI boom during the 2020s, US innovation is high, and the dollar appreciates in real terms.

This positive correlation between the US dollar index and US innovation is robust to alternative specifications. Specifically, Appendix Table A.1 shows that our results remain qualitatively similar when using the trade-weighted dollar index from the Fed. In addition, we define annual US innovation as the log of the ratio of the total real economic value of patents (Kogan et al., 2017) to the total number of patents. Appendix Table A.2 presents the results, showing that this alternative measure is positively correlated with the growth of the real dollar index.

Last, we also examine the correlation between US innovation and the US dollar in a panel regression,

$$\Delta \log e_{F,t+1} = \alpha + \beta\, Inno_{US,t+1} + c\, \mathbf{Z}_t + \varepsilon_{F,t+1}. \tag{2}$$

Compared with (1), the dependent variable now is the growth in the bilateral exchange rate $e$ between the foreign country $F$ and the US. The advantage of doing so is that now we can include several country-level controls that can account for the variation in bilateral exchange rates. The control variables $\mathbf{Z}_t$ include the lagged innovation level, lagged growth of output ratio, and the lagged exchange rate level. We include country fixed effects, with standard errors computed using the Driscoll and Kraay (1998) methodology to account for heteroskedasticity, serial correlation, and cross-sectional dependence due to the fact that all the bilateral exchange rates are against the US dollar.

We report the estimates from equation (2) in the last column of Table 1. Examining the estimated coefficient $\beta$, we note that its point estimate is similar in magnitude with the response of the US dollar index: a one-standard-deviation increase in the dollar value of innovation is associated with a 2.6 to 3.9 log-point appreciation of the dollar over the next year. Last, Appendix Table A.4 reports results separately for individual countries. Even though the standard errors are larger due to the smaller number of observations, we see that the point estimates are positive in 10 out of the 11 cases.

Overall, we show that the level of innovation in the US is strongly associated with appreciation in the US dollar over short horizons. Here, we note that our results are largely in line with the recent literature emphasizing the importance of news about TFP shocks as a key driver of exchange rates (Nam and Wang, 2015; Chahrour et al., 2024). In particular, Chahrour et al. (2024) argue, using a vector auto-regression, that news shocks about future TFP are the dominant driver of exchange rates. Given that our innovation measure is positively correlated with future TFP growth (Kogan et al., 2017), our results are highly complementary to Chahrour et al. (2024). More specifically, Kogan et al. (2017) show that the measure of innovation that we use is positively correlated with future productivity and output growth in the US. For completeness, we replicate their results in Appendix Figure A.1. In terms of magnitudes, a one-standard-deviation increase in US innovation is associated with an annual growth of 0.3 to 0.4 log points in US TFP.

### 1.3 Innovation, Income and Wealth

Next, we provide evidence consistent with incomplete markets. We show that when the US innovation rate rises, the gains are not fully shared internationally or within the US. We find that a rise in US innovation is associated with an increase in the US wealth share. At the same time, top income inequality within the US also increases. Both patterns indicate that innovation benefits are concentrated rather than broadly shared.

First, we examine the response of countries' relative wealth in response to innovation shocks. To this end, we re-estimate equation (2), but now use the change in the wealth ratio between the US and foreign countries as the dependent variable. As before, estimating this relation in a panel allows us to partial out global fluctuations in wealth that are unrelated to innovation. As our baseline, we measure country wealth using the World Inequality Database, which provides each country's total net wealth in local currency. To convert each country's wealth into US dollars, we multiply the total net wealth by the corresponding exchange rate. Columns (1) to (4) of Table 2 present the results.

Examining Table 2, we see that increases in innovation are associated with an increase in US wealth relative to foreign countries. A one-standard-deviation increase in US innovation is associated with a 3 log point increase in the share of US wealth relative to foreign countries. Overall, we see that an increase in US innovation is associated with a net transfer of wealth from foreign countries to the US. Put differently, the gains from US innovation accrue disproportionately more to US rather than foreign households. This fact is consistent with incomplete markets—imperfect risk sharing across foreign and US investors.

Second, we examine the extent to which US innovation is associated with reallocation of wealth within a country. Given the difficulty of measuring wealth inequality across countries, we focus on income inequality instead. We examine the response of country level income inequality to US Innovation. Specifically, we re-estimate equation (2), but now replace the dependent variable with the growth in the income inequality in the United States relative to foreign countries. As before, estimating this relation using a panel specification allows us to parcel out common movements in inequality across countries. Columns (3) and (4) of Table 2 report our estimates. We see that an increase in the rate of innovation in the United States is also associated with an increase in income inequality, which again indicates imperfect risk sharing, but now within rather than simply across countries.

### 1.4 Innovation and Capital Flows

In a world where countries share the benefits of US innovation, the arrival of innovation shocks in the US should translate into capital flows from the US to the rest of the world. By contrast, in a world where innovation shocks are imperfectly shared, we would expect to see a capital inflow from the rest of the world to the US as US firms become more innovative.

We first examine the relationship between US innovation, US foreign direct investment (FDI) inflows, and US portfolio equity inflows at the aggregate level. Panel A of Figure 2 shows the trends in US innovation intensity and FDI inflows over time. The correlation between US innovation and FDI inflows is approximately equal to 31 percent. US innovation experienced a significant boom around 2000, driven by advancements in internet technology, and this period was associated with a large increase in FDI inflows. Panel B plots the relationship between US innovation and aggregate portfolio equity flows. We observe a significant positive correlation between the two time series (approximately 30 percent). Moreover, periods of higher innovation intensity are associated with increased portfolio equity inflows.

A key advantage of our innovation measure is its granularity: we can observe the value of innovation performed by a given firm in a given year. This granularity allows for a sharper test of our hypothesis: does foreign capital flow into innovative firms? To explore this, we next shift our focus to portfolio equity flows at the firm level using measures of firm innovation based on patents. We use three approaches to adjust for patent quality. First, we adjust the number of patents based on their number of forward citations. Second, we adjust patents for their economic value, according to Kogan et al. (2017). Breakthrough patents are defined as being in the top 20% based on citations or economic value in each year. Lastly, we use consider an alternative definition of patent importance based on Kelly, Papanikolaou, Seru, and Taddy (2021), where we breakthrough patents as those that are in the top 20% of the distribution in terms of their impact and novelty.

We then examine how foreign institutional capital responds to firm-level innovation shocks,

$$\Delta \text{ForeignInstOwn}_{i,t+1} = \alpha + \beta \log(inno)_{i,t} + \gamma \mathbf{Z}_{i,t} + \varepsilon_{i,t+1}, \tag{3}$$

where the dependent variable is the change in foreign institutional ownership for firm $i$ between $t$ and $t+1$, obtained from the FactSet Lionshare database. The main independent variable is the (log) number of important patents granted to firm $i$ in the previous year $t$, according to three innovation measures to capture patent quality. When *inno* is equal to zero, we replace $\log(inno)$ by zero and add a dummy equal to one if *inno* is equal to 0, thereby preventing the removal of the observation from the data. The vector of controls $X_{i,t}$ includes foreign institutional ownership at time $t$, along with firm and year fixed effects. We also estimate a specification where we add the firm's sales (log) and size at time $t$ as additional controls. The sample covers 2000-2017, allowing patents a five-year window for citation accumulation.

Table 3 presents the estimated coefficient $\beta$ from equation (3). Examining the table, we see that foreign institutional ownership increases after firm innovation increases based on all three of our measures. In terms of magnitude, a one-standard-deviation increase in quality-adjusted patent grants is associated with approximately a 0.2 percentage point increase in the ownership of foreign institutional investors—which is quantitatively meaningful given that the average foreign institutional ownership in our sample is approximately equal to 3 percent. Moreover, these estimates remain robust after controlling for firm size and revenue (Columns 4 to 6 of Table 3), as well as for foreign institutions' time-varying preferences for specific sectors (Columns 7 to 9 of Table 3). These findings are consistent with the notion that technological innovations attract international equity capital flows. The heightened demand for US stocks, which embody frontier technology, drives up the demand for dollars.

# 2 Model

So far, we have documented that increases in the rate of innovation in the US result in appreciation of the dollar and capital inflows, together with an increase in the wealth share of the US and income inequality. The responses of capital flows, relative wealth and income inequality strongly suggest that an incomplete market for innovation shocks is a key ingredient. That is, it appears to be the case that households, either in the home or foreign country, cannot purchase Arrow-Debreau securities whose payoff is contingent on the realization of innovation shocks. If households cannot commit ex-ante to sharing the gains from innovation with others, then the arrival of innovation shocks will coincide with wealth reallocation, both within but also across countries, consistent with our findings in the previous section.

Why would innovation shocks lead to a dollar appreciation? To fix ideas, consider first a closed economy. If innovation shocks are imperfectly shared across households within the innovative country, then there is a wedge between the average marginal utility of individual households, and the marginal utility of a representative agent that consumes the aggregate endowment (Kogan et al., 2020; Gârleanu et al., 2016). Thus, it is possible that higher innovation increases both aggregate consumption but also leads to higher average marginal utility across households. Since the absence of arbitrage implies that the real exchange rate is related to the ratio of marginal utilities across countries, this mechanism could rationalize why innovation shocks in the US lead to an appreciation of the dollar.

In what follows, we embed this mechanism in a two-country model that introduces a minimal departure from the standard models. Households in both the foreign and home country can trade goods and can invest in stocks and bonds issued by firms in either country. The only market incompleteness is that the gains from innovation are imperfectly shared: part of the benefits of innovation accrue to new firms, which are randomly allocated to a small fraction of existing households in the economy. Once these new firms enter the market, other households (domestic or foreign) purchase shares as part of holding a diversified portfolio. To simplify the exposition, we start with a simple endowment economy model that provides analytic expressions. Section 2.5 provides explicit microfoundations for our key assumptions. Section 3 embeds our mechanism in a more general model that can be calibrated to quantitatively fit the data.

## 2.1 Setup

The economy consists of two countries, home ($H$) and foreign ($F$), and two goods, $Y_H$ and $Y_F$ produced by each country. Time is discrete and is indexed by $t$.

**Production**

There is a continuum of firms in each country that produce output. Firms in each respective country only produce the local good. That is, the firms in the home country only produce the $Y_H$ good, while foreign firms only produce the $Y_F$ good. There is an expanding measure of firms in each country, indexed by $(i, s, c)$ where $s$ denotes the date at which the firm is created, $i \in [0, 1]$ denotes the index of the firm within its cohort in each country, and $c \in \{H, F\}$ denotes the country.

A firm characterized by $(i, s, c)$ produces a flow of output $y_{t,s}^{i,c}$ at time $t$, according to

$$y_{t,s}^{i,c} = a_{t,s}^{i,c} Y_{c,t} \tag{4}$$

Here, $a_{t,s}^{i,c} \in [0, 1]$ denotes the fraction of aggregate output accruing to a firm $i$ located in country $c$. By construction, these shares add to one

$$\sum_{s \leq t} \left( \int_{i \in [0,1]} a_{t,s}^{i,c} \, di \right) = 1, \quad c \in \{H, F\} \tag{5}$$

The model has an element of creative destruction, in which new productive units displace existing ones. We model this in reduced form, following Gârleanu et al. (2016), but provide an explicit microfoundation in Appendix B.2. Each period a new set of firms arrives exogenously in each country. These new firms, indexed by $i \in [0, 1]$, are heterogeneous in their productivity. The productivity of a newly arriving firm $i$ in country $c \in \{H, F\}$ satisfies

$$a_{t,t}^{i,c} = (1 - e^{-u_t^c}) \, dL_t^{i,c} \tag{6}$$

where $u_t^H, u_t^F$ are random, non-negative, shocks in home and foreign countries, affecting all firms in each country at time $t$. The components $L_t^{i,H}, L_t^{i,F}$ denote cross-sectional measures and its increment $dL_t^{i,H}, dL_t^{i,F}$ are random, non-negative, idiosyncratic productivity components, which are determined at time $t$ and satisfies $\int_{i \in [0,1]} dL_t^{i,H} = 1$ and $\int_{i \in [0,1]} dL_t^{i,H} = 1$. It follows that the total output produced by the cohort of firms born at time $t$ is equal to

$$\int_{i \in [0,1]} y_{t,t}^{i,c} = \left(1 - e^{-u_t^c}\right) Y_{c,t}. \tag{7}$$

Examining (7), we see that the innovation shocks $u_t^c$ reallocate revenue from incumbents to new entrants. Hence, we will also term them displacement shocks throughout the paper. Collectively, the fraction of output produced by existing firms in country $c$ is $e^{-u_t^c}$ . Specifically, the output share of an incumbent firm created at a time $s < t$ in country $c \in \{H, F\}$ is given by

$$a_{t,s}^{i,c} = a_{s,s}^{i,c} \exp \left( - \sum_{n=s+1}^{t} u_n^c \right) \tag{8}$$

Aggregate output in each country evolves according to

$$\Delta \log Y_{c,t+1} = \mu + \varepsilon^c_{t+1} + \delta\, u^c_{t+1}. \tag{9}$$

Note that output in each country $c$ is driven by two country-specific shocks, $\varepsilon$ and $u$. The first shock, $\varepsilon$, affects the output (and dividends) of all firms symmetrically. The second shock, $u$, is the innovation, or displacement, shock discussed above, which reallocates market share from incumbents to new firms. We allow this shock to affect aggregate output and parameterize its impact by $\delta \in (0, 1)$. Importantly, equation (9) can be explicitly derived from a relatively standard quality ladder model of endogenous growth. We provide such a microfoundation in Section 2.5 below.

**Households**

Each country is populated by a unit measure of infinitely-lived agents, indexed by $(i, c)$ where $i \in [0, 1]$ and $c \in \{H, F\}$ denotes their country. At time zero, households are equally endowed with all firms in existence at that time. Households have access to the financial market and maximize their expected utility of consumption

$$U^c_{i,t} = \mathrm{E}_t \sum_{s=t}^{\infty} \beta^s \log(C^c_{i,s}). \tag{10}$$

Household consumption $C^c_t$ is an aggregate of the two goods produced by the home country and the foreign country. Importantly, households exhibit 'home bias', that is, they tilt their consumption basket to the domestically produced good. That is, the consumption basket of each household living in country $c \in \{H, F\}$ at date $t$ is given by

$$C^H_t = (x^H_{H,t})^{\alpha}(x^H_{F,t})^{1-\alpha}, \qquad C^F_t = (x^F_{H,t})^{1-\alpha}(x^F_{F,t})^{\alpha} \qquad \text{with} \quad \alpha \in \left(\frac{1}{2}, 1\right) \tag{11}$$

Here, $x^c_{H,t}$ and $x^c_{F,t}$ denote the consumption of the home and foreign good by country $c \in \{H, F\}$ at date $t$. The parameter $\alpha \in (\frac{1}{2}, 1)$ captures the degree of home bias in household preferences.

To ensure that wealth distribution within each country is stationary, we assume that households have finite lives: at each date $t$, a mass $\xi$ of agents, chosen randomly, die, and a mass of $\xi$ of new agents are born, so that the population remains constant. As in Blanchard (1985), households can hedge their mortality risk using a competitive annuity market that operates within each country. Households are risk averse, hence they all purchase annuities. The annuity issuer collects the wealth of deceased households $\xi W$ and distributes the proceeds to the surviving population and the newly born agents in the same country.

Last, we normalize the price of the home consumption good (the numeraire) to one; hence,

$$\alpha\, p_{h,t} + (1 - \alpha)\, p_{f,t} = 1 \tag{12}$$

where $p_{h,t}$ and $p_{f,t}$ are the price of the home and foreign goods, respectively.

### Creative Destruction and New Firms

Each period, households innovate with some probability. Successful innovation leads to the creation of new firms. The key feature of the model is that households cannot share this risk ex-ante, that is, they cannot sell claims against their future endowment of these new firms, as in Kogan et al. (2020). As a result, a shock to the relative profitability of new firms $u$ leads to the redistribution of wealth from the owners of existing firms to the new entrepreneurs.

In particular, at time zero, agents are equally endowed with all the firms in existence at that time. From that point onward, agent $(i, c)$ where $i \in [0, 1]$ and $c \in \{H, F\}$ receives firm $(i, t, c)$ at time $t$, i.e., a new firm with productivity proportional to $a_{t,t}^{i,c}$. To simplify the exposition, we first focus on the limiting case in which firm creation generates extreme inequality—as in Gârleanu et al. (2016). Specifically, we assume that only a set of measure zero of firms manages to produce non-zero profits; by contrast, the vast majority of new firms are worthless.[7] Consequently, when making consumption and saving decisions, households attach zero probability to the event that they receive a profitable firm.[8]

### Financial Markets

Households can trade a complete set of securities contingent on the realization of aggregate shocks. That is, they can trade equity claims on existing firms and risk-less, zero-net-supply bonds in either country. Effectively, consumers can trade a full set of contingent claims on the realizations of the displacement shocks $(u^H, u^F)$ and the neutral shocks $(\varepsilon^H, \varepsilon^F)$ that drive output growth.

Importantly, however, a key market is missing: consumers cannot enter contracts that are contingent on the realized value of their future endowments of new firms. This market incompleteness is a key part of the mechanism, as it introduces a wedge between aggregate consumption growth and the marginal utility of the average investor.

## 2.2 Equilibrium

Our definition of equilibrium is standard. An equilibrium is a set of price processes, consumption choices, and asset allocations such that (a) consumers maximize expected utility over consumption and asset choices subject to their dynamic budget constraint, (b) all asset and goods markets clear.

[7] More formally, we assume that, for every $t$, the distribution of idiosyncratic productivity $dL_t^{i,c}$ consists exclusively of point masses. That is, we assume that $L_t^c$ is a discrete measure on $[0, 1]$, so that it is an increasing, right-continuous, left-limits process that is constant on $[0, 1]$ except on a countable set, where it is discontinuous. Both the magnitudes of the jumps of $L_t$, and the locations of the points of discontinuity are random. This assumption ensures that only a set of measure zero of consumers obtains the profitable new firms.

[8] More precisely, what matters for household portfolio decisions is the probability of obtaining a new firm times the marginal utility of consumption in that state. Not only is the probability of receiving a new firm equal to zero, but also is the marginal utility of wealth (and consumption) since each firm is extremely valuable.

Markets are incomplete, hence households' marginal utilities are not equalized across states. To solve for the competitive equilibrium, we construct a representative agent whose preferences are a weighted average of household utilities in each country

$$\max_{\{x_{c,t}^H, x_{c,t}^F\}} \sum_t \beta^t \left(\log C_t^H + \lambda_t \log C_t^F\right) \tag{13}$$

This representative agent maximizes her utility subject to the resource constraints,

$$x_{c,t}^H + x_{c,t}^F = Y_{c,t}, \qquad c \in \{H, F\}, \tag{14}$$

along with the consumption aggregator in (11).

Importantly, the Pareto-Negishi weight $\lambda_t$ is not a constant but depends on the state of the economy. In particular, $\lambda_t$ is the time-varying ratio of marginal utilities of either good in the two countries at time $t$. It is equal to the wealth ratio between the two countries, and it varies over time as a result of market incompleteness

$$\lambda_t = \frac{W_{F,t}}{W_{H,t}}, \qquad W_{c,t} \equiv \int_{i \in [0,1], c} w_t^{i,c} \tag{15}$$

where $W_{c,t}$ is the total wealth of households in country $c \in \{H, F\}$.[9]

In equilibrium, the ratio of wealth $\lambda_t$ between the foreign and the home country affects both real allocations and the terms of trade. For example, the relative price of the foreign good $Y$ in units of the domestic good $X$ is equal to

$$p_t \equiv \frac{p_{f,t}}{p_{h,t}} = \frac{Y_{H,t}}{Y_{F,t}} \frac{1 - \alpha + \alpha\lambda_t}{\alpha + (1-\alpha)\lambda_t}, \tag{16}$$

and depends not only on aggregate quantities $Y_{c,t}$, but also on the countries' relative wealth $\lambda_t$.

## 2.3 Displacement Risk and the SDF

The presence of displacement risk introduces a wedge between aggregate consumption growth and the stochastic discount factor. To understand why this is the case, note that, because of incomplete markets, the marginal utility of the 'representative' household is not only determined by aggregate consumption, but also by the realization of the displacement shock.

To see this, consider the following simplified version of the model, in which a) households have extreme home bias preferences $\alpha = 1$ (or equivalently, the single-country version of the model) and

[9] Here, we note that even though households in both countries are heterogeneous in their wealth, consumption-wealth ratios are equalized within each country which facilitates aggregation. Hence, the representative consumer in each country solves the same optimization problem. That said, it is important to emphasize that even though we construct the preferences of each representative household as a function of the country-level consumption variables $C_t^H$ and $C_t^F$, no household actually consumes that amount. Given our assumption, the effect of market incompleteness collapses into a scaling factor $\lambda_t^c$—and without loss of generality we have normalized $\lambda_t^H = 1$. See Appendix B.1 for more details.

b) the value of all new firms is equally and randomly allocated to a measure $\pi$ of the population. In this case, we can divide all households at each point in time into two groups, those that receive profitable new firms and those that do not. Agents have a constant consumption to wealth ratio, hence their consumption process is directly linked to the dividends of the firms they own. Hence, the equilibrium stochastic discount factor can be written as

$$\frac{M_{t+1}^c}{M_t^c} = \beta \left(\frac{Y_{c,t+1}}{Y_{c,t}}\right)^{-1} \left( (1-\pi)\, e^{u_{t+1}^c} + \pi \left(\frac{1-e^{-u_{t+1}^c}}{\pi}\right)^{-1} \right). \tag{17}$$

Recall that we have assumed that income inequality is extreme, that is, $L_t^i$ is comprised of point masses or equivalently $\pi \to 0$. In this case, the expression for the SDF simplifies to

$$\frac{M_{t+1}^c}{M_t^c} = \beta \left(\frac{Y_{c,t+1}}{Y_{c,t}}\right)^{-1} e^{u_{t+1}^c}. \tag{18}$$

Examining equation (18), we see that incomplete markets introduce a wedge between our stochastic discount factor and the one arising in a standard, Lucas-tree endowment economy. This additional term, given by $e^{u_{t+1}}$, adjusts for the fact that not all households experience the same growth rate in consumption; a set of measure zero experiences a dramatic increase as they receive new firms. Since marginal utility is a convex function of consumption, an increase in the dispersion of consumption growth raises the level of the stochastic discount factor, as in Constantinides and Duffie (1996).

Given the above, the dynamics of the stochastic discount factor in each country are given by

$$\frac{M_{t+1}^H}{M_t^H} = \beta \frac{C_t^H}{C_{t+1}^H} \frac{1}{b_{H,t+1}} \quad \text{and} \quad \frac{M_{t+1}^F}{M_t^F} = \beta \frac{C_t^F}{C_{t+1}^F} \frac{1}{b_{F,t+1}}, \tag{19}$$

where $b_{H,t+1}$ and $b_{F,t+1}$ are the wealth shares of the people in home and foreign country who did not receive profitable firms at $t+1$,

$$b_{H,t+1} = \frac{\int_{i\in[0,1],a_{t+1,t+1}^{i,H}=0} w_{t+1}^{i,H}}{\int_{i\in[0,1]} w_t^{i,H}} \quad \text{and} \quad b_{F,t+1} = \frac{\int_{i\in[0,1],a_{t+1,t+1}^{i,F}=0} w_{t+1}^{i,F}}{\int_{i\in[0,1]} w_t^{i,F}} \tag{20}$$

The difference between (19) and equation (18) above is due to the fact that households own both domestic as well as foreign stocks, which implies that $b_{H,t+1}$ depends on both the domestic as well as the foreign displacement shocks $u_H$ and $u_F$. That said, the relationship between $b$ and $u$ depends on the state of the economy, specifically, the relative wealth of the two countries, as captured by $\lambda$. For instance, when $\lambda$ is high, country $F$ is richer than country $H$. In this case, a small $u_H$ shock will likely lead to a larger change in $b_H$ than would be the case if country $H$ were richer than $F$—since the new trees created in country $H$ constitute a large share of wealth relative to the wealth of $H$ households.

### 2.4 Exchange Rates

We next characterize the behavior of the real exchange rate in the model. Because financial markets are integrated between the two countries, the absence of arbitrage implies that the exchange rate is equal to the ratio of the two countries' stochastic discount factors,

$$e_{t+1} = \frac{M^H_{t+1}}{M^F_{t+1}}. \tag{21}$$

The change in the exchange rate (in logs) can be written as

$$\begin{aligned}\Delta \log e_{t+1} &= \Delta \log C^F_{t+1} - \Delta \log C^H_{t+1} + \underbrace{\Delta \log W_{H,t+1} - \Delta \log W_{F,t+1}}_{-\Delta\lambda_{t+1}} \\ &= \Delta \log C^F_{t+1} - \Delta \log C^H_{t+1} + \log b_{F,t+1} - \log b_{H,t+1}.\end{aligned} \tag{22}$$

Equation (22) summarizes the main result in this paper. Given that households have log utility, if markets were complete, the ratio of home to foreign wealth in equation (15) would be a constant. In that case, bilateral exchange rate movements are purely determined by movements in the relative consumption growth between the home and foreign country. More generally in the case where the coefficient of relative risk aversion was different from one, the ratio of wealth could vary over time, but its movements would still be determined by movements in relative consumption growth (either in the short run or in the long run). As a result, these models imply that exchange rates are *counter-cyclical*: an economic boom in the home country (an increase in $Y_{H,t}$ and thus, due to home-bias, $C^H_t$) leads to a decline in $e$, that is, a *depreciation* of the home currency relative to the foreign currency.

By contrast, in our model, there is an additional factor in play that arises due to market incompleteness: displacement risk, which is captured by $b_{H,t+1}$ and $b_{F,t+1}$ defined in equation (20). To obtain some intuition for this result, we can approximate the evolution of $\lambda_t$ in equation (15) around its long-run mean using a first-order Taylor expansion,

$$\log\left(\frac{\lambda_{t+1}}{\lambda_t}\right) = \Delta \log\left(\frac{W_{F,t+1}}{W_{H,t+1}}\right) = \log\left(\frac{b_{H,t+1}}{b_{F,t+1}}\right) \approx u^F_{t+1} - u^H_{t+1}. \tag{23}$$

See Appendix B.1 for more details on the derivation of (23).

Examining (23), we see that a positive realization of $u^F_{t+1}$ implies that a measure-zero of households in the foreign country receive claims to new firms. Since there are no securities whose payoff is contingent on which household receives claims to these new firms, these households are not able to share the benefits ex-ante with the other households in either the home or foreign country. As a result, the relative wealth of the foreign country $\lambda_t$ rises.

Overall, the log growth rate of the exchange rate can be approximated as

$$\begin{aligned}\Delta e_{t+1} &\approx \Delta c^F_{t+1} - \Delta c^H_{t+1} + u^H_{t+1} - u^F_{t+1} \\ &\approx \underbrace{(2\alpha - 1)(1 - \delta)}_{>0}(u^H_{t+1} - u^F_{t+1}) + (1 - 2\alpha)(\varepsilon^H_{t+1} - \varepsilon^F_{t+1}). \end{aligned} \tag{24}$$

Consistent with the discussion so far, a positive displacement shock $u^H_{t+1}$ will lead to an appreciation of the exchange rate, while a positive 'neutral' shock $\varepsilon^H_{t+1}$ will cause the exchange rate to depreciate. Since country output and consumption depend on both shocks, exchange rates in the model can be either positively or negatively correlated with consumption or output growth.

Our model can generate pro-cyclical exchange rates. To see this, consider the log growth in the relative country output,

$$\Delta \log Y_{H,t+1} - \Delta \log Y_{F,t+1} = \delta \left(u^H_{t+1} - u^F_{t+1}\right) + \varepsilon^H_{t+1} - \varepsilon^F_{t+1} \tag{25}$$

which is increasing in both $u^H_{t+1}$ and $\varepsilon^H_{t+1}$. Similarly, the growth in relative consumption can be written as

$$\Delta c^H_{t+1} - \Delta c^F_{t+1} \approx (1 - 2\alpha) \Big( (1 + \delta - 2\alpha) \left(u^H_{t+1} - u^F_{t+1}\right) - \left(\varepsilon^H_{t+1} - \varepsilon^F_{t+1}\right) \Big). \tag{26}$$

In what follows, we will assume that,

$$\delta < 2\alpha - 1, \tag{27}$$

which implies that the aggregate consumption growth in the home country is positively correlated with the displacement shock in that country, $u^H_{t+1}$.

In brief, we see that the presence of the displacement shock $u$ induces a positive correlation between exchange rates and the growth in aggregate consumption, output, and productivity. By contrast, the presence of the neutral shock $\varepsilon$ tends to make exchange rates counter-cyclical, just like the standard models in the literature. As a result, the unconditional correlation (disconnect) between exchange rates, country output and consumption depends on model parameters, for instance, the relative variance of the two aggregate shocks.

### 2.5 A Microfoundation Based on a Model of Creative Destruction

Here, we provide a microfoundation for the process of creative destruction in the model in the previous section based on Aghion and Howitt (1992). Firms compete on a fixed set of product lines. Innovation by new entrants takes the form of quality improvements across different product lines. The displacement shock $u$ drives the measure of varieties that experience innovation. The parameter $\delta$ is related to the size of the productivity improvement from each innovation. To conserve space, we briefly detail the outline of the model. Appendix B.2 contains all details.

Output in country $c \in \{H, F\}$ is produced as a CES aggregate of a continuum of varieties indexed by $j$,

$$Y_{c,t} = Z_{c,t} \left( \int_0^1 [x_{c,t}(j)]^{\frac{\sigma-1}{\sigma}} \, dj \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1, \tag{28}$$

where

$$\Delta \log Z_{c,t+1} = \mu + \varepsilon^c_{t+1} \tag{29}$$

is an exogenous productivity shock, and $x_{c,t}(j)$ denotes the quantity of variety $j$ produced at time $t$, and $\sigma$ is the elasticity of substitution across varieties. Intermediate goods are produced using a linear technology with land as the only input:

$$x_{c,t}(j) = A_{c,t}(j) \, l_{c,t}(j), \tag{30}$$

where $A_{c,t}(j)$ denotes the productivity of the leading producer in variety $j$ and $l_{c,t}(j)$ is the land input used in production. Land is in fixed supply,

$$\int_0^1 l_{c,t}(j) = 1. \tag{31}$$

Claims on land are traded in international markets, and both foreign and domestic households can own these claims.

At the beginning of each period $t$, a displacement (innovation) shock $u_{c,t}$ is realized in each country. This displacement shock raises the probability that each product line is challenged by a new entrant,

$$m_{c,t} = 1 - e^{-u^c_t}. \tag{32}$$

If an entrant arrives at line $j$, the entrant has a productivity advantage: it can produce in variety $j$ with productivity $e^{\delta} A_{c,t-1}(j)$, where $\delta > 0$ and $A_{c,t-1}(j)$ is the productivity of the incumbent firm. New entrants and incumbents compete under Bertrand competition. As a result, the entrant undercuts the incumbent and takes over the product line.

The assumptions above yield the key equations in the model above. First, note that, each period $t$, a fraction $m_{c,t}$ of incumbents are displaced and replaced by new entrants. In each displaced line, the old firm's profits fall to zero, and the entrant captures the full profit stream. Thus, the total fraction of output that is produced by new firms at time $t$ is equal to $m_{c,t} Y_{c,t}$, which yields equation (7) above. Second, aggregate output in country $c$ is given by

$$\begin{aligned} \Delta \log Y_{c,t+1} &= \mu + \varepsilon^c_{t+1} + \frac{1}{\sigma - 1} \log \left[ e^{-u^c_{t+1}} + (1 - e^{-u^c_{t+1}}) \, e^{\delta(\sigma-1)} \right] \\ &\approx \mu + \varepsilon^c_{t+1} + \delta \, u^c_{t+1}, \end{aligned} \tag{33}$$

which yields equation (9).

In brief, the setup illustrates how the innovation shock $u^c_{t+1}$ can serve to both increase aggregate output by $\delta$, but also serve to displace incumbent firms by reallocating profits from existing firms to new entrants. This setup captures the key intuition of Aghion and Howitt (1992), that economic growth takes place through a process of creative destruction. Here, note that, for simplicity, we have assumed that all innovation takes place by new entrants. This assumption is not crucial for the qualitative predictions of the model. As we do later in Section 3, we could also allow incumbent firms to innovate. This would imply that a fraction of the output $m_{c,t}Y_{c,t}$ accrues to incumbent firms, with the remainder to new entrants. As long as new entrants appropriate some of the benefits of innovation, and crucially, households cannot buy claims today to future new firms, the main qualitative predictions of our setup remain.

### 2.6 Testable Predictions

Our model has predictions that are directly testable in the data. We explore these next.

**Exchange rates and relative consumption growth**

Our model has direct implications for the Backus and Smith (1993) puzzle. Importantly, equation (22) suggests that, the bilateral exchange rate should be a function of not only of relative consumption growth between the two countries, but also relative wealth. Importantly, once we control for wealth fluctuations between countries, we should be able to observe a negative correlation between consumption growth and the exchange rate growth, as predicted by risk-sharing.

To explore this implication in the data, we estimate the response of the bilateral exchange rate between country $c$ and the US using the following specification,

$$\Delta \log e_{F,t+1} = \beta_1 \left(g_{us,t+1} - g_{c,t+1}\right) + \beta_2 \left(R_{US,t+1} - R_{F,t+1}\right) + c\,\mathbf{Z}_t + \varepsilon_{F,t+1}. \tag{34}$$

Here, $g_{c,t+1}$ refers to consumption or output growth and $R_{c,t+1}$ is the change in log nominal wealth of the US or foreign country $F$ in dollars. The vector of controls $Z_t$ includes lagged dependent and independent variables: the level of lagged exchange rate, the lagged level of relative consumption or output, and the lagged level of relative wealth.

Panel A of Table 4 reports the estimated coefficients $\beta_1$ and $\beta_2$ from equation (34). Examining the table, we can see that the estimated slope coefficient $\beta_2$ is positive in both the individual country regressions and the panel regression. A positive estimate of $\beta_2$ implies that an increase in a country's relative wealth is associated with appreciation of its currency. More importantly, after controlling for changes in a country's relative wealth, the coefficient $\beta_1$ on consumption growth is both negative and statistically significant—which is consistent with theory. Focusing on the panel regression result, a one-standard-deviation increase in consumption growth differentials is associated with a 2 log point depreciation of its currency against the dollar. Examining the results for individual countries, we note that the correlation is negative in 10 out of the 11 countries in the sample. Panel B of Table 4 shows that the estimates for output are similar. The estimated coefficient $\beta_2$ is always positive. In the panel regression, the estimate of $\beta_1$ on relative output is equal to -0.016 with a Driscoll and Kraay (1998) standard error of 0.004. When estimating (34) separately for each country, we again see that the point estimates $\beta_1$ on relative output growth are all negative.

The fact that the estimated coefficient $\beta_2$ is positive and statistically significant aligns with the findings in Dahlquist et al. (2023), who document that a country's currency appreciation typically increases the dollar value of its domestic assets, which results in an increase in its relative wealth. Importantly, a country's wealth denominated in local currency does not adjust enough to offset the movement from the nominal exchange rate. Consequently, fluctuations in the nominal exchange rate lead to significant changes in a country's wealth measured in dollars, which is thus reflected in the high R-squared values when estimating (34), which range from 78 to 95 percent. Naturally, this raises the question of whether the high R-squared values from estimating equation (34), simply reflect the low sensitivity of wealth in local currency to nominal exchange rates. That may indeed be possible; however, a high correlation between nominal exchange rates and wealth ratios would not necessarily imply a negative estimate of $\beta_1$.

In brief, after modifying the Backus-Smith specification, we show that, after conditioning on these imperfectly shared wealth fluctuations, there is a (re)connection between exchange rate and macroeconomic fundamentals. That is, the ratio of marginal utilities (the real exchange rate) appreciates when the relative fundamentals are weaker. This result complements recent work by Aguiar, Itskhoki, and Mukhin (2024), which shows that risk-sharing across countries is better than implied by the Backus-Smith correlation when analyzed through consumption allocation and trade shares, as these are less influenced by financial market imperfections. Unlike Aguiar et al. (2024), who use trade shares to circumvent imperfectly shared shocks and test risk-sharing through quantities, our method accounts for these imperfectly shared shocks by conditioning on relative wealth across countries.

#### A measure of displacement based on the value of new projects

Here, we construct a proxy for the displacement shock that follows directly from our theoretical model. Similar to Gârleanu et al. (2016), the displacement shock in our model is related to the difference between the aggregate market capitalization growth and the returns from holding the market portfolio. To see this, consider the value of existing firms in each country (the stock market) in country $c \in \{H, F\}$,

$$S_t^c = D_{c,t} + \mathrm{E}_t\left[\frac{M_{t+1}^c}{M_t^c}\left(S_{t+1}^c e^{-u_{t+1}^c}\right)\right] = D_{c,t}\left(1 + pd_t^c\right), \tag{35}$$

where $pd_t^c$ is the price-dividend ratio in country $c$, and

$$D_{c,t} \equiv p_{c,t}\, Y_{c,t} \tag{36}$$

are the total dividends (the value of output) in country $c$.

Given the above, the log return, in local currency and excluding dividends, of holding the market portfolio of country $c$ is

$$\begin{aligned} r_{t+1}^c &= \log\left(\frac{D_{c,t+1}}{D_{c,t}}\frac{pd_{t+1}^c}{pd_t^c}\, e^{-u_{t+1}^c}\right) - \log\left(\frac{p_{c,t+1}}{p_{c,t}}\right) \\ &= \mu + (\delta - 1)\, u_{t+1}^c + \varepsilon_{t+1}^c + \log\left(\frac{pd_{t+1}^c}{pd_t^c}\right) \end{aligned} \tag{37}$$

Equation (37) highlights an important feature of our model: the distinction between aggregate dividend growth $p_{c,t}\, Y_{c,t}$ and the growth of dividends accruing to incumbent firms (the market portfolio). The reason for this distinction is that aggregate dividends do not constitute the gains from holding the stock market: investing in the stock market at time $t$ only generates $p_{c,t}\, Y_{c,t+1}\, e^{-u_{t+1}^c}$ dividends at $t+1$. A positive displacement shock increases aggregate dividends by introducing new firms, but also dilutes the shares of the existing firms. On the other hand, following a positive displacement shock the price-dividend ratio also decreases. As a result, a positive displacement shock leads to a decline in the stock market returns of incumbents.

Equation (37) provides guidance on how to estimate the realizations of the displacement shock $u$ from the difference between the aggregate market capitalization growth and the returns from holding the market portfolio. In particular, the difference between the growth in the aggregate market capitalization $S_{c,t}$ and the return of the market portfolio $r_{t+1}^c$ can be written as

$$\log\left(\frac{D_{c,t+1}}{D_{c,t}}\frac{pd_{t+1}^c}{pd_t^c}\right) - \log\left(\frac{D_{c,t+1}}{D_{c,t}}\frac{pd_{t+1}^c}{pd_t^c}\, e^{-u_{t+1}^c}\right) = u_{t+1}^c \tag{38}$$

The difference between the growth of aggregate market capitalization and the returns on the market portfolio in (38) is equal to the innovation or displacement shock. This difference arises because an investor holding the market portfolio must pay to acquire new firms entering the market. To maintain the self-financing nature of the strategy, the investor must continually liquidate some of the shares she holds to purchase shares of new firms. Since new firms enter the market each period, the growth of the market portfolio falls short of the growth of the aggregate market capitalization.Here, we should emphasize that the displacement gap also reflects dilution arising from equity issuances by incumbent firms. These issuances introduce new claims on future cash flows, diluting incumbent shareholders. This channel is particularly relevant in innovative sectors where firms reward key employees and innovators with equity grants.[10]

[10] In addition to new firm entry, displacement can also result from internal innovation within incumbent firms. When employees initiate new projects, the future cash flows generated are typically not contractible ex ante. As a

We next use this result to construct a direct proxy for the displacement shock in the data. Each month, we calculate the value of a portfolio that holds the entire market, excluding all dividend payments but adjusted for stock splits (CRSP item RETX). We then compare this with the aggregate market capitalization at the end of each month. The log difference between the two values is due to newly issued shares, and can be interpreted as the realization of the displacement shock $u$ for that month. We aggregate all monthly displacement shocks over a year to obtain the annual displacement series.[11]

Figure 3 plots the displacement shock against the growth of the real US dollar index. We observe that the correlation between the displacement shocks and the US dollar index is positive and approximately equal to 35 percent. Notably, during periods of significant innovation, many new firms emerge, and these periods coincide with times when the dollar appreciates in real terms.

Using this direct proxy for the displacement shock, we revisit our motivating evidence in Sections 1.2 and 1.3. As we see in Tables 5 and 6 we obtain qualitatively and quantitatively similar estimates to those Tables 1 to 2. In particular, a one-standard-deviation increase in our displacement measure leads to a 3.6 to 4.4 percentage point appreciation in the dollar, a 4.9 to 5.3 percentage point increase in the relative wealth of the US, and a 1.6 to 1.8 percentage point increase in income inequality in the US compared to the rest of the world. Appendix Table A.3 shows that the estimated correlations between our displacement shocks and the bilateral dollar exchange rates are uniformly positive across all individual countries, and, in most cases, statistically different from zero.

### Exchange rates and the growth of top incomes

Our notion of the displacement shock $u$ captures the idea that the benefits of economic growth are not shared equally. In the model, $u$ directly affects the wealth reallocation between owners of existing firms and entrepreneurs who create new firms. These entrepreneurs consist of a very small fraction of the population (measure zero), but they receive a significant share of overall output. If we were to treat this transfer as capital income, fluctuations in $u$ would translate into fluctuations in income inequality in the model.

Here, we develop this idea further and connect the displacement shock $u$ in the model to an observable quantity, the top 1% share of income. In particular, the top 1% income consists of two groups of households. The first group consists of the households that receive new firms in the

result, compensation and ownership claims are resolved ex post—often through equity-based instruments which lead to effective dilution of existing shareholders.

[11] Here, there are two issues that are related to timing that need to be discussed. First, it is possible that the actual displacement occurs when the new firms are created, rather than when the firms are listed in the stock market. If that is the case, then the displacement shock that we are measuring is likely to be a moving average of the true displacement shocks in the past. In this case, it would make sense to include as controls lags of the displacement series. That said, given that shares become liquid only after the IPO, it is also possible that the reallocation in wealth is realized then. However, these wealth effects may be delayed if there are lock-up periods post IPO. Similar delays may also arise from other forms of new equity issuance, such as employee stock grants, which often come with vesting schedules or resale restrictions. Thus, to account for the possibility of a lock-up period, we lag the annual displacement series by one year.

current period. The total capital income from new firms in country $c$ is given by

$$I_{c,t}^{ent} = S_t^c \left(1 - e^{-u_t^c}\right). \tag{39}$$

The second group consists of households that have had previously received new firms in the past and consequently earn a large capital income from their wealth. These households derive capital income equal to

$$I_{c,t}^{inc} = \xi \, W_{c,t} + \left(D_{H,t}\, e^{-u_t^H} + D_{F,t}\, e^{-u_t^F}\right) \frac{W'_{c,t}}{W'_{H,t} + W'_{F,t}}, \tag{40}$$

where $W'_{H,t}$ and $W'_{F,t}$ are the total wealth of the two countries excluding new projects,

$$W'_{c,t} = W_{c,t} - (1 - e^{-u_t^c})\, S_t^c, \qquad c \in (H, F).$$

These capital gains in (40) are distributed to all households in direct proportion to their wealth.

Contrasting equations (39) and (40), we see that the size of the $u$ shock at time $t$ determines the amount of wealth that is transferred from the shareholders of existing firms to the owners of new firms. The value of these new firms constitutes a capital gain for the successful entrepreneurs, and they are randomly distributed to a small part of the population. Hence, some of it is part of the income share of the top 1%.

The above discussion illustrates how these model-implied joint dynamics of income inequality and exchange rates are informative about the significance of the model's mechanism in the data. In particular, recall equation (22), which states that exchange rate growth is determined by relative consumption growth and changes in the wealth share of households that are displaced in each country $b_H$ and $b_F$, which are primarily driven by the displacement shock $u_H$ and $u_F$, respectively. To the extent that income inequality is a useful proxy for the $u$ shock in the model, the correlation between exchange rates and income inequality would reveal the importance of the displacement shock $u$ as a driver of exchange rates.

To explore this idea further, we estimate the following specification,

$$\Delta X_{t+1,F} = \beta \left( \log \frac{\theta_{t+1}^{US}}{\theta_t^{US}} - \log \frac{\theta_{t+1}^{F}}{\theta_t^{F}} \right) + c\, \mathbf{Z}_{F,t} + \varepsilon_{F,t+1}. \tag{41}$$

Here, the dependent variable $X_{t,F}$ is equal to the growth in the bilateral exchange rate between the US and country $F$. The independent variable $\theta_t^c$ is the level of income inequality in country $c$ at time $t$. As our baseline case, we measure $\psi$ using the income share of the top 1%. We control for the level of the exchange rate and the level of inequality at time $t$.

Table 7 presents the estimated coefficients from the panel regression (41), along with country-by-country estimates. Focusing on estimates of $\beta$ from the panel specification in the first column, we see that the estimated coefficient $\beta$ is positive and both economically and statistically significant. In particular, increases in income inequality in the foreign country are associated with an appreciation of its currency relative to the US. The magnitudes are not small: a one-standard-deviation increase in income inequality in the foreign country is associated with a 1.7 log point appreciation of its currency relative to the US dollar. Examining the country-level regressions, we observe a consistent pattern: the estimated coefficients $\beta$ are generally positive, though not always statistically significant.

# 3 Quantitative Implications

So far, we have presented a stylized model that allows us to highlight the key mechanism in the paper. Though transparent, however, the model is not rich enough to quantitatively capture all the interesting aspects of the data. Here, we introduce several additional features that allow for a full quantitative exploration of the mechanism.

## 3.1 Modifications to the Baseline Model

To conserve space, we only highlight the differences with the simpler model in the previous section. Appendix B.3 contains all details and derivations.

We make two changes relative to the previous setup. First, we modify household preferences. Agents have non-time separable preferences; in addition, they care about not only their own absolute level of consumption but also their consumption relative to an index. In particular, households' continuation utility at time $t$ is of the Epstein-Zin form,

$$U_{i,t}^c = \left[(1-\beta)(\hat{C}_{i,t}^c)^{1-\frac{1}{\psi}} + \beta\left(\mathbb{E}_t\left[(U_{i,t+1}^c)^{1-\gamma}\right]\right)^{\frac{1-\frac{1}{\psi}}{1-\gamma}}\right]^{\frac{1}{1-\frac{1}{\psi}}} \tag{42}$$

The parameters $\gamma$ and $\psi$ measure the relative risk aversion (RRA) and the elasticity of intertemporal substitution (EIS), respectively. The coefficient $\beta$ is the effective time-preference parameter, which also incorporates the probability of death, that is, $\beta = \tilde{\beta}(1-\xi)$ where $\xi$ is the probability of death and $\tilde{\beta}$ is the households' subjective time discount factor.

In equation (42), we allow for preferences over relative consumption: $\hat{C}_{i,t}^c$ refers to a composite good that depends both on the households' own consumption $C_{i,t}^c$ but also its level relative to the aggregate level $\bar{C}_t^c$ of consumption in their country,

$$\hat{C}_{i,t}^c = \left(C_{i,t}^c\right)^h \left(\frac{C_{i,t}^c}{\bar{C}_t^c}\right)^{1-h}. \tag{43}$$

Here, $C_{i,t}^c$ is the agent $i$'s own consumption bundle in country $c \in \{H, F\}$—defined in (11)—which is comprised of both home and foreign goods. The parameter $h$ denotes the strength of the relative preference effect. When $h = 1$, these preferences specialize to the standard Epstein-Zin preferences.

In general, for $h \in [0,1]$ agents place a weight $h$ on their own consumption and a weight $1-h$ on their consumption relative to average consumption in country $c \in \{H, F\}$.

Second, we relax the assumption of extreme inequality, by assuming that the measure of population that receives the value of new firms is non-negligible, that is, $\pi > 0$. Though this modification makes the model significantly less tractable, it helps the model match the observed patterns of inequality in the data.

Given our assumptions, the stochastic discount factor in country $c$ is now given by

$$\frac{M^c_{t+1}}{M^c_t} = \beta \left( \frac{\bar{C}_{c,t+1}}{\bar{C}_{c,t}} \right)^{-\frac{h}{\psi}+h-1} \tilde{b}_{c,t+1} \left( \frac{U^{1-\gamma}_{c,t+1}}{\mathrm{E}_t[U^{1-\gamma}_{c,t+1}]} \right)^{\frac{1/\psi-\gamma}{1-\gamma}} \tag{44}$$

where now the share of wealth of incumbent households at $t+1$ is given by

$$\tilde{b}_{c,t+1} = \pi \left( \frac{1-(1-\pi)\, b_{c,t+1}}{\pi} \right)^{-\frac{1}{\psi}+\frac{1/\psi-\gamma}{1-\gamma}} + (1-\pi)\, b_{c,t+1}^{-\frac{1}{\psi}+\frac{1/\psi-\gamma}{1-\gamma}}, \tag{45}$$

where $b_{c,t+1}$ is given by equation (20).

As before, exchange rates are determined by the absence of arbitrage (21). The exchange rate between the home and foreign country is now given by

$$\begin{aligned} \Delta \log e_{t+1} = {} & \left( \frac{h}{\psi} + 1 - h \right) \left( \Delta \log C^F_{t+1} - \Delta \log C^H_{t+1} \right) + \Big( \log(\tilde{b}_{F,t+1}) - \log(\tilde{b}_{H,t+1}) \Big) \\ & + \frac{1/\psi - \gamma}{1-\gamma} \left( \log \frac{U^{1-\gamma}_{H,t+1}}{\mathrm{E}_t[U^{1-\gamma}_{H,t+1}]} - \log \frac{U^{1-\gamma}_{F,t+1}}{\mathrm{E}_t[U^{1-\gamma}_{F,t+1}]} \right) \end{aligned} \tag{46}$$

Examining equation (46), we note the similarities with the log utility case—equation (22) in the baseline model. Specifically, exchange rate dynamics are still driven by relative consumption growth in the two countries, as well as the relative degree of displacement in the current period given by equation (45). The key difference with the baseline case with log utility is that, the shocks to the future distribution of these variables matters also matter for exchange rate dynamics, which are reflected in households' continuation utilities $U_{H,t+1}$ and $U_{F,t+1}$.

Last, we relax the assumption that new projects are allocated only to new firms: we now allow a fraction $1-\eta > 0$ of new projects to be allocated to incumbent firms. Allowing $\eta < 1$ weakens the degree of market incompleteness—markets would be complete in the case $\eta = 0$. Importantly, the allocation of new projects among incumbent firms is not uniform—we assume heterogeneity in investment opportunities across firms. In particular, we allow for two types of firms: high-growth (growth) firms, that is, firms that can receive these new projects, and low-growth (i.e. value) firms, that is, firms that do not receive new projects and derive their value only from assets in place. Growth firms command higher valuation multiples in equilibrium than value firms; we denote them by $H$, and value firms by $L$. Firms can transition between the two types, $H$ and $L$, according to the following transition probability matrix:

$$\Sigma = \begin{bmatrix} 1 - p_s & p_s \\ q_s & 1 - q_s \end{bmatrix}. \tag{47}$$

Given (47), there is a constant fraction of high- and low-growth firms in each region. Note that these transition probabilities do not influence aggregate quantities in the model.

## 3.2 Calibration

In this section, we describe how we calibrate the model to the data. Given the degree of non-linearity in our model, solution methods that are based on log-linearizations around the steady state are not necessarily reliable. As such, we solve for the global solution of the model by discretizing the state-space and using a combination of value and policy function iteration. See Appendix B.4 for a brief description of our numerical procedure.

### Aggregate Shocks

First, we make distributional assumptions about the shocks driving aggregate dynamics. We allow for the displacement shocks in each country to be correlated, possibly due to technology spillovers. That is, the effective displacement shock $u_t^c$ in each country is a weighted average of each country's idiosyncratic displacement shock $\bar{u}$,

$$\begin{aligned} u_{t+1}^H &= (1 - \rho_u)\, \bar{u}_{t+1}^H + \rho_u\, \bar{u}_{t+1}^F \\ u_{t+1}^F &= (1 - \rho_u)\, \bar{u}_{t+1}^F + \rho_u\, \bar{u}_{t+1}^H. \end{aligned} \tag{48}$$

We parameterize the distribution of the idiosyncratic displacement shocks in each country $\bar{u}_t^c, c \in \{H, F\}$ as a Markov chain with three states $[u_1, u_2, u_3]$ and transition matrix $T$. To reduce the number of parameters, we make simplifying restrictions on the dynamics of $u$ shocks. Specifically, we assume that the matrix $T$ is parameterized by two parameters $p$ and $q$,

$$T = \begin{bmatrix} p^2 & 2\,p\,(1-p) & (1-p)^2 \\ p\,(1-q) & p\,q + (1-p)\,(1-q) & q\,(1-p) \\ (1-q)^2 & 2\,q\,(1-q) & q^2 \end{bmatrix}. \tag{49}$$

The transition matrix (49) allows for asymmetric dynamics between low- and high-displacement states. The parameters $q$ and $p$ control the persistence of the displacement shock $u$ when it takes high and low values, respectively. This structure reduces the number of free parameters while allowing for state-dependence in the degree of persistence.

We parameterize the process for $u$ to allow for shifts in both the current but also future realizations of innovation $u$. As a result, we calibrate the model so that the transition from $u_1$ to $u_2$

corresponds to the early stage of a technological progress: that is, even though the benefits have yet to materialize ($u_2 \approx u_1$) the transition from $u_1$ to $u_2$ corresponds to news about the arrival of future technologies, as it increases the probability that the technology improves in the future (the arrival of the state $u_3 > u_2 \approx u_1$). Last, we assume that the neutral shocks are i.i.d. and jointly normally distributed $[\varepsilon^h, \varepsilon^f]$ with standard deviation $\sigma_e$. We allow for the correlation $\rho_e$ between the neutral shocks in each country to be positive.

**Parameter Choice**

The model has a total of 19 parameters. We choose the probability of household death $\xi = 1/40$, which corresponds to an average working life of 40 years. To conserve space, we briefly describe the calibration procedure here. Appendix B.5 contains all details.

To calibrate the model we choose a set of target moments, reported in the first column of Table 8. Our list of calibration targets includes a combination of first and second moments of aggregate quantities, asset prices and exchange rates. In addition, we also target the comovement of key variables that are informative about the relative importance of the two shocks in the model. Specifically, the relative importance of the neutral and the displacement shocks are important for the cyclicality of exchange rates and relative wealth ratios. Thus, we target the degree of comovement between wealth changes and consumption, and output. We also target the correlation between dollar index growth and our model-implied proxy for displacement shocks in Section 2.6 and presented in Table 5 and 6. To account for leverage, we consider the stock market as a levered claim on domestic consumption by a factor of two.

Table 9 reports our choice of parameters. In terms of preference parameters, the calibration requires a moderate level of relative risk aversion (6.2) and an elasticity of inter-temporal substitution (1.6). The coefficient of relative risk aversion $\gamma$ is identified from the mean and volatility of stock returns, as well as the volatility of the risk-free rate. Similarly, the EIS affects the volatility of interest rates and hence is primarily identified by the volatility of excess returns. In line with most equilibrium models of exchange rates (for instance, Colacito and Croce, 2013), the model requires a very high level of home bias (0.989) in order to generate volatile exchange rates. In addition, the preference weight on relative consumption is moderately high (0.80), which is in line with Kogan et al. (2020). This parameter is identified by the volatility of exchange rate and the correlation between wealth and consumption growth. As $h$ falls, households place a higher emphasis on relative consumption, thereby increasing the significance of the displacement shock. The subjective discount factor $\beta$ is mainly identified by the mean of the risk-free rate.

In terms of the parameters of technology shocks, the mean $\mu = 0.012$ and volatility $\sigma_e = 0.013$ of the neutral shock are identified by the first two moments of consumption and output growth. The distribution of the displacement shock $u$ is primarily identified by the volatility of exchange rate; the stock market (since the spread between $u_1$ and $u_3$ affects the volatility of the SDF in the model);

and the correlation of $u$ with wealth changes and exchange rates growth. The two parameters governing the correlation between the home/foreign shocks ($\rho_e$ and $\rho_u$) are primarily identified by the correlation of home and foreign consumption growth, output, and the stock market. The persistence of the displacement shock $u$ is primarily identified by the equity premium and volatility of stock returns, since the $u$ shock is a key driver of stock returns. In addition, its level of skewness helps the model replicate the failure of the UIP in the data. The parameter $\eta$, which affects the division of surplus between shareholders and innovators, is calibrated at 0.714. This implies that approximately 30% of the value generated from new investment opportunities in the economy accrues to the owners of publicly traded securities. Last, the parameter driving the productivity impact of displacement shocks to aggregate output $\delta$ is primarily identified by the correlation between wealth and output, and the volatility of exchange rates, since it determines the joint dynamics of the SDF and output growth. We calibrate firms' transition probabilities $p_s$ and $q_s$ using U.S. data. Specifically, each year, we sort U.S. firms into growth and value categories based on the median book-to-market breakpoint. Then we estimate the transition probability over the sample period, which yields $p_s = 0.267$ and $q_s = 0.224$.

### 3.3 Model Fit

Table 8 shows that the baseline model fits data reasonably well. Most of the empirical moments are close to their model counterparts and fall within the 5th to 95th intervals from simulations. Our model reproduces the realistic patterns of both aggregate consumption and output growth. On the asset pricing side, the model generates realistic levels of equity risk premium and volatility of the stock market. The volatility of the realized interest rate in the data is more volatile than the simulated data, but this may be largely driven by the high inflation around 1980s.

On the international side, our model successfully replicates the three key anomalies in the literature: the volatility puzzle of Brandt et al. (2006), the Backus-Smith correlation puzzle, and the violation of the UIP. Moreover, the model generates positive correlation between wealth changes and consumption. This is because the $u$ shock is not only positively correlated with the aggregate consumption and output but also associated with significant wealth transfer due to imperfect risk sharing. That is, our model can replicate the pattern in the data where shocks that drive up wealth ratios are positive supply shocks. The key to the replication of the UIP anomaly is the time-varying volatility—more precisely, the time-varying distribution of the effective size of the $u$-shock—that endogenously arises in the equilibrium. Despite the fact that consumption, output and the stock market are highly correlated, the exchanges rate in our model is as volatile as in the data due to a high level of home-bias. Finally, net exports in our model are counter-cyclical, as in the data.

In addition, the replication of international puzzles does not require an unrealistic magnitude of displacement shocks. Targeting the moments of income inequality helps impose some discipline in the calibration of the displacement shocks. As we can see in Table 8, our model generates a realistic level of income inequality. The correlation between wealth and inequality in the data falls within the 5th and 95th percentiles of the simulation intervals. Furthermore, our model reproduces the estimated coefficients of the bivariate regression of exchange rate growth on wealth changes, consumption, and output in Table 4. That is, the model can quantitatively replicate the observed joint dynamics between exchange rates, wealth, and consumption or output growth.

# 4 Model Mechanisms

Here, we focus on the key mechanisms in the model and their implications for the data.

## 4.1 The Backus-Smith Puzzle

Figure 4 presents the response of key model quantities to the two shocks in the model. Panel A shows the response to the displacement shock $u$, and Panel B shows the response to the neutral shock $\varepsilon$. The first two columns of Figure 4 show the response of the exchange rate and consumption growth to the two shocks. As we can see, a positive $\varepsilon$ shock in the home country leads to a depreciation of the currency and an increase in consumption growth. This is the standard shock in most models and the reason why exchange rates are counter-cyclical. By contrast, we see that a positive $u$ shock leads to an appreciation of the exchange rate as well as an increase in consumption growth.

The next two columns of Figure 4 illustrate why the exchange rate appreciates in response to a positive $u$ shock. Columns three and four of Figure 4 illustrate how the last two terms of equation (46) respond to the shocks in the model. We see that an increase in the level of displacement in the home country $u_H$ leads to a decline in the wealth share of the owners of incumbent firms in the home country $b_H$. In addition, we see that this increase in $u_H$ leads to a decline in the continuation utility of households in the home country $U_H$. Both of these forces lead the home currency to appreciate, since they both lead to an increase in the level of the stochastic discount factor (the equivalent of marginal utility in the log utility case) as we see in equation (44).

This figure illustrates why the model is able to generate a positive correlation between countries' differences in consumption growth, and exchange rate growth, resolving the Backus-Smith anomaly. The displacement shocks produce a positive comovement between consumption and exchange rate, while neutral shocks generate a negative correlation between two variables. To resolve the Backus-Smith puzzle, it needs to be that the impact of displacement shock in driving this correlation is larger than the impact of the neutral shock. This magnitude depends on the calibration of its displacement effect $\delta$ and households' preference $h$ over relative consumption, as well as the relative magnitudes of the two shocks.

## 4.2 Productivity Shocks and Exchange Rates

Our model delivers a positive correlation between exchange rates and future productivity growth, consistent with the evidence in Chahrour et al. (2024). In particular, Chahrour et al. (2024) revisit the exchange rate disconnect puzzle using a vector auto-regression to argue that news about future US productivity drives exchange rate movements. They show that shocks to expectations about future US productivity explain a large fraction of the variation in both exchange rates and real macroeconomic quantities, though at different horizons. Despite both focusing on medium-to-long-term productivity growth, these authors argue that two-country models with long-run productivity shocks (for instance, Colacito and Croce, 2013) are at odds with their findings.

By contrast, our model is consistent with the evidence in Chahrour et al. (2024). The reason is that the displacement shock $u$ generates a positive correlation between the exchange rate and subsequent growth in consumption and output, as we saw in Panel A of Figure 4. To the extent that the displacement shock is persistent, an increase in the displacement shock can also increase the likelihood of future displacement shocks, which will be reflected in increases in future output and productivity. Put differently, the displacement shock $u$ in the model is also a driver of future productivity growth. To see this, we replicate the VAR analysis in Chahrour et al. (2024) in simulated data from the model.[12]

Figure 5 shows that our model is quantitatively consistent with these facts. In particular, we plot the median impulse response across all simulations (black line) along with the empirical impulse response and 90th percent confidence intervals from Chahrour et al. (2024). Examining the figure, we see that, in both the model and the data, the main FX shock identified by the VAR is strongly positively related to subsequent productivity and consumption growth.

## 4.3 The Forward Premium Anomaly

The Uncovered interest rate parity (UIP) states that the expected change in exchange rates should be equal to the interest rate differential between two countries, and that the currency with lower interest rate tends to appreciate. Therefore, the regression coefficient of future exchange rates growth on interest rate differential should be equal to one. Empirically, the coefficient is much smaller than one and even negative, which is referred to as the forward premium puzzle (Fama, 1984).

We next show that the downward bias in UIP regressions is an endogenous equilibrium outcome in our model, thanks to the time-varying distribution of innovation shocks. In particular, we

[12] Specifically, we consider a vector of variables that includes the real exchange rate, home consumption, foreign consumption, home TFP, and interest rate differentials between the home and foreign countries. We estimate the VAR with one lag. Following Chahrour et al. (2024), we apply the methodology in Uhlig (2004) to extract the "main exchange rate" (main FX) shock, which accounts for the largest share of variation in the real exchange rate. We then calculate the impulse response functions of the real exchange rate, consumption, and productivity (i.e. output) based on the model's simulation. Specifically, we simulate the model for 100 periods, estimate the impulse response, and repeat the process 10,000 times.

estimate the standard UIP regression in simulated data.[13] Figure 6 displays the distribution of UIP coefficients. Examining the figure, we observe that UIP is largely violated in the model: the sample average of the UIP coefficient closely aligns with its counterpart in the data. To illustrate why UIP fails in our model, Figure 7 shows the responses of home and foreign interest rate differentials, the exchange rate, and the difference in volatility of the log-SDF to positive displacement shocks. The top panel of Figure 7 shows the response when the economy transitions from $u_1$ to $u_3$, while the lower panel shows the response when the economy transitions from $u_1$ to $u_2$.

In the first column of Figure 7, we see that following a positive displacement shock $u$ to the home country, the home interest rate falls relative to the foreign country. If UIP were to hold, this would imply an appreciation of the home currency in the future—which is indicated by the dotted red line in the second column. However, we see in the second column of the figure that the home currency depreciates in the near future in response to the shock. The reason why this pattern occurs in the model is due to time variation in the higher order moments of consumption growth in equilibrium. Specifically, the third column of Figure 7 shows that after the transitions $u_1 \to u_3$ and $u_1 \to u_2$, the conditional volatility of the domestic log-SDF is higher than that of the foreign SDF in the subsequent periods. This greater volatility, which leads to an increase in the market price of risk, causes the interest rate in the home country to decline.[14]

Replicating the failure of UIP has been a major focus of the literature. Indeed, models with habit preferences or long run risk can also reproduce the failure of the UIP (Verdelhan, 2010; Colacito and Croce, 2013). However, recent work has criticized these models on two grounds. First, Hassan et al. (2024) argue that the difference in currency returns should arise mostly from interest rate differentials, as exchange rates are notoriously difficult to predict empirically Meese and Rogoff (1983). They point out that the inverse relationship between the mean and higher moments of log-SDFs in the international finance literature is inconsistent with the observed unpredictability of exchange rates. Second, Chahrour et al. (2024), argue that shocks to the expectation of future TFP changes are actually associated with exchange rate appreciation, rather than depreciation as implied by models with long run risk.

Our model is robust to both of these criticisms. First, in our model, exchange rates are essentially unpredictable based on interest rate differentials: a regression of exchange rate growth on interest rate differentials has a median $R^2$ of 0.02 across model simulations, which is in line with empirical estimates (Fama, 1984; Lustig, Stathopoulos, and Verdelhan, 2019). The reason why exchange rate movements are not predictable, even though the conditional moments of the stochastic discount factor vary over time, is that the distribution of log-SDFs is highly skewed. In particular, our parameterization of the displacement shock $u$ implies that the states $u_1$ and $u_2$ differ mainly in

[13] We initialize the model at the symmetric steady state and it is simulated for 150 periods, repeated 10000 times. We use the last 50 periods for each simulated sample to perform the UIP regression.

[14] This mechanism is consistent with prior empirical evidence on the relation between declining real interest rates and rising risk premia across various markets (see, for example Fama and French, 1989; Bekaert, Engstrom, and Xing, 2009).

their expectations of future innovation shocks, which could reflect early-stage learning during a technological revolution. As a result, even though the two states have different mean values of log-SDFs, exchange rate growth is still almost unpredictable in our model because these shocks are infrequent. Second, as we saw in Figure 5, our model is in fact able to quantitatively reproduce the positive relation between exchange rates and future TFP growth documented by Chahrour et al. (2024).

### 4.4 Trade and Financial Flows

Our framework delivers implications for output growth and international financial flows. In equilibrium, net exports in each country are a simple function of the relative wealth of the two countries, $\lambda_t$:

$$\begin{aligned}\frac{NX_t^H}{Y_{H,t}} &\equiv \frac{p_{h,t}Y_{H,t} - p_{h,t}x_{H,t}^H - p_{f,t}x_{F,t}^H}{p_{h,t}Y_{H,t}} = 1 - \frac{1}{\alpha + (1-\alpha)\lambda_t}, \\ \frac{NX_t^F}{Y_{F,t}} &\equiv \frac{p_{f,t}Y_{F,t} - p_{f,t}x_{F,t}^F - p_{h,t}x_{H,t}^F}{p_{f,t}Y_{F,t}} = 1 - \frac{\lambda_t}{1-\alpha+\alpha\lambda_t}.\end{aligned} \tag{50}$$

Examining equation (50), we see that fluctuations in $\lambda_t$ drive fluctuations in trade flows.

To see how these quantities respond to the shocks in the model, Figure 8 plots impulse responses for the relative wealth share $w_t$, output growth and trade surplus (net export scaled by output). The top two panels show the response to the displacement shock $u$ in the home country while the bottom panel shows the response to the neutral shock $\varepsilon$. The first two figures show that a positive displacement shock in the home country increases its relative wealth and consumption share (first panel) while its output grows relative to the foreign country.

The third column of Figure 8 shows that the dynamics of the international flows are mostly driven by the displacement shocks. Specifically, the third column shows that following a positive displacement shock in the home country, net exports to the foreign country decline as the country becomes richer, domestic households want to consume more, and therefore imports rise. Overall, the home country exports less of domestic goods and imports more of the foreign goods.

The increase in the trade deficit is mirrored by capital inflows. Each period, foreign and domestic investors who hold the market portfolio need to acquire the new firms that enter the market in order to remain diversified. When the home country receives a larger displacement shock than the foreign country, there are more new firms in home country than in the foreign country. Households receiving these new firms (entrepreneurs) sell their shares to other households (domestic and foreign). The net result is that foreign demand for home assets increases relative to home demand for foreign assets, and therefore the home country experiences net capital inflows as its wealth increases.

Overall, the model is able to reproduce the positive correlation between exchange rate appreciation and capital inflows (Hau and Rey, 2006). As we contrast the top and bottom panels of Figure 8, we see that this pattern arises purely due to the innovation shock in the model. The neutral productivity shock simply leads to an increase in output but no changes in the country's trade balance.

The model's predictions about capital flows are consistent with the evidence in Section 1.4. Recall that, at the aggregate level, there is a strong correlation between US foreign direct investment inflows and US innovation intensity (Figure 2). At the firm level, in Table 3 we saw that firms which innovate attract foreign capital inflows to these firms, leading to an increase in foreign ownership. These firm-level results are consistent with the model.

The model also implies a link between innovation, inequality, and external balances. Displacement shocks raise inequality, and under incomplete markets this mechanism generates current account deterioration. We examine this prediction in the data using measures of current account balances from the World Economic Outlook database. Figure A.2 shows that countries experiencing larger increases in current account deficits also exhibit greater increases in inequality. The magnitudes are economically meaningful: a one–percentage point rise in the top 1 percent income share is associated with a 1.7–percentage point deterioration in the current-account-to-GDP ratio.

### 4.5 Stock Returns

Next, we explore the implications of our model for the relation between the stock market and exchange rates. Importantly, in addition to the aggregate stock market, we focus on the heterogeneity in responses between firms that are currently in the high-growth state $H$ (growth firms) and firms in the low-growth state $L$ (value firms). We compute the differences in stock returns between these firms and compute the returns to a growth-minus-value (GMV) portfolio. Since growth firms receive new projects while value firms do not, the GMV portfolio is highly exposed to the country's displacement shock.

The first two columns of Figure 10 plot the impulse responses of GMV portfolio (cumulative) returns and aggregate stock market returns in both countries. The top panel (Panel A) shows the responses to an early-stage displacement shock (a transition from $u_1$ to $u_2$), while the middle panel (Panel B) displays responses to a mature-stage shock (a transition from $u_2$ to $u_3$). The bottom panel (Panel C) shows the response to the neutral shock in the model. The last two columns plot the responses of the risk premia of these portfolios to the structural shocks.

In Panel A of Figure 10, we see that when the home economy enters the early stage of a technological shock, the GMV return rises on impact but exhibits lower average returns in subsequent periods. The reason for this is that, when the state transitions from $u_1$ to $u_2$, the realized innovation remains unchanged—only the probability of future displacement increases. Therefore, investors, anticipating future displacement shocks, buy growth stocks as a hedge, which lowers their required rate of return relative to value stocks. In addition, since the stock market is primarily composed of the value of incumbent firms, it declines in anticipation of a future technological revolution. As the last two columns confirm, the transition from $u_1$ to $u_2$ essentially represents an increase in the price of hedging displacement risk. The resulting price increase in growth stocks in response to future technological improvements—absent any realized innovation—echoes earlier work on stock price responses to technological revolutions (Greenwood and Jovanovic, 1999; Pastor and Veronesi, 2009).

In Panel B of Figure 10, we see that in the mature stage—when the economy moves from $u_2$ to $u_3$, returns on the GMV portfolio rise on impact, since growth firms primarily benefit from the increase in the innovation shock relative to value firms. By contrast, the stock market further declines in response to the displacement shock as incumbents are displaced by new firms. These predictions are in stark contrast to the lack of significant responses of these stock returns to the neutral shock in Panel C.

Overall, the model suggests that, within a country, growth stocks appreciate relative to value firms upon the realization of a displacement shock. This behavior resembles a 'fear of missing out' motive for holding growth stocks: investors buy growth stocks not because they expect higher returns, but because these stocks appreciate more in states where large displacement shocks occur and marginal utilities are high. This prediction is similar to Papanikolaou (2011); Gârleanu et al. (2016); Kogan et al. (2020) in a single country context. However, in our multi-country model, this mechanism has a testable implication: returns of a country's growth firms should be more highly correlated with its exchange rate than the returns of the country's value firms.

To test this model's prediction across countries, we next estimate

$$\Delta \log e^F_{t+1} = \alpha_t + \beta_1 GMV_{F,t+1} + \beta_2 X_t + \varepsilon_{t+1}. \tag{51}$$

The dependent variable in (51) is the exchange rate of country $F$ with respect to the reference currency (US dollar). The key dependent variable $GMV$ is equal to minus the high-minus-low book to market portfolio in country $F$, obtained from Ken French's data library. To isolate the cross-sectional relation between exchange rates and GMV returns and remove the influence of the U.S. dollar as the base currency, we include time fixed effects $\alpha_t$ in the specification. Depending on the specification, we also include controls for lagged real exchange rates, output and consumption growth.

Table 10 presents the results from estimating (51). We see that, there is a strong positive correlation between a country's real exchange rate and the relative returns of growth vs value stocks. The magnitudes are economically meaningful: a one-standard-deviation increase in GMV portfolio returns is associated with an appreciation of the country's currency by approximately 0.8 percentage points. This prediction is both qualitatively but also quantitatively consistent with the predictions of our model in Figure 10. That is, the median estimate of $\beta_1$ from estimating equation (51) in 10,000 simulations implies that a one-standard-deviation increase in GMV portfolio returns leads to a 1.2 percentage point appreciation of the exchange rate in our model.

# 5 Conclusion

In sum, our evidence suggests that U.S. innovation is an important driver of dollar dynamics. Periods of major innovative activity coincide with real dollar appreciation, and once wealth effects are accounted for, exchange rates line up more closely with fundamentals such as consumption and output growth. Wealth fluctuations, in turn, appear tied to technology shocks, and foreign capital flows toward innovative U.S. firms.

A small modification of the standard endowment model—introducing displacement shocks that reallocate output across agents—goes a long way toward matching these patterns. The model captures the joint behavior of exchange rates, consumption growth, trade flows, and returns. It reproduces the familiar puzzles of volatility, Backus-Smith correlations, and UIP, while delivering testable implications supported by the data.

Naturally, the model is stripped down. It leaves out many forces that also shape exchange rates. But the results suggest that a relatively simple mechanism, centered on the distributional consequences of technology shocks, may account for much of what we see in the data. Future work can ask how richer frictions, institutions, and asset markets amplify or dampen this mechanism, and how far innovation shocks can go in explaining the broader dynamics of global capital flows.

# References


Aghion, P., U. Akcigit, A. Bergeaud, R. Blundell, and D. Hemous (2018, 06). Innovation and Top Income Inequality. *The Review of Economic Studies 86*(1), 1–45.

Aghion, P. and P. Howitt (1992). A model of growth through creative destruction. *Econometrica 60*(2), 323–351.

Aguiar, M., O. Itskhoki, and D. Mukhin (2024). How Good is International Risk Sharing. Nber working paper.

Alvarez, F., A. Atkeson, and P. J. Kehoe (2002). Money, interest rates, and exchange rates with endogenously segmented markets. *Journal of Political Economy 110*(1), 73–112.

Alvarez, F., A. Atkeson, and P. J. Kehoe (2007, May). If exchange rates are random walks, then almost everything we say about monetary policy is wrong. *American Economic Review 97*(2), 339–345.

Alvarez, F., A. Atkeson, and P. J. Kehoe (2009). Time-varying risk, interest rates, and exchange rates in general equilibrium. *The Review of Economic Studies 76*(3), 851–878.

Atkeson, A., J. Heathcote, and F. Perri (2022). The end of privilege: A reexamination of the net foreign asset position of the united states. Working paper.

Bacchetta, P. and E. Van Wincoop (2006, June). Can information heterogeneity explain the exchange rate determination puzzle? *American Economic Review 96*(3), 552–576.

Backus, D. K., S. Foresi, and C. I. Telmer (2001). Affine term structure models and the forward premium anomaly. *The Journal of Finance 56*(1), 279–304.

Backus, D. K. and G. W. Smith (1993). Consumption and real exchange rates in dynamic economies with non-traded goods. *Journal of International Economics 35*(3), 297–316.

Balassa, B. (1964). The purchasing-power parity doctrine: A reappraisal. *Journal of Political Economy 72*(6), 584–596.

Bekaert, G., E. Engstrom, and Y. Xing (2009). Risk, uncertainty, and asset prices. *Journal of Financial Economics 91*(1), 59–82.

Björkman, M. and K. Holmström (2000, 12). Global optimization of costly nonconvex functions using radial basis functions. *Optimization and Engineering 1*, 373–397.

Blanchard, O. J. (1985). Debt, deficits, and finite horizons. *Journal of Political Economy 93*(2), 223–47.

Brandt, M. W., J. H. Cochrane, and P. Santa-Clara (2006). International risk sharing is better than you think, or exchange rates are too smooth. *Journal of Monetary Economics 53*(4), 671–698.

Camanho, N., H. Hau, and H. Rey (2020). Global portfolio rebalancing and exchange rates. Technical report.

Chahrour, R., V. Cormun, P. De Leo, P. A. Guerrón-Quintana, and R. Valchev (2024, June). Exchange rate disconnect revisited. Working Paper 32596, National Bureau of Economic Research.

Colacito, R. and M. M. Croce (2011). Risks for the long run and the real exchange rate. *Journal of Political Economy 119*(1), 153–181.

Colacito, R. and M. M. Croce (2013). International asset pricing with recursive preferences. *The Journal of Finance 68*(6), 2651–2686.

Colacito, R., M. M. Croce, F. Gavazzoni, and R. Ready (2018). Currency risk factors in a recursive multicountry economy. *The Journal of Finance 73*(6), 2719–2756.

Constantinides, G. M. and D. Duffie (1996). Asset pricing with heterogeneous consumers. *Journal of Political Economy 104*(2), 219–240.

Dahlquist, M., C. Heyerdahl Larsen, A. Pavlova, and J. Penasse (2023). International capital market and wealth transfers.

Driscoll, J. C. and A. C. Kraay (1998). Consistent covariance matrix estimation with spatially dependent panel data. *The Review of Economics and Statistics 80*(4), 549–560.

Fama, E. F. (1984). Forward and spot exchange rates. *Journal of Monetary Economics 14*(3), 319–338.

Fama, E. F. and K. R. French (1989). Business conditions and expected returns on stocks and bonds. *Journal of Financial Economics 25*(1), 23–49.

Fang, X. (2021, 09). Intermediary Leverage and the Currency Risk Premium. *working paper 35*(5), 2345–2385.

Fang, X. and Y. Liu (2021). Volatility, intermediaries, and exchange rates. *Journal of Financial Economics 141*(1), 217–233.

Farhi, E. and I. Werning (2014). Dilemma not trilemma? capital controls and exchange rates with volatile capital flows. *IMF Economic Review 62*(4), 569–605.

Fernald, J. (2014). A Quarterly, Utilization-Adjusted Series on Total Factor Productivity. Federal reserve bank of san francisco working paper.

Froot, K. A. and K. Rogoff (1995). Chapter 32 perspectives on ppp and long-run real exchange rates. Volume 3 of *Handbook of International Economics*, pp. 1647–1688. Elsevier.

Fukui, M., E. Nakamura, and J. Steinsson (2023, May). The macroeconomic consequences of exchange rate depreciations. Working Paper 31279, National Bureau of Economic Research.

Gabaix, X. and M. Maggiori (2015, 03). International Liquidity and Exchange Rate Dynamics *. *The Quarterly Journal of Economics 130*(3), 1369–1420.

Gârleanu, N., S. Panageas, D. Papanikolaou, and J. Yu (2016). Drifting apart: The pricing of assets when the benefits of growth are not shared equally. Working paper, University of California, Berkeley.

Gavazzoni, F. and A. M. Santacreu (2020). International r&d spillovers and asset prices. *Journal of Financial Economics 136*(2), 330–354.

Gourinchas, P. and H. Rey (2007a). International financial adjustment. *Journal of Political Economy 115*(4), 665–703.

Gourinchas, P.-O., W. Ray, and D. Vayanos (2020). A preferred-habitat model of term premia and currency risk. Technical report.

Gourinchas, P.-O. and H. Rey (2007b). From World Banker to World Venture Capitalist: US External Adjustment and the Exorbitant Privilege. In *G7 Current Account Imbalances: Sustainability and Adjustment*, NBER Chapters, pp. 11–66. National Bureau of Economic Research, Inc.

Gourinchas, P.-O., H. Rey, and N. Govillot (2010, August). Exorbitant Privilege and Exorbitant Duty. IMES Discussion Paper Series 10-E-20, Institute for Monetary and Economic Studies, Bank of Japan.

Greenwood, J. and B. Jovanovic (1999). The information-technology revolution and the stock market. *American Economic Review 89*(2).

Greenwood, R., S. G. Hanson, J. C. Stein, and A. Sunderam (2020, July). A quantity-driven theory of term premia and exchange rates. Working Paper 27615, National Bureau of Economic Research.

Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2005). Market value and patent citations. *The RAND Journal of Economics 36*(1), pp. 16–38.

Hassan, T., T. M. Mertens, and J. Wang (2024). A currency premium puzzle. Working paper.

Hassan, T. A. (2013). Country size, currency unions, and international asset returns. *The Journal of Finance 68*(6), 2269–2308.

Hau, H. and H. Rey (2006). Exchange rates, equity prices, and capital flows. *Review of Financial Studies 19*(1), 273–317.

Huang, Q., L. Kogan, and D. Papanikolaou (2023). Productivity shocks and inflation in incomplete markets. Working paper.

Itskhoki, O. and D. Mukhin (2021). Exchange rate disconnect in general equilibrium. *Journal of Political Economy 129*(8), 2183–2232.

Jiang, Z., A. Krishnamurthy, and H. Lustig (2021). Foreign safe asset demand and the dollar exchange rate. *The Journal of Finance 76*(3), 1049–1089.

Jiang, Z., A. Krishnamurthy, and H. Lustig (2023, November). Implications of asset market data for equilibrium models of exchange rates. Working Paper 31851, National Bureau of Economic Research.

Jiang, Z., A. Krishnamurthy, H. Lustig, and J. Sun (2021, July). Beyond Incomplete Spanning: Convenience Yields and Exchange Rate Disconnect. Research Papers 3964, Stanford University, Graduate School of Business.

Kekre, R. and M. Lenel (2024a, September). Exchange rates, natural rates, and the price of risk. Working Paper 32976, National Bureau of Economic Research.

Kekre, R. and M. Lenel (2024b, June). The flight to safety and international risk sharing. *American Economic Review 114*(6), 1650–91.

Kelly, B., D. Papanikolaou, A. Seru, and M. Taddy (2021, September). Measuring technological innovation over the long run. *American Economic Review: Insights 3*(3), 303–20.

Kocherlakota, N. and L. Pistaferri (2008). Inequality and real exchange rates. *Journal of the European Economic Association 6*(2-3), 597–608.

Kogan, L., D. Papanikolaou, A. Seru, and N. Stoffman (2017). Technological Innovation, Resource Allocation, and Growth. *The Quarterly Journal of Economics 132*(2), 665–712.

Kogan, L., D. Papanikolaou, and N. Stoffman (2020). Left behind: Creative destruction, inequality, and the stock market. *Journal of Political Economy 128*(3).

Lee, B.-S. and B. F. Ingram (1991). Simulation estimation of time-series models. *Journal of Econometrics 47*(2), 197–205.

Liu, Y. and I. Shaliastovich (2022). Government policy approval and exchange rates. *Journal of Financial Economics 143*(1), 303–331.

Lustig, H., A. Stathopoulos, and A. Verdelhan (2019, December). The term structure of currency carry trade risk premia. *American Economic Review 109*(12), 4142–77.

Lustig, H. and A. Verdelhan (2019, June). Does incomplete spanning in international financial markets help to explain exchange rates? *American Economic Review 109*(6), 2208–44.

Martin, I. (2011, November). The forward premium puzzle in a two-country world. Working Paper 17564, National Bureau of Economic Research.

Meese, R. A. and K. Rogoff (1983). Empirical exchange rate models of the seventies: Do they fit out of sample? *Journal of International Economics 14*(1), 3–24.

Nam, D. and J. Wang (2015). The effects of surprise and anticipated technology changes on international relative prices and trade. *Journal of International Economics 97*(1), 162–177.

Obstfeld, M. and K. Rogoff (2001). The six major puzzles in international macroeconomics: Is there a common cause? *NBER Macroeconomics Annual 15*, 339–390.

Papanikolaou, D. (2011). Investment shocks and asset prices. *Journal of Political Economy, forthcoming*.

Pastor, L. and P. Veronesi (2009, September). Technological revolutions and stock prices. *American Economic Review 99*(4), 1451–83.

Pavlova, A. and R. Rigobon (2007, 01). Asset Prices and Exchange Rates. *The Review of Financial Studies 20*(4), 1139–1180.

Pavlova, A. and R. Rigobon (2008). The role of portfolio constraints in the international propagation of shocks. *The Review of Economic Studies 75*(4), 1215–1256.

Pavlova, A. and R. Rigobon (2010). An asset-pricing view of external adjustment. *Journal of International Economics 80*(1), 144–156. Special Issue: JIE Special Issue on International Macro-Finance.

Pavlova, A. and R. Rigobon (2011). Equilibrium Portfolios and External Adjustment under Incomplete Markets. Technical report.

Ready, R., N. Roussanov, and C. Ward (2017). Commodity trade and the carry trade: A tale of two countries. *The Journal of Finance 72*(6), 2629–2684.

Richmond, R. J. (2019). Trade network centrality and currency risk premia. *The Journal of Finance 74*(3), 1315–1361.

Samuelson, P. A. (1964). Theoretical notes on trade problems. *The Review of Economics and Statistics 46*(2), 145–154.

Sauzet, M. (2023). Asset prices, global portfolios, and the international financial system.

Uhlig, H. (2004, August). What moves GNP? Econometric Society 2004 North American Winter Meetings 636, Econometric Society.

Verdelhan, A. (2010). A habit-based explanation of the exchange rate risk premium. *The Journal of Finance 65*(1), 123–146.

Wiriadinata, U. (2021). External debt, currency risk, and international monetary policy transmission. Working paper.

# Figures and Tables

**Table 1:** Dollar Index growth and U.S. Innovation

| Growth in Real Dollar | Time Series Estimate (EW Dollar Index) | | | | Panel Estimate |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| US Innovation (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 |

**Notes:** The table reports regression results of the growth of log dollar index on U.S. innovation:

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

The sample period is 1974-2022. U.S. innovation is measured by the log of the ratio of the total value of patents each year (Kogan et al. (2017)) to the total market value. The dollar index is computed as an equal weighted average real value of the US dollar against the group of currencies in our sample. Control variables $X_t$ includes lagged innovation, lagged output growth and lagged Dollar Index level at $t$. Both series are in logs. The last column presents estimates from the following panel regression:

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

where $X_t^{US,f}$ accounts for the lagged exchange rate level, lagged innovation, and the lagged growth of the output ratio between the U.S. and each foreign country. The sample consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors (in parentheses) are obtained using Newey-West with one period lag. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table 2:** U.S. Innovation and Imperfect Risk Sharing

| Growth | Relative Wealth (US vs F) | | Relative Inequality (US vs F) | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| US Innovation (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 |

**Notes:** Columns 1-2 of this table report regression results of the growth of wealth ratio on US innovation:

$$\Delta \log W^{US}_{t+1}/{W^f}_{t+1} = \alpha + \beta_1 Inno_{US,t+1} + \beta_2 X_t + \varepsilon_{t+1}$$

The sample period is 1974–2022. The dependent variable is the growth of wealth ratio of the U.S. to a foreign country. U.S. innovation is measured as the logarithm of the ratio of patent value (KPSS) to total market capitalization. The unbalanced panel consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. Control variable $X_t$ includes lagged innovation, lagged wealth ratio, and the lagged growth of the output ratio between the U.S. and each foreign country. Independent variables are standardized to unit standard deviation using unconditional moments. Columns 3-4 report regression results where the dependent variable is replaced with the relative inequality growth, defined as the difference in log top 1 percent income share between the US and foreign countries. The panel regressions include country fixed effects, and standard errors are reported in parentheses using the Driscoll and Kraay (1998) method. Data on income inequality and wealth are from World Inequality Database. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table 3:** Innovation and Foreign Institutional Ownership in the US

| $\Delta$ Foreign Inst. Own. | (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 |

**Notes:** This table reports regression coefficients (times 100) of :

$$\Delta \text{IO\_FOR}_{i,t+1} = \alpha + \beta \log(inno)_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t+1}. \tag{52}$$

The dependent variable $\Delta\text{IO\_FOR}_{i,t+1}$ is the change in foreign institutional ownership for firm $i$ between $t$ and $t+1$. The foreign institutional ownership data are from FactSet Lionshare database. The independent variable is the (log) number of important patents granted to firm $i$ in the last year $t$. Important patents are defined as those in the top 20% of the distribution in terms of three different innovation measures: market value of patents (Kogan et al., 2017), forward citations (Hall, Jaffe, and Trajtenberg, 2005), and patent importance (Kelly et al., 2021). When *inno* is equal to zero, we replace $\log(inno)$ with zero and add a dummy equal to one if *inno* is equal to 0, thereby preventing the removal of the observation from the data. The vector of controls $X_{i,t}$ includes foreign institutional ownership at time $t$, $\text{IO\_FOR}_{i,t}$, firm and year fixed effects. In columns (4)-(6), we add firm size and sales (log) at $t$ as additional controls. In columns (7)-(9), we replace year fixed effects with industry × year fixed effects. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors in parentheses are clustered at the SIC industry and year level. $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$.

**Table 4:** Exchange Rate Growth, Wealth Growth and Consumption and Output Growth

Panel A. Real Exchange Rate Growth, Consumption Growth and Wealth Changes

| | Panel | AUS | CAN | CHE | DEU | FRA | GBR | ITA | JPN | NOR | NZL | SWE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wealth change | 0.107*** | 0.103*** | 0.099*** | 0.108*** | 0.131*** | 0.106*** | 0.116*** | 0.094*** | 0.101*** | 0.101*** | 0.082*** | 0.114*** |
| | (0.004) | (0.007) | (0.009) | (0.010) | (0.009) | (0.006) | (0.008) | (0.010) | (0.006) | (0.007) | (0.015) | (0.007) |
| Consumption growth | -0.020*** | -0.010 | -0.015* | -0.027** | -0.024** | -0.005 | -0.027*** | -0.001 | -0.032*** | -0.011 | 0.003 | -0.022** |
| | (0.003) | (0.007) | (0.008) | (0.010) | (0.009) | (0.008) | (0.008) | (0.009) | (0.008) | (0.008) | (0.023) | (0.008) |
| Observations | 420 | 49 | 49 | 31 | 25 | 25 | 49 | 25 | 49 | 42 | 27 | 49 |
| R2 | 0.840 | 0.860 | 0.779 | 0.870 | 0.950 | 0.961 | 0.870 | 0.893 | 0.881 | 0.867 | 0.843 | 0.882 |

Panel B. Real Exchange Rate Growth, Output Growth and Wealth Changes

| | Panel | AUS | CAN | CHE | DEU | FRA | GBR | ITA | JPN | NOR | NZL | SWE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wealth change | 0.103*** | 0.103*** | 0.096*** | 0.105*** | 0.129*** | 0.105*** | 0.109*** | 0.095*** | 0.100*** | 0.099*** | 0.102*** | 0.106*** |
| | (0.004) | (0.007) | (0.008) | (0.010) | (0.008) | (0.006) | (0.008) | (0.011) | (0.007) | (0.007) | (0.014) | (0.007) |
| GDP growth | -0.016*** | -0.011* | -0.015* | -0.039*** | -0.019** | -0.007 | -0.014* | -0.001 | -0.026*** | -0.010 | -0.036 | -0.007 |
| | (0.004) | (0.006) | (0.008) | (0.013) | (0.007) | (0.005) | (0.008) | (0.010) | (0.007) | (0.010) | (0.021) | (0.008) |
| Observations | 420 | 49 | 49 | 31 | 25 | 25 | 49 | 25 | 49 | 42 | 27 | 49 |
| R2 | 0.832 | 0.865 | 0.811 | 0.862 | 0.950 | 0.965 | 0.849 | 0.878 | 0.874 | 0.863 | 0.860 | 0.856 |

**Notes:** Panel A of the table reports regression results of the growth of log exchange rate on log wealth ratio and log consumption growth ratio:

$$\Delta \log e_{t+1} = \alpha + \beta_1 \Delta \log W_{t+1} + \beta_2 \Delta \log C_{t+1} + \gamma X_t + \varepsilon_{t+1}$$

where the vector of controls $X_t$ includes lagged relative levels of exchange rates, consumption and relative wealth. The sample period is 1974-2022. The unbalanced panel consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. Independent variables are standardized to unit standard deviation using unconditional moments. In individual country regressions, standard errors (in parentheses) are obtained using Newey-West with five periods lag. The panel regressions include country fixed effects, and we report Driscoll and Kraay (1998) standard errors in parentheses. Panel B repeats the analysis, replacing consumption with the country's GDP. Income inequality data is from World Inequality Database. Exchange rate, consumption and GDP data are from the World Bank and the IMF. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table 5:** Model-implied Displacement shock and US Dollar

| Growth in Real Dollar | Time Series Estimate | | | | Panel Estimate |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Displacement | 0.036*** | 0.037*** | 0.044*** | 0.042*** | 0.037*** |
| | (0.008) | (0.007) | (0.013) | (0.012) | (0.015) |
| 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 | 0.266 | 0.266 | 0.187 | 0.277 | 0.239 |

**Note:** The table reports regression results of the growth of log dollar index on U.S. innovation:

$$\Delta \log e_{t+1}^{USD} = \alpha + \beta_1 \mathit{Displacement}_{US,t} + \beta_2 X_t + \varepsilon_{t+1}$$

The sample period is 1974-2022. Here, *Displacement* refers to the model-implied displacement shock, which is related to the difference between the aggregate market capitalization growth and the returns from holding the market portfolio. See Section 2.6 for more details. The dollar index is computed as an equal weighted average real value of the US dollar against the group of currencies in our sample. Control variable $X_t$ includes lagged innovation, lagged output growth and lagged dollar index level at $t$. Both series are in logs. The last column presents estimates from the following panel regression:

$$\Delta \log e_{t+1}^{US,f} = \alpha + \beta_1 \mathit{Displacement}_{US,t} + \beta_2 X_t^{US,f} + \varepsilon_{t+1}$$

where $X_t^{US,f}$ accounts for the lagged exchange rate level, lagged innovation, and the lagged growth of the output ratio between the U.S. and each foreign country. The sample consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors (in parentheses) are obtained using Newey-West with one period lag. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table 6:** Model-implied Displacement Shock and Imperfect Risk Sharing

| Growth | US relative wealth | | Rel. Inequality | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Displacement | 0.049*** | 0.055*** | 0.018** | 0.016** |
| | (0.014) | (0.013) | (0.008) | (0.007) |
| 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 | 0.118 | 0.215 | 0.069 | 0.139 |

**Note:** Columns 1-2 of this table report regression results of the growth of wealth ratio on US innovation:

$$\Delta \log W^{US}_{t+1}/W^{f}{}_{t+1} = \alpha + \beta_1 \mathit{Displacement}_{US,t} + \beta_2 X_t + \varepsilon_{t+1}$$

The sample period is 1974–2022. The dependent variable is the growth of wealth ratio of the U.S. to a foreign country. U.S. displacement is measured as described in section 2.6. The unbalanced panel consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. Control variable $X_t$ includes lagged innovation, lagged wealth ratio, and the lagged growth of the output ratio between the U.S. and each foreign country. Independent variables are standardized to unit standard deviation using unconditional moments. Columns 3-4 report regression results where the dependent variable is replaced with the relative inequality growth. The panel regressions include country fixed effects, and standard errors are reported in parentheses using the Driscoll and Kraay (1998) method. Data on income inequality and wealth are from World Inequality Database. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table 7:** Inequality Growth and Exchange Rates

Exchange Rate and Inequality Growth

| | Panel | AUS | CAN | CHE | DEU | FRA | GBR | ITA | JPN | NOR | NZL | SWE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inequality growth | 0.017*** | 0.065*** | -0.007 | 0.015 | 0.058 | 0.027 | 0.037** | 0.093** | 0.023 | -0.004 | 0.008 | 0.014 |
| | (0.005) | (0.021) | (0.017) | (0.023) | (0.064) | (0.029) | (0.017) | (0.038) | (0.022) | (0.013) | (0.012) | (0.019) |
| Observations | 418 | 49 | 49 | 42 | 18 | 25 | 42 | 18 | 42 | 42 | 49 | 42 |
| R2 | 0.124 | 0.412 | 0.138 | 0.189 | 0.202 | 0.176 | 0.302 | 0.385 | 0.080 | 0.094 | 0.161 | 0.114 |

**Note:** Panel A of the table reports regression results of the growth of log exchange rate on log income inequality growth ratio.

$$\Delta \log e_{t+1} = \alpha + \beta \Delta \log I_{t+1} + \gamma X_t + \varepsilon_{t+1}$$

where $\Delta \log I_{t+1}$ is the growth of the ratio of top 1% income share between $t$ and $t+1$. The sample period is 1974-2022. Control vector $X_t$ includes lagged inequality level and lagged exchange rate. The unbalanced panel consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. Independent variables are standardized to unit standard deviation using unconditional moments. In individual country regressions, standard errors (in parentheses) are obtained using Newey-West with one period lag. The panel regressions include country fixed effects, and we report Driscoll and Kraay (1998) standard errors in parentheses. Exchange rate, consumption, and GDP data are from the World Bank and the IMF. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table 8:** Moments used in Model Estimation

| | Data | Model | | |
|---|---|---|---|---|
| | | Median | 5% | 95% |
| *A. Aggregate Quantities* | | | | |
| Consumption growth, mean | 0.014 | 0.013 | 0.004 | 0.020 |
| Consumption growth, volatility | 0.022 | 0.019 | 0.016 | 0.053 |
| Output growth, mean | 0.014 | 0.013 | 0.008 | 0.020 |
| Output growth, volatility | 0.021 | 0.018 | 0.016 | 0.023 |
| *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 |
| *iii. Pairwise Correlations* | | | | |
| Consumption growth (H and F) | 0.454 | 0.745 | 0.170 | 0.905 |
| Output growth (H and F) | 0.596 | 0.831 | 0.697 | 0.932 |
| Stock returns (H and F) | 0.598 | 0.137 | -0.238 | 0.648 |
| Trade surplus growth and consumption growth | -0.299 | -0.148 | -0.926 | 0.311 |
| *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 |

**Note:** This table reports both empirical moments computed using the G-7 & G-10 dataset and simulated moments from the model. The model is calibrated to an annual frequency using the parameters in Table 9. .

**Table 9:** Parameter Estimates

| Description | Symbol | Value |
|---|---|---|
| *Preferences:* | | |
| Home bias | $\alpha$ | 0.989 |
| Preference for own consumption | $h$ | 0.194 |
| Subjective discount rate | $\beta$ | 0.975 |
| Risk aversion | $\gamma$ | 6.232 |
| Elasticity of intertemporal substitution | $\psi$ | 1.634 |
| *Endowments:* | | |
| Displacement shock productivity | $\delta$ | 0.211 |
| Measure of projects-receiver | $\pi$ | 0.097 |
| Mean of output growth | $\mu$ | 0.010 |
| Displacement shock low and middle state | $u_1 = u_2$ | 0.001 |
| Displacement shock high state | $u_3$ | 0.222 |
| Persistence of displacement shock | | |
| — persistence in low state | $p$ | 0.938 |
| — persistence in high state | $q$ | 0.836 |
| Volatility of neutral shock | $\sigma_e$ | 0.016 |
| Technology spillover | $\rho_u$ | 0.729 |
| Correlation of neutral shock | $\rho_e$ | 0.863 |
| Fraction of project that goes to inventors | $\eta$ | 0.714 |

**Note:** This table reports the calibrated parameters of the model. See the main text and the Appendix B.5 for details on the calibration.

**Table 10:** Real Exchange Rates and GMV Portfolio Returns

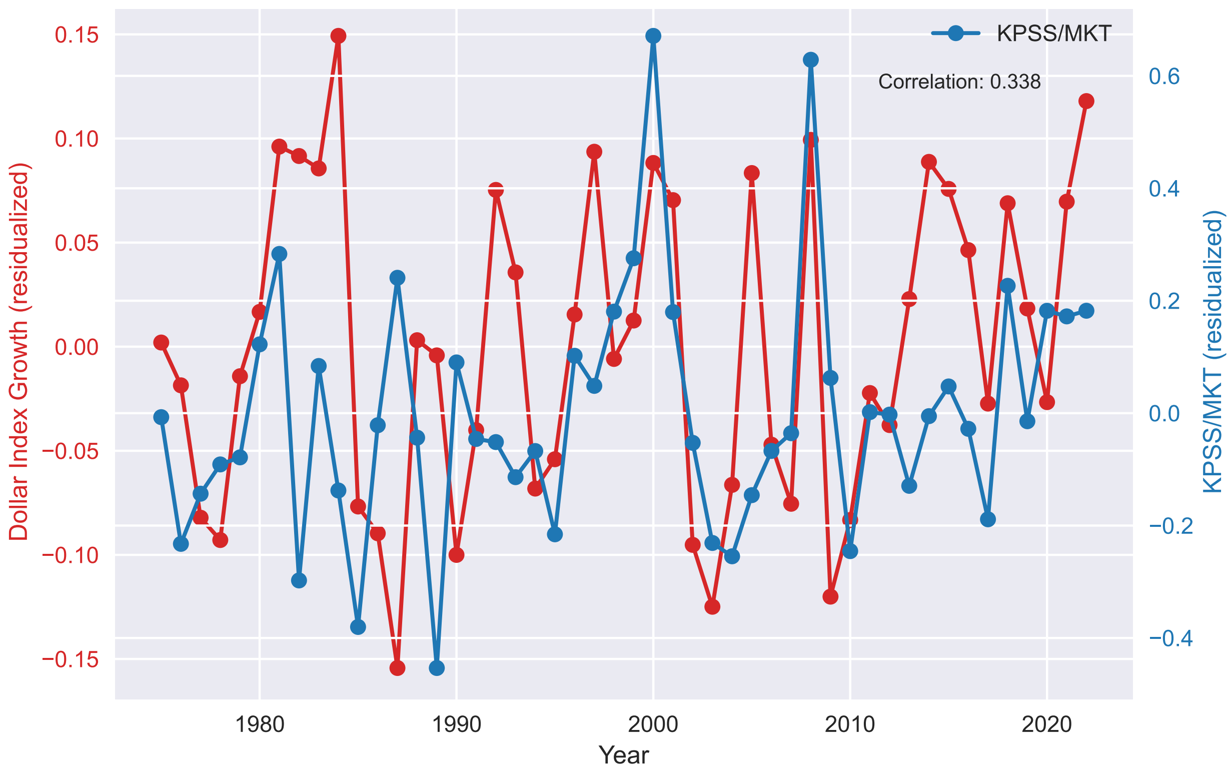
| Growth in real exchange rates | Panel Estimates | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| GMV return | -0.008** | -0.008** | -0.008** |
| | (0.003) | (0.003) | (0.003) |
| Time Fixed Effects | Y | Y | Y |
| Lagged real exchange rates | Y | Y | Y |
| Lagged output growth | | Y | Y |
| Lagged consumption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

**Note:** This table reports regression results for the growth of real exchange rates on GMV return differentials:

$$\Delta \log e^F_{t+1} = \alpha_t + \beta_1 GMV_{F,t+1} + \beta_2 X_t + \varepsilon_{t+1}$$

The sample period is 1974–2022. The independent variable is the return of growth and value stocks (GMV) in country $F$. The international GMV returns (the negative of HML returns) data are from the Ken French website. Depending on the specification, the vector of controls $X_t$ includes lagged real exchange rates and lagged output or consumption growth. $\alpha_t$ is the time fixed effects. Independent variables are standardized to have unit standard deviation using unconditional moments. Standard errors (in parentheses) are clustered at the country level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

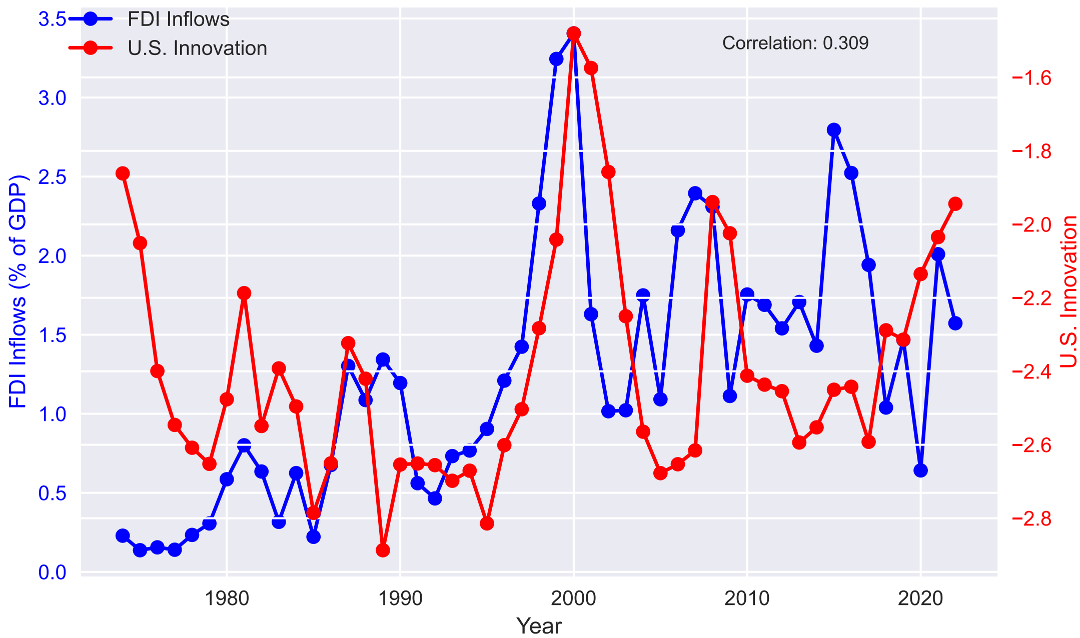
**Figure 1:** U.S. Innovation and US Dollar



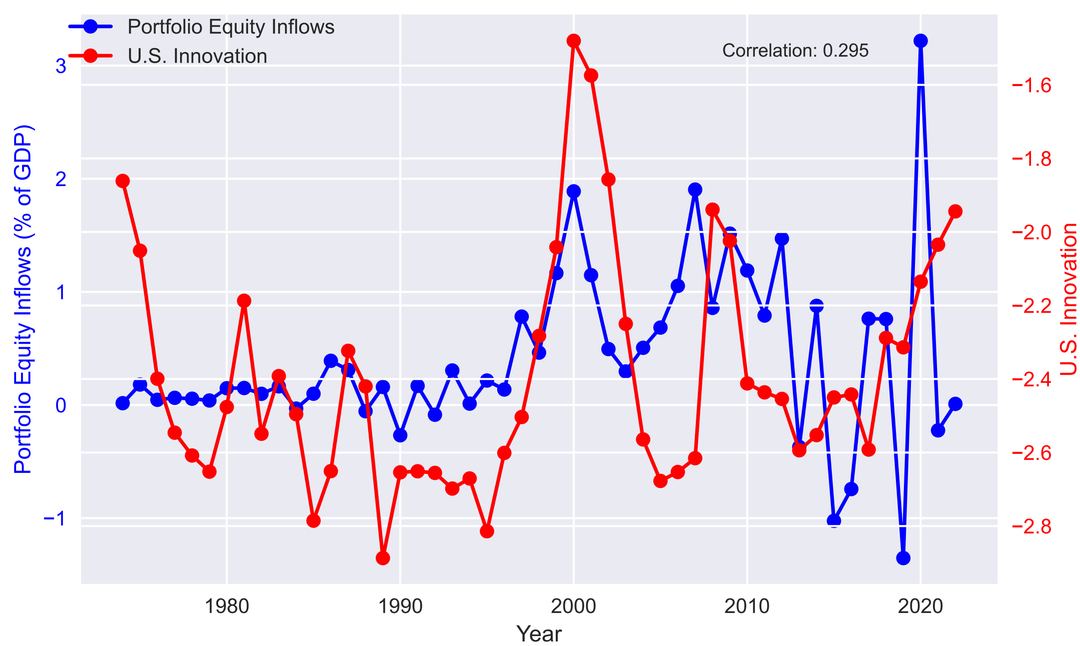

**Note:** This figure plots the real dollar index growth against U.S. innovation from 1974-2022. U.S. innovation is measured as the log of the ratio of the total value of patents each year (Kogan et al., 2017) to the total market value. The real dollar index is computed as an equal weighted average real value of the US dollar against the group of currencies in our sample. Both series are in logs. Both series are residualized to the lagged levels, corresponding to the regression specification in (1).

**Figure 2:** US Innovation and Portfolio Flows

Panel A. FDI Inflows

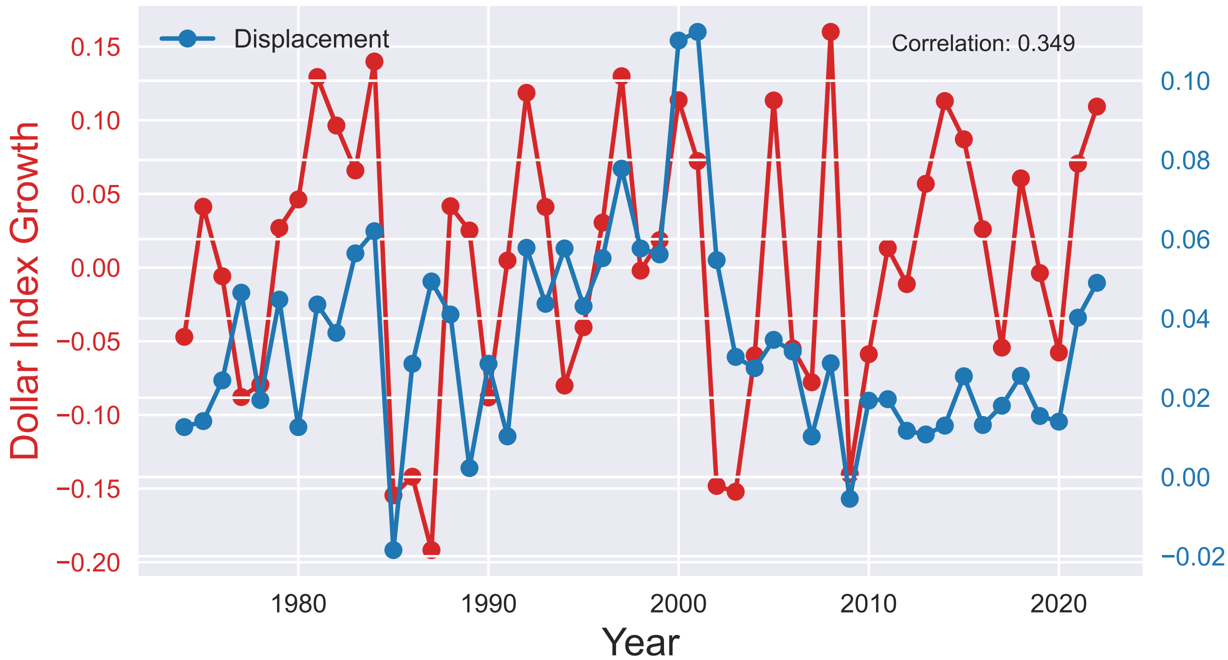



Panel B. Portfolio Equity Inflows



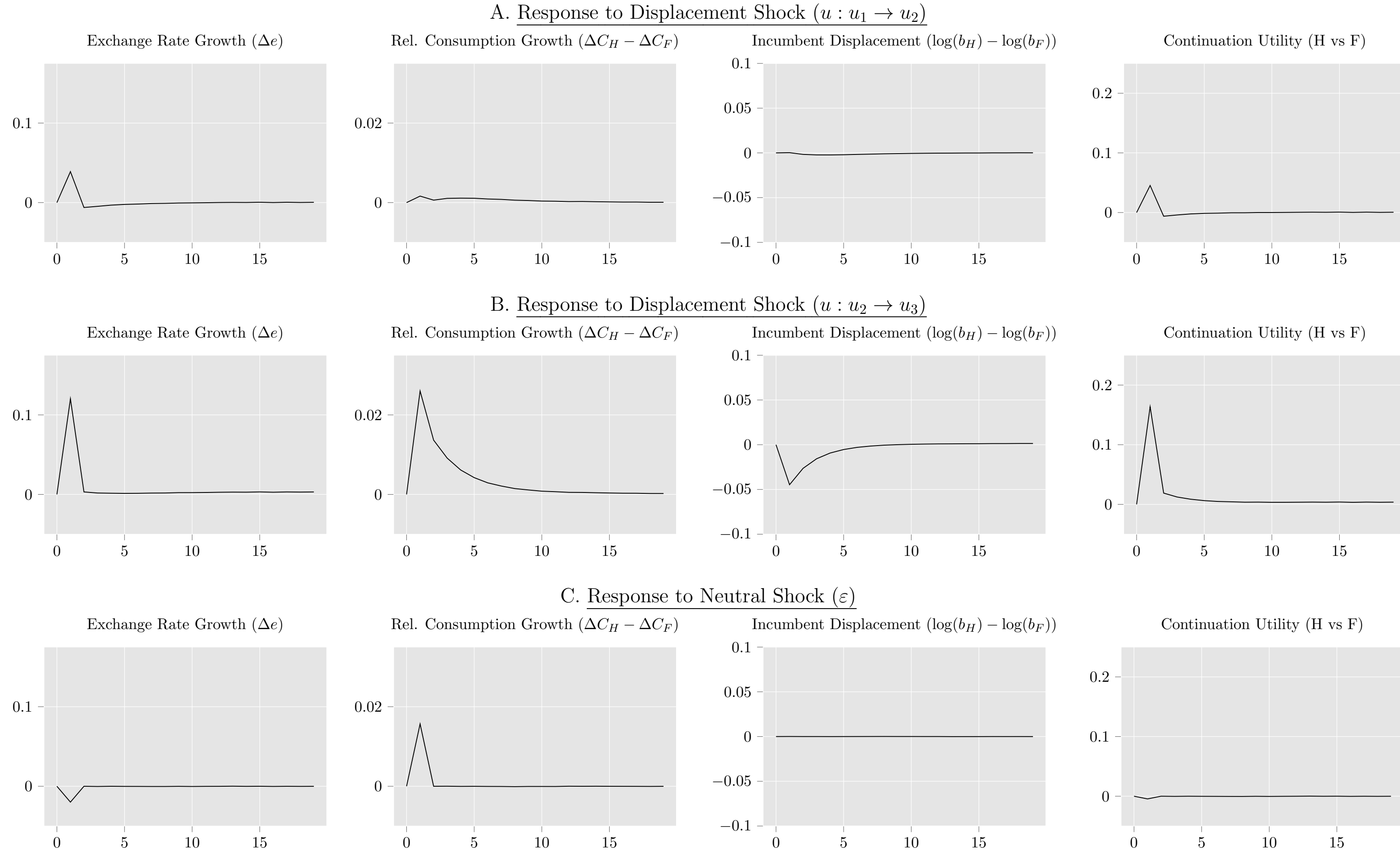

**Note:** This figure plots the U.S. innovation index and foreign direct investment inflows (in Panel A) and portfolio equity inflows (in Panel B) in the U.S. The U.S. innovation is measured as the log of the ratio of the total value of patents each year (Kogan et al. (2017)) to the total market value of the stock market. The aggregate FDI inflows and portfolio equity inflows are obtained from the World Bank. See Appendix A for details.

**Figure 3:** Model-implied displacement shock and growth in the real dollar index



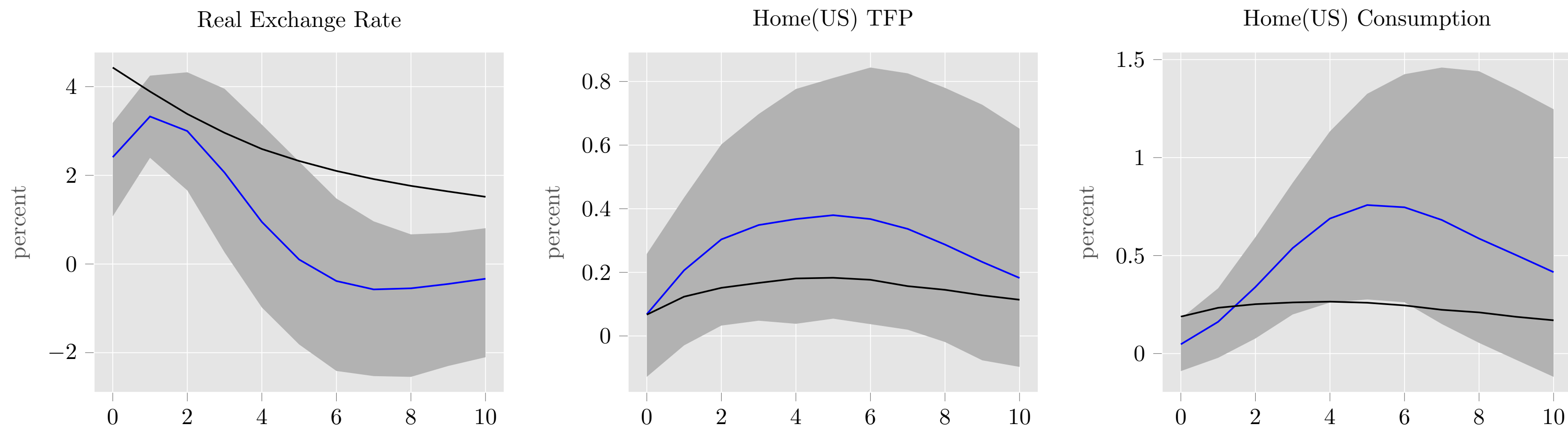

**Note:** This figure plots the growth of the real dollar index (red) and the alternative US displacement series (blue) constructed in Section 2.6 that is based on the difference between the aggregate market capitalization growth and the returns from holding the market portfolio. The red line represents the equal-weighted real dollar index.

**Figure 4:** The Backus-Smith Correlation



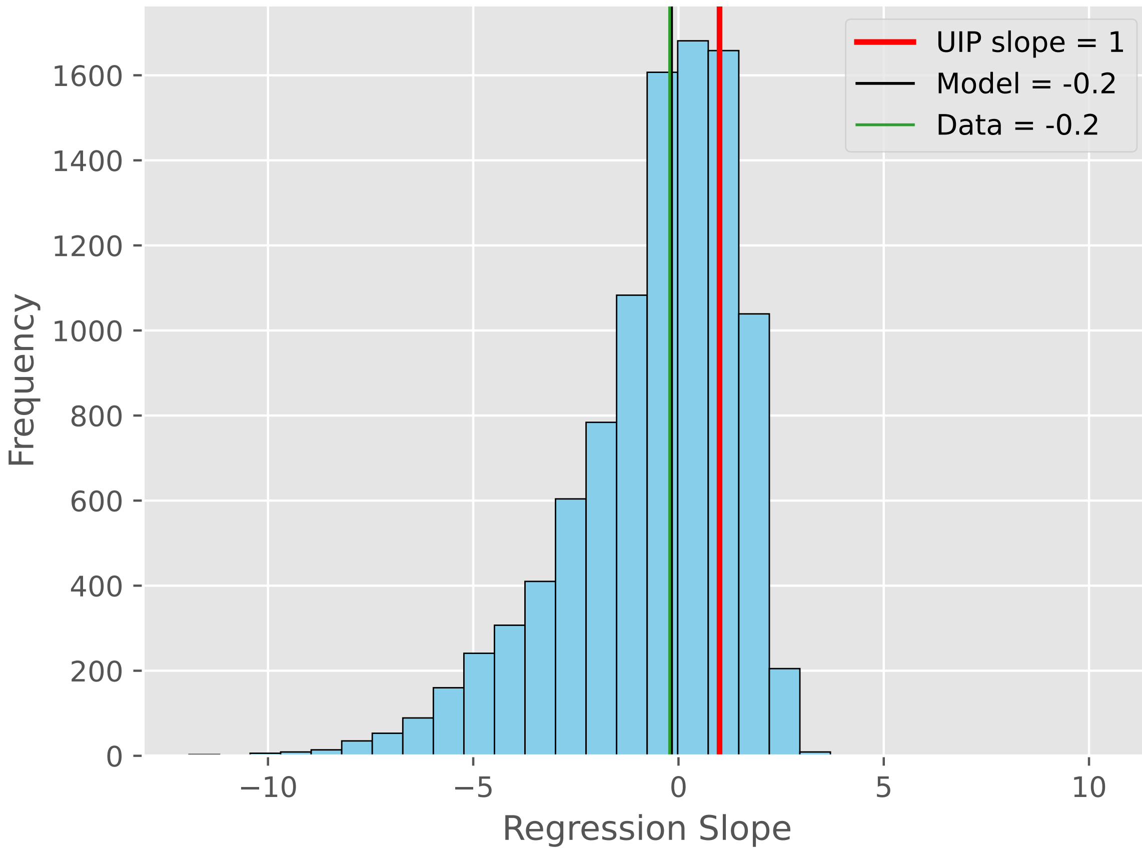

**Note:** This figure plots the impulse response of the difference between the home and foreign countries' variables in response to a shock to the home country. The model is calibrated to an annual frequency using the parameters in Table 9. We construct the impulse responses by introducing an additional one-standard deviation shock at time t=1 without altering the realization of future shocks. The impulse responses are computed at the symmetric steady state and reported as the mean across simulations. In the top and middle panels we plot the response of model quantities to a shift in $\bar{u}^H$, which drives both the domestic and foreign level of displacement—see equation (48). The last columns plot the continuation utility $\left(\log \frac{U_{H,t+1}^{1-\gamma}}{\mathrm{E}_t[U_{H,t+1}^{1-\gamma}]} - \log \frac{U_{F,t+1}^{1-\gamma}}{\mathrm{E}_t[U_{F,t+1}^{1-\gamma}]}\right)$ as in (48). The bottom panel plots the impulse response to a unit standard deviation domestic neutral shock $\varepsilon^H$.

**Figure 5:** Model vs Data: US Dollar and future TFP growth



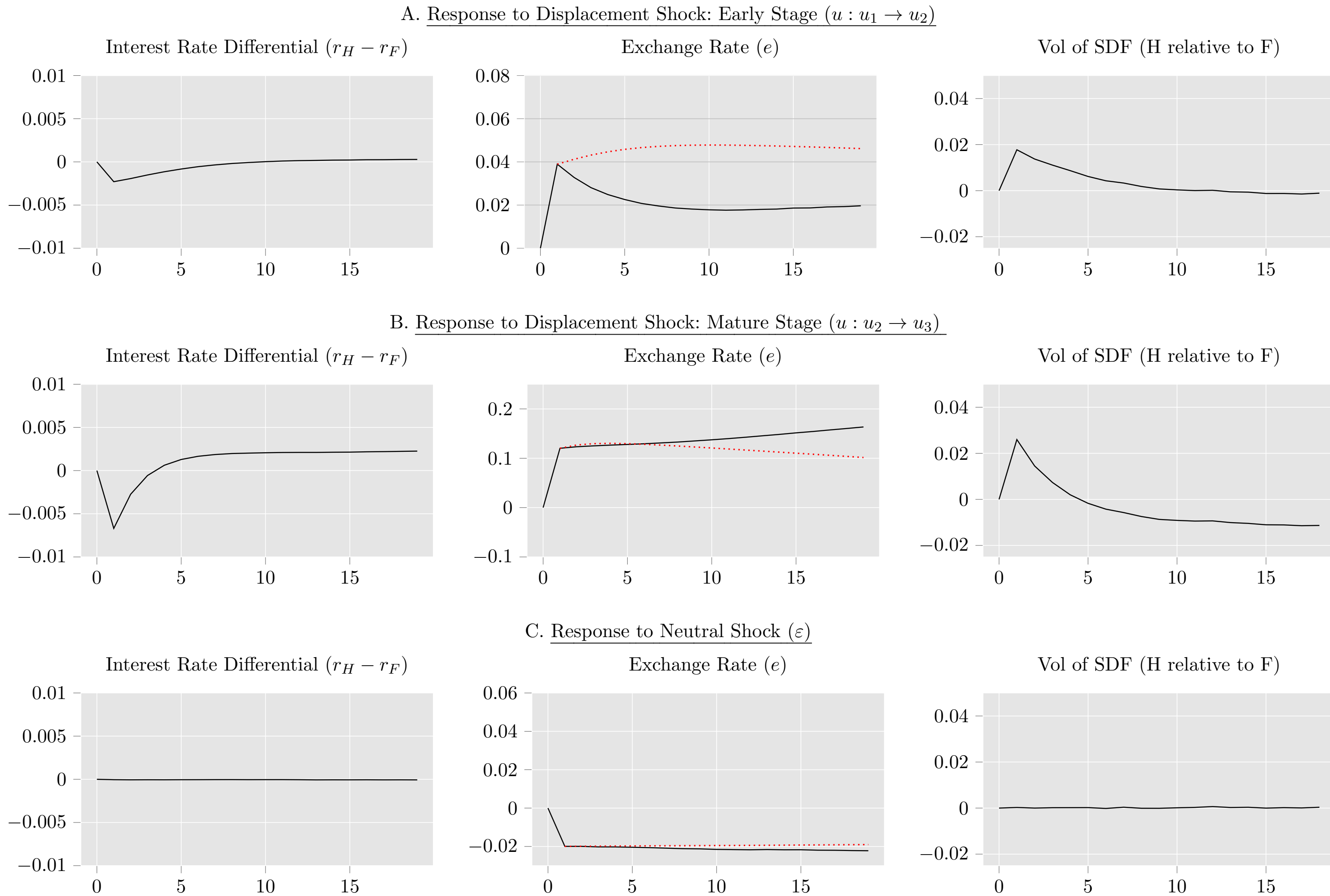

**Note:** The figure plots the model-implied impulse response to the 'FX shock' from Chahrour et al. (2024). In particular, we replicate their VAR analysis in simulated data from the model. The first figure plots the extracted 'FX shock', the second figure plots the response of productivity (output) 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. The original data in Chahrour et al. (2024) are at quarterly frequency, which we convert to annual frequency to match the model's timing. All parameters are calibrated to the values reported in Table 9.

**Figure 6:** Model vs Data: UIP Regression Slopes



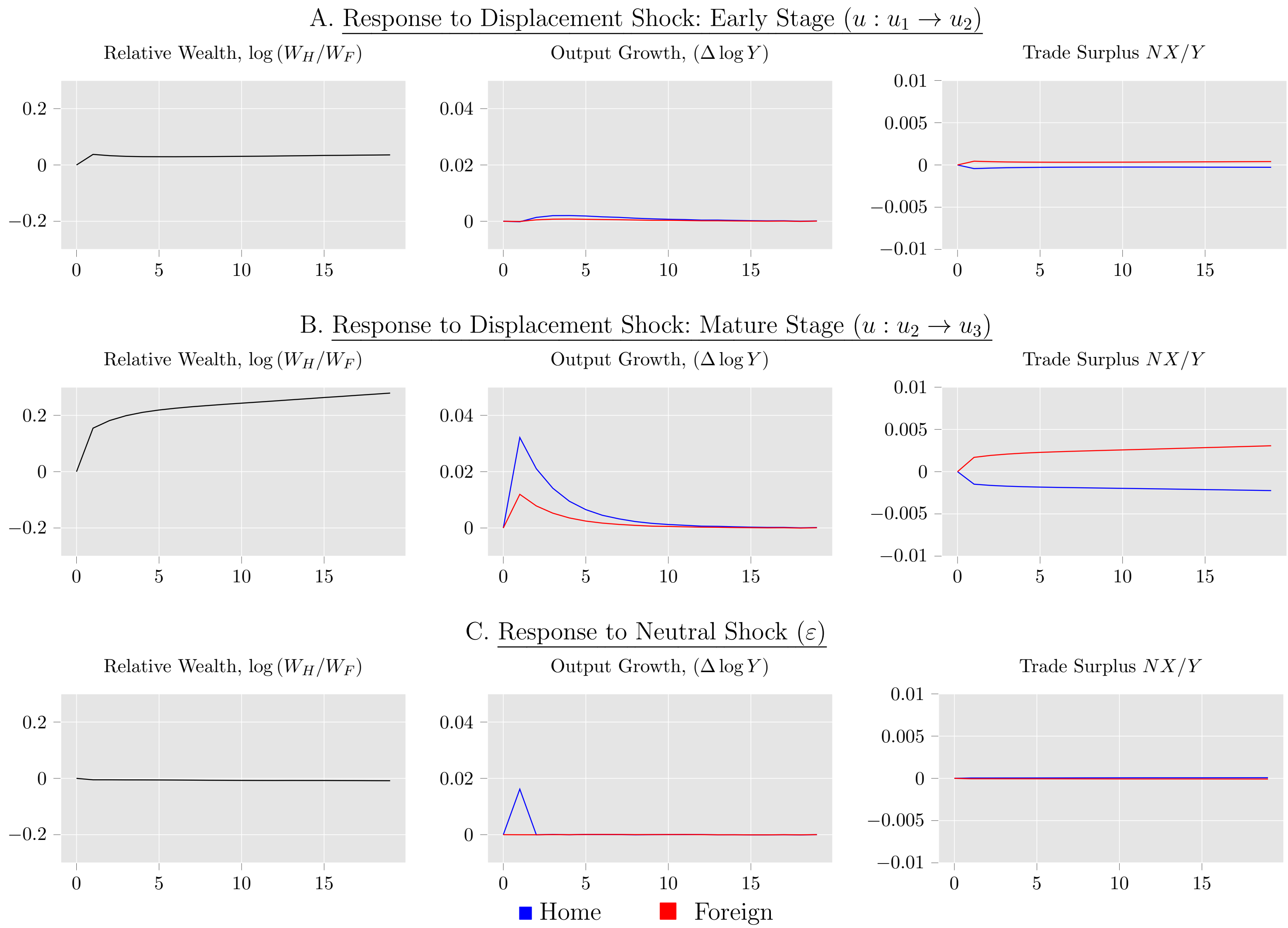

**Note:** This figure shows the histogram of UIP regression slopes from individual simulations. The model is calibrated to an annual frequency using the parameters in Table 9. The calibrated model is simulated 10000 times, each spanning 150 periods, with UIP regressions performed using the last 50 years of each simulation. The black line represents the mean of the estimated UIP coefficients across all simulations, while the blue line represents the estimate from the data.

**Figure 7:** The Forward Premium Puzzle (UIP)




**Note:** This figure summarizes the intuition behind the failure of the UIP in the model. The first column plots the interest-rate differential, the second column plots the exchange rate, and the third column plots the difference in the conditional future volatility of the stochastic discount factor (SDF). The red dotted line in the middle column shows the path that would obtain if Uncovered Interest Parity (UIP) were to hold. The model is calibrated to an annual frequency using the parameters in Table 9. See notes to Figure 4 for further details on the computation of these impulse responses.

**Figure 8:** Output and Trade Flows




**Note:** This figure plots the impulse response of variables to a shock to the home country ($u$ in Panel A and $\varepsilon$ in Panel B), for both the home country (the blue line) and the foreign country (the red line). The model is calibrated to an annual frequency using the parameters in Table 9. See notes to Figure 4 for further details on the computation of these impulse responses.

**Figure 9:** Stock Returns

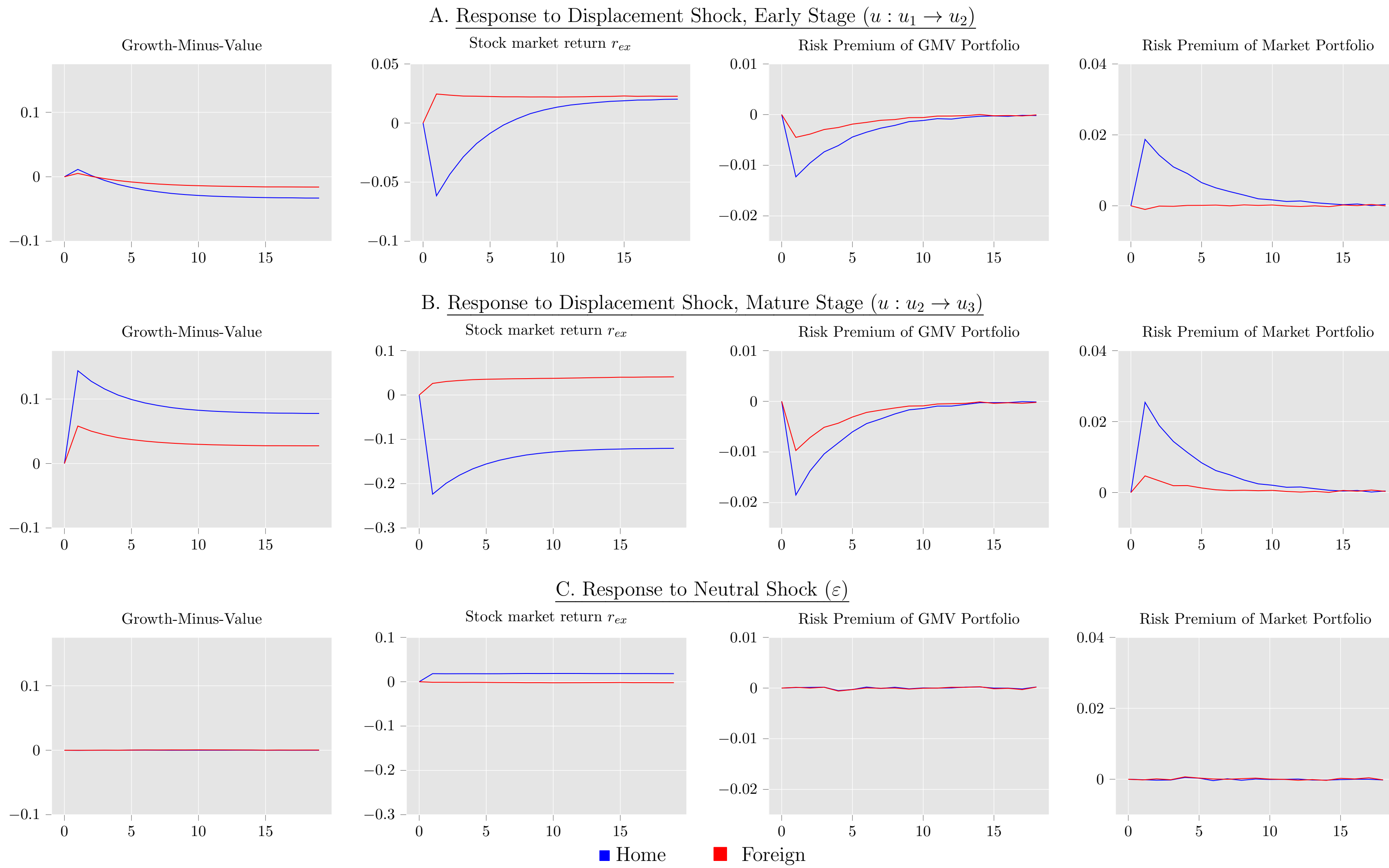



**Figure 10:** This figure plots the impulse response of stock returns in both the home country (the blue line) and the foreign country (the red line). The first column plots the cumulative return to the growth-minus-value portfolio and the second column plots the cumulative return to the market portfolio. Columns three and four plot their respective risk premia, defined as the covariance with the stochastic discount factor. The model is calibrated to an annual frequency using the parameters in Table 9. See notes to Figure 4 for further details on the computation of these impulse responses.

# Appendix

## A Data Appendix

The consumption, GDP and net export data come from the World Bank. We use households final consumption expenditure for consumption series, and the difference between the indices of export of goods and imports of goods and services as our net export series. Both consumption and GDP are real. We use end-of-period exchange rate data from the International Financial Statistics (IMF). Sample period is 1974-2022.

Inflation rates are calculated using Consumer Price Index (CPI) from the World Bank. The real exchange rates are calculated by adjusting nominal exchange rates by the relative CPI index of the corresponding country.

Real interest rates are constructed using three-month T-bills yields from the Global Financial Data, adjusting for realized inflation using annual changes in CPI. The interest rates series for New Zealand and Switzerland starts from 1978 and 1980, respectively. For the rest, the sample period is 1974-2022.

Data on equity index returns (MSCI series) is obtained from Datastream. Equity returns data for New Zealand starts from 1980. Data on top 1% (0.1%) percentage income share and country's total wealth is from World Inequality Database. To calculate each country's wealth in dollars, we multiply the total wealth (data code = mnweal) from the World Inequality Database, denominated in local currency, by the corresponding nominal exchange rate.

The current account data are from the World Economic Outlook Database, spanning from 1980-2022. Data on foreign direct investment net inflows (as a percentage of GDP) and portfolio equity investment net inflows are obtained from the World Development Indicators (World Bank)[15]. We divide portfolio equity net inflows by the corresponding year's GDP to measure equity inflows. The foreign institutional ownership is from the Factset Lionshare database. Patents data is from Kogan et al. (2017). U.S. firms fundamentals are from Compustat.

## B Model Appendix

Here, we discuss the derivation of the model.

### B.1 Simplified Model

**The representative agent in each country**

First, we show that within a country, finding optimal solutions for heterogeneous agents is equivalent to finding optimal solution for a representative agent.

[15] Data is from World Development Indicators. Data code for foreign direct investment is BX.KLT.DINV.WD.GD.ZS; Data code for porfolio equity net inflows is BX.PEF.TOTL.CD.WD.

In each country, even though agents are heterogeneous in their wealth, because of homethetic preference consumption-wealth ratios are equalized.

Consider H country for example, we define the representative agent as

$$U_t^H = \int_{i \in [0,1]} U_{i,t} w_t^{i,H}$$

where $U_{i,t}$ and $w^{i,t}$ are the utility and wealth share of household $i$. That is, the representative agent takes the country-level endowment and the wealth distribution as given and maximizes the wealth-weighted utility.

Because all agents within a country are solving the same optimization problem up to their wealth, so is the wealth-weighted representative agent. Put differently, the representative agent behaves the same way as the individual agent, but scaled up to a wealth that is equal to the country's aggregate wealth. Thus, solving for the equilibrium solutions for heterogeneous agents within a country is equivalent to finding the optimal solution for the representative agent.

Denote $C_t^c$ as the country-level aggregate consumption, the utility of the representative agent can be written as

$$U_t^H = \lambda_t^H U(C_t^H)$$

Where $U(x)$ is the utility function for individual household – $U(x) = \log(x)$ in this case. That is, the utility of the representative agent is proportional to a fictitious agent who consumes country-level aggregate consumption. The time-varying scaling factor $\lambda_t^H$ reflects the change of wealth distribution $w_t^{i,c}$ within the country. If the market is complete, the wealth distribution is invariant and $\lambda_t^H$ would be a constant.

Now the equilibrium allocation problem reduces to a problem with two (representative) agents and incomplete markets.

### Aggregation with log preference

The H's representative agent's utility can be written as

$$U_t^H = \sum_{s=t}^{\infty} \beta^{s-t} \log C_s^H$$

With incomplete markets, the usual construction of a planner's utility as a weighted sum, with constant weights, of individual representative utility function is not possible. Instead, we are going to employ a fictitious planner with stochastic weights.

This fictitious representative agent maximizes his utility subject to the resource constraints:

$$\max_{\{x_{H,t}^H, x_{F,t}^H, x_{H,t}^F, x_{F,t}^F\}, t=0,1,2,..} \sum_t \beta^t \left( \log C_t^H + \lambda_t \log C_t^F \right)$$
$$\text{s.t.} \qquad x_{H,t}^H + x_{H,t}^F = Y_{H,t}$$

$$x^H_{F,t} + x^F_{F,t} = Y_{F,t}$$
$$C^H_t = (x^H_{H,t})^\alpha (x^H_{F,t})^{1-\alpha}$$
$$C^F_t = (x^F_{H,t})^{1-\alpha} (x^F_{F,t})^\alpha$$

where we have normalized the weight on the Home representative agent to be equal to one and assigned the weight $\lambda$ to the foreign representative agent. $\lambda_t$ is the marginal utilities of either good of the two countries.

**Allocations**

For concreteness, we focus on the exposition on the Home consumer. First, at each $t$, we derive the consumer's demands for $Y_H$ and $Y_F$ goods, keeping overall consumption expenditure $\mathcal{C}_H$ fixed.

$$\max_{\{x^H_{H,t}, x^H_{F,t}\}} \alpha \log x^H_{H,t} + (1-\alpha) \log x^H_{F,t} \tag{A.1}$$

$$\text{s.t.} \quad p_{h,t} x^H_{H,t} + p_{f,t} x^H_{F,t} = \mathcal{C}_H \tag{A.2}$$

We obtain the following demands

$$x^H_{H,t} = \frac{\alpha \mathcal{C}_H}{p_{h,t}}, \qquad x^H_{F,t} = \frac{(1-\alpha)\mathcal{C}_H}{p_{f,t}} \tag{A.3}$$

The indirect utility function defined as $U_H(\mathcal{C}_H, p_{h,t}, p_{f,t})$ is then given by

$$U_H(\mathcal{C}_H, p_{h,t}, p_{f,t}) = \log(\mathcal{C}_H) + F(p_{h,t}, p_{f,t}) \tag{A.4}$$

Function $F$ depends only on variables that are exogenous from the viewpoint of the consumer and therefore, because of the separability, it drops out the portfolio choice.

Hence, the optimization problem of the consumer is equivalent to the single-good consumption-investment problem, with consumption expenditure $\mathcal{C}_H$ replacing the consumption. Importantly, it implies that the prices of individual goods $p_{h,t}, p_{f,t}$ do not pose a risk that the consumer desires to hedge.

With log preference, consumers have constant consumption-to-wealth ratio. Thus, the Pareto weights $\lambda_t$ is equal to the consumption expenditure ratio, which in turn is equal to the wealth ratio between two countries $\lambda_t = \frac{W_{F,t}}{W_{H,t}}$. Substituting the demand functions in the budget constraints, we get the allocations.

$$x^H_{H,t} = \frac{\alpha}{\alpha + (1-\alpha)\lambda_t} Y_{H,t} \tag{A.5}$$

$$x^F_{H,t} = \frac{(1-\alpha)\lambda_t}{\alpha + (1-\alpha)\lambda_t} Y_{H,t} \tag{A.6}$$

$$x^H_{F,t} = \frac{1-\alpha}{1-\alpha+\alpha\lambda_t} Y_{F,t} \tag{A.7}$$

$$x_{F,t}^F = \frac{\alpha\lambda_t}{1-\alpha+\alpha\lambda_t} Y_{F,t}. \tag{A.8}$$

**SDFs and Asset Prices**

*SDF.* Let $\mathcal{N}_{t+1}^c$ denote the set of all indices of agents in country $c$ who receive worthless ideas at time $t+1$. In what follows, we will focus on the exposition on the Home consumer. By definition,

$$\frac{M_{t+1}^H}{M_t^H} = \beta \mathrm{E}\left(\frac{c_{t+1}^{i,H}}{c_t^{i,H}}\right)^{-1} = \beta\left(\frac{\int_{i\in\mathcal{N}_{t+1}^H} dC_{t+1}^{i,H}}{\int_{i\in\mathcal{N}_{t+1}^H} dC_t^{i,H}}\right)^{-1} \tag{A.9}$$

where the first equation follows from the consumer's Euler equation and the second equation follows from the probability of receiving a profitable firm being zero. As a result, households' anticipated consumption growth coincides with the consumption growth of the cohort $\mathcal{N}_{t+1}^H$. Market clearing implies:

$$C_{t+1}^H = \int_{i\in\mathcal{N}_{t+1}^H} dC_{t+1}^{i,H} + \int_{i\notin\mathcal{N}_{t+1}^H} dC_{t+1}^{i,H} \tag{A.10}$$

Note that $\mathbf{1}_{i\notin\mathcal{N}_{t+1}^H} \times \mathbf{1}_{i\notin\mathcal{N}_t^H} = 0$ almost surely, so

$$\int_{i\in\mathcal{N}_{t+1}^H} dC_t^{i,H} = C_t^H \tag{A.11}$$

Combining (A.9)-(A.11) along with the allocation rules (A.5)-(A.8) we have that

$$\frac{M_{t+1}^H}{M_t^H} = \beta\left(\frac{Y_{H,t+1}}{Y_{H,t}}\right)^{-\alpha}\left(\frac{Y_{F,t+1}}{Y_{F,t}}\right)^{\alpha-1}\left(\frac{\alpha+(1-\alpha)\lambda_t}{\alpha+(1-\alpha)\lambda_{t+1}}\right)^{-\alpha}\left(\frac{\alpha\lambda_t+1-\alpha}{\alpha\lambda_{t+1}+1-\alpha}\right)^{\alpha-1}\left(1-\frac{\int_{i\notin\mathcal{N}_{t+1}^H} dC_{t+1}^{i,H}}{\int_{i\in[0,1]} dC_{t+1}^{i,H}}\right)^{-1} \tag{A.12}$$

Note that with log preference, consumption bundles are proportional to consumption expenditure, which in turn is proportional to wealth. Therefore the last term can be written as

$$b_{H,t+1} = \frac{\int_{i\in\mathcal{N}_{t+1}^H} w_{t+1}^{i,H}}{\int_{i\in[0,1]} w_{t+1}^{i,H}} = \frac{\int_{i\in\mathcal{N}_{t+1}^H} dC_{t+1}^{i,H}}{\int_{i\in[0,1]} dC_{t+1}^{i,H}} = 1 - \frac{\int_{i\notin\mathcal{N}_{t+1}^H} dC_{t+1}^{i,H}}{\int_{i\in[0,1]} dC_{t+1}^{i,H}} \tag{A.13}$$

Substituting back we obtain (19). Similarly, we can derive the SDF for foreign consumers.

$$\frac{M_{t+1}^F}{M_t^F} = \beta\left(\frac{Y_{H,t+1}}{Y_{H,t}}\right)^{\alpha-1}\left(\frac{Y_{F,t+1}}{Y_{F,t}}\right)^{-\alpha}\frac{1}{b_{F,t+1}}\frac{\lambda_t}{\lambda_{t+1}}\left(\frac{\alpha+(1-\alpha)\lambda_t}{\alpha+(1-\alpha)\lambda_{t+1}}\right)^{\alpha-1}\left(\frac{\alpha\lambda_t+1-\alpha}{\alpha\lambda_{t+1}+1-\alpha}\right)^{-\alpha} \tag{A.14}$$

*Asset Prices.* Let us first focus on the stock market in Home country. The SDF can be used to price the risky stocks by no arbitrage:

$$S_t^H = p_{h,t} Y_{H,t} + \mathrm{E}_t \left[ \sum_{s=t+1}^{T} \frac{M_s^H}{M_t^H} p_{h,s} Y_{H,s} e^{-\sum_{n=t+1}^{s} u_n^H} \right] \tag{A.15}$$

Note that $M_t^H$ is the SDF using consumption bundles of the home country; if we define $\zeta_t^H$ as the SDF using local goods of home country, then we have

$$M_t^H p_{h,t} = \zeta_t^H$$

Note that the first-order condition of $Y_H$-good for consumers gives:

$$\zeta_s^H = \beta^{s-t} \frac{\alpha}{c_{H,s}^H} \tag{A.16}$$

where $c_{H,s}^H$ is the total consumption of $Y_H$ goods by the households who have not received any profitable firms between $t+1$ and $s$, which has a probability of one. Therefore,

$$c_{H,s}^H = \frac{\alpha}{\alpha + (1-\alpha)\lambda_s} Y_{H,s} \Pi_{t+1}^s b_{H,s} \tag{A.17}$$

Substituting (A.16) and (A.17) into (A.15), we have

$$S_t^H = p_{h,t} Y_{H,t} \mathrm{E}_t \left[ \sum_{s=t+1}^{T} \beta^{s-t} \frac{\Pi_{t+1}^s \frac{1}{b_{H,s}} \left(\alpha + (1-\alpha)\lambda_s\right)}{\frac{1}{b_{H,t}} \left(\alpha + (1-\alpha)\lambda_t\right)} e^{-\sum_{n=t+1}^{s} u_n^H} \right] + p_{h,t} Y_{H,t} \tag{A.18}$$

The derivation for the foreign country's stock market is similar.

### The Change of Wealth Distribution

In B.1 we show that the optimization of consumer is equivalent to the single-good consumption -investment problem, with consumption expenditure $\mathcal{C}$ replacing the consumption. Moreover, the consumers do not hedge the prices of individual goods $p_{x,t}, p_{y,t}$.

This implies that the consumers in home and foreign are solving the same portfolio-choice problem. As a result, their optimal portfolios and wealth growth are the same across different states. Hence, the wealth ratio at $t+1$ is given by

$$\lambda_{t+1} = \frac{\int_{i \in [0,1]} w_{t+1}^{i,F}}{\int_{i \in [0,1]} w_{t+1}^{i,H}} = \frac{\int_{i \in \mathcal{N}_{t+1}^F} w_{t+1}^{i,F} + \int_{i \notin \mathcal{N}_{t+1}^F} w_{t+1}^{i,F}}{\int_{i \in \mathcal{N}_{t+1}^H} w_{t+1}^{i,H} + \int_{i \notin \mathcal{N}_{t+1}^H} w_{t+1}^{i,H}} \tag{A.19}$$

Note that the total value of profitable firms at $t+1$ is related to the displacement shocks $u_{t+1}^H, u_{t+1}^F$.

From 7 it follows that the total value of new firms are:

$$\int_{i \notin \mathcal{N}^H_{t+1}} w^{i,H}_{t+1} = S^H_{t+1}(1 - e^{-u^H_{t+1}}) \tag{A.20}$$

$$\int_{i \notin \mathcal{N}^F_{t+1}} w^{i,F}_{t+1} = S^F_{t+1}(1 - e^{-u^F_{t+1}}) \tag{A.21}$$

And the total value of old firms is

$$\int_{i \in \mathcal{N}^F_{t+1}} w^{i,F}_{t+1} + \int_{i \in \mathcal{N}^H_{t+1}} w^{i,H}_{t+1} = S^H_{t+1} e^{-u^H_{t+1}} + S^F_{t+1} e^{-u^F_{t+1}} \tag{A.22}$$

Because the consumers in home and foreign hold the same portfolio, the wealth ratio for the households that do not receive new firms are the same at $t$ and $t+1$. Hence,

$$\lambda_t = \frac{\int_{i \in [0,1]} w^{i,F}_t}{\int_{i \in [0,1]} w^{i,H}_t} = \frac{\int_{i \in \mathcal{N}^f_{t+1}} w^{i,F}_t}{\int_{i \in \mathcal{N}^h_{t+1}} w^{i,H}_t} \tag{A.23}$$

Combining (A.19)-(A.23) we obtain

$$\frac{\lambda_{t+1}}{\lambda_t} = \frac{\frac{1}{1+\lambda_t}\left(S^H_{t+1} e^{-u^F_{t+1}} + S^F_{t+1} e^{-u^F_{t+1}}\right) + \frac{1}{\lambda_t} S^F_{t+1}(1 - e^{-u^F_{t+1}})}{\frac{1}{1+\lambda_t}\left(S^H_{t+1} e^{-u^F_{t+1}} + S^F_{t+1} e^{-u^F_{t+1}}\right) + S^H_{t+1}(1 - e^{-u^H_{t+1}})} \tag{A.24}$$

**Approximate solution**

We now derive the approximate analytical solutions near the long-term steady state. That is, when $\lambda_t = 1$ and when $u^H_{t+1}, u^F_{t+1}$ are small.

By symmetry, when $\lambda_t = 1$ the price-dividend ratio of the stock markets are the same. Let us denote this ratio as $C_{pd}$, i.e.,

$$\left(\frac{S^H_t}{p_{h,t} Y_{H,t}}\right)_{\lambda_t = 1} = \left(\frac{S^F_t}{p_{f,t} Y_{F,t}}\right)_{\lambda_t = 1} = C_{pd} \tag{A.25}$$

Using the price ratio relation given by (16), we can rewrite (A.24) as

$$\frac{\lambda_{t+1}}{\lambda_t} = \frac{\frac{1}{1+\lambda_t}\left(e^{-u^H_{t+1}} pd^H_{t+1} + \frac{1-\alpha+\alpha\lambda_{t+1}}{\alpha+(1-\alpha)\lambda_{t+1}} e^{-u^F_{t+1}} pd^F_{t+1}\right) + \frac{1}{\lambda_t}\frac{1-\alpha+\alpha\lambda_{t+1}}{\alpha+(1-\alpha)\lambda_{t+1}}(1 - e^{-u^F_{t+1}})}{\frac{1}{1+\lambda_t}\left(e^{-u^H_{t+1}} pd^H_{t+1} + \frac{1-\alpha+\alpha\lambda_{t+1}}{\alpha+(1-\alpha)\lambda_{t+1}} e^{-u^F_{t+1}} pd^F_{t+1}\right) + (1 - e^{-u^H_{t+1}}) pd^H_{t+1}} \tag{A.26}$$

where $pd^c_{t+1}$ is the price-dividend ratio of the stock market in country $c \in \{H, F\}$ at $t+1$. To further simplify, we use the fact that $u^H_{t+1}, u^F_{t+1}$ are small so that $pd^c_{t+1} \approx C_{pd}$ for $c \in \{H, F\}$. Denote the total wealth of the stock market as $\bar{W} = W_H + W_F$, we make the following observation:

$$\bar{W} = S^H_{t+1} + S^F_{t+1} \tag{A.27}$$

$$\frac{S_{t+1}^F}{S_{t+1}^H} \approx \frac{1-\alpha+\alpha\lambda_{t+1}}{\alpha+(1-\alpha)\lambda_{t+1}} \tag{A.28}$$

The second equation is because $pd_{t+1}^c \approx C_{pd}$. It follows that

$$S_{t+1}^H = \frac{\alpha+(1-\alpha)\lambda_{t+1}}{1+\lambda_{t+1}}\bar{W}, \qquad S_{t+1}^F = \frac{1-\alpha+\alpha\lambda_{t+1}}{1+\lambda_{t+1}}\bar{W} \tag{A.29}$$

The dynamics of wealth distribution can thus be written as

$$\frac{\lambda_{t+1}}{\lambda_t} = \frac{\frac{1}{1+\lambda_t}\left(e^{-u_{t+1}^H}(\alpha+(1-\alpha)\lambda_{t+1})+(1-\alpha+\alpha\lambda_{t+1})e^{-u_{t+1}^F}\right)+\frac{1}{\lambda_t}(1-\alpha+\alpha\lambda_{t+1})(1-e^{-u_{t+1}^F})}{\frac{1}{1+\lambda_t}\left(e^{-u_{t+1}^H}(\alpha+(1-\alpha)\lambda_{t+1})+(1-\alpha+\alpha\lambda_{t+1})e^{-u_{t+1}^F}\right)+(\alpha+(1-\alpha)\lambda_{t+1})(1-e^{-u_{t+1}^H})} \tag{A.30}$$

Denote the common terms in both the numerator and denominator as

$$B = \left(e^{-u_{t+1}^H}(\alpha+(1-\alpha)\lambda_{t+1})+(1-\alpha+\alpha\lambda_{t+1})e^{-u_{t+1}^F}\right) \tag{A.31}$$

Some algebra gives

$$\frac{\lambda_{t+1}}{\lambda_t} = \frac{\frac{1}{1+\lambda_t}B+\frac{1-\alpha}{\lambda_t}(1-e^{-u_{t+1}^F})}{\frac{1}{1+\lambda_t}B+\alpha(e^{-u_{t+1}^F}-e^{-u_{t+1}^H})+(1-\alpha)\lambda_{t+1}(1-e^{-u_{t+1}^H})} \tag{A.32}$$

To progress further, we use the result from B.1 that consumers in both countries have the same portfolios and therefore the same wealth growth. At $t+1$, the wealth of households in both countries who do not receive profitable firms is

$$\int_{i\in N_{t+1}^H} w_{t+1}^{i,H} + \int_{i\in N_{t+1}^F} w_{t+1}^{i,F} = \left(e^{-u_{t+1}^H}(\alpha+(1-\alpha)\lambda_{t+1})+(1-\alpha+\alpha\lambda_{t+1})e^{-u_{t+1}^F}\right) \tag{A.33}$$

$$\frac{1}{1+\lambda_{t+1}}\bar{W} \tag{A.34}$$

Because consumers hold the same portfolio, we have

$$\frac{\int_{i\in N_{t+1}^H} w_{t+1}^{i,H}}{\int_{i\in N_{t+1}^F} w_{t+1}^{i,F}} = \frac{\int_{i\in[0,1]} w_t^{i,H}}{\int_{i\in[0,1]} w_t^{i,F}} = \frac{1}{\lambda_t} \tag{A.35}$$

Therefore

$$\int_{i\in N_{t+1}^H} w_{t+1}^{i,H} = \frac{1}{1+\lambda_t}\left(e^{-u_{t+1}^H}(\alpha+(1-\alpha)\lambda_{t+1})+(1-\alpha+\alpha\lambda_{t+1})e^{-u_{t+1}^F}\right)\frac{1}{1+\lambda_{t+1}}\bar{W} \tag{A.36}$$

On the other hand, by definition

$$\int_{i\in[0,1]} w_{t+1}^{i,H} = \int_{i\in N_{t+1}^H} w_{t+1}^{i,H} + \int_{i\notin N_{t+1}^H} w_{t+1}^{i,H} \tag{A.37}$$

so that

$$\int_{i\in N_{t+1}^H} w_{t+1}^{i,H} = \int_{i\in[0,1]} w_{t+1}^{i,H} - \int_{i\notin N_{t+1}^H} w_{t+1}^{i,H}$$
$$= \frac{1}{1+\lambda_{t+1}}\bar{W} - (1-e^{-u_{t+1}^H})\frac{\alpha+(1-\alpha)\lambda_{t+1}}{1+\lambda_{t+1}}\bar{W} \tag{A.38}$$

Substituting (A.36) and (A.38) into (A.32), after some algebra we get

$$\frac{\lambda_{t+1}}{\lambda_t} = \frac{1-\alpha+\alpha e^{-u_{t+1}^H}+(1-\alpha)(1-e^{-u_{t+1}^F})\frac{1}{\lambda_t}}{1-\alpha+\alpha e^{-u_{t+1}^F}+(1-\alpha)\lambda_t(1-e^{-u_{t+1}^H})} \tag{A.39}$$

Using the fact that $e^x \approx 1+x$ and $\lambda_t = 1$, we have

$$\Delta\log\lambda_{t+1} = \log\frac{1-\alpha+\alpha e^{-u_{t+1}^H}+(1-\alpha)(1-e^{-u_{t+1}^F})\frac{1}{\lambda_t}}{1-\alpha+\alpha e^{-u_{t+1}^F}+(1-\alpha)\lambda_t(1-e^{-u_{t+1}^H})}$$
$$\approx u_{t+1}^F - u_{t+1}^H \tag{A.40}$$

To get the approximate expression for log growth of consumption ratio, substituting (A.5)-(A.8) into (11), we have

$$\Delta c_{t+1}^H - \Delta c_{t+1}^F = (2\alpha-1)\left[\Delta\log Y_{H,t+1} - \Delta\log Y_{F,t+1} + \Delta\log\frac{1-\alpha+\alpha\lambda_{t+1}}{\alpha+(1-\alpha)\lambda_{t+1}}\right] - \Delta\log\lambda_{t+1} \tag{A.41}$$

note that $\lambda_{t+1} \approx 1+\Delta\log\lambda_{t+1}$, so we have

$$\Delta\log\frac{1-\alpha+\alpha\lambda_{t+1}}{\alpha+(1-\alpha)\lambda_{t+1}} \approx (2\alpha-1)\Delta\log\lambda_{t+1} \tag{A.42}$$

substituting back we get (26). The derivation for log growth of output ratio is straightforward from definitions.

### B.2 A micro-foundation for the displacement shock

We consider a continuum of varieties indexed by $j \in [0,1]$ in each country $c \in \{H, F\}$. Each variety is produced by a monopolist who faces CES (constant elasticity of substitution) demand and sets its price accordingly. The final good in sector $c$ at time $t$, denoted by $Y_{c,t}$, is aggregated from these varieties as:

$$Y_{c,t} = Z_{c,t}\left(\int_0^1 [x_{c,t}(j)]^{\frac{\sigma-1}{\sigma}}\, dj\right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1, \tag{A.43}$$

where

$$\Delta\log Z_{c,t+1} = \mu + \varepsilon_{t+1}^c \tag{A.44}$$

and $x_{c,t}(j)$ denotes the quantity of variety $j$ consumed at time $t$, and $\sigma$ is the elasticity of substitution across varieties.

Intermediate goods are produced using a linear technology with land as the only input:

$$x_{c,t}(j) = A_{c,t}(j)\, l_{c,t}(j), \tag{A.45}$$

where $A_{c,t}(j)$ denotes productivity and $l_{c,t}(j)$ is the land input. Given the rental rate of land $R_t$, cost minimization implies:

$$l_{c,t}(j) = \frac{x_{c,t}(j)}{A_{c,t}(j)}, \qquad \mathrm{MC}_{c,t}(j) = \frac{R_t}{A_{c,t}(j)}. \tag{A.46}$$

Each intermediate variety is demanded by final-good producers who aggregate across varieties using a CES aggregator. This implies that the monopolist producing variety $j$ faces the isoelastic demand curve:

$$x_{c,t}(j) = \left(\frac{p_{c,t}(j)}{P_{c,t}}\right)^{-\sigma} Y_{c,t}, \tag{A.47}$$

where $P_{c,t}$ is the CES price index and $\sigma > 1$ is the elasticity of substitution across varieties.

Given this demand and marginal cost $\mathrm{MC}_{c,t}(j) = R_t/A_{c,t}(j)$, the monopolist sets its price as a constant markup over marginal cost:

$$p_{c,t}(j) = \frac{\sigma}{\sigma - 1} \cdot \frac{R_t}{A_{c,t}(j)}. \tag{A.48}$$

And price index is

$$P_{c,t} = \left(\int_0^1 p_{c,t}(j)^{1-\sigma}\, dj\right)^{\frac{1}{1-\sigma}}. \tag{A.49}$$

**Displacement via Entry and Bertrand Competition**

At the beginning of period $t{+}1$, a displacement (or innovation) shock $u_{c,t+1}$ is realized. This shock raises the probability that each product line is challenged by a new entrant,

$$m_{c,t+1} = 1 - e^{-u^c_{t+1}}, \qquad 0 < m_{c,t+1} < 1. \tag{A.50}$$

If an entrant arrives at line $j$, it competes with the incumbent under Bertrand pricing. The entrant operates with a productivity advantage: it can produce with productivity $e^{\delta} A_{c,t}(j)$, where $\delta > 0$. As a result, the entrant undercuts the incumbent and takes over the product line. The productivity in line $j$ at time $t+1$ is therefore:

$$A_{c,t+1}(j) = \begin{cases} e^{\delta} A_{c,t}(j), & \text{with probability } m_{c,t+1}, \\ A_{c,t}(j), & \text{otherwise.} \end{cases} \tag{A.51}$$

A fraction $m_{c,t+1}$ of incumbents are therefore displaced and replaced by more productive entrants. In each displaced line, the old firm's profits fall to zero, and the entrant captures the full profit stream.

### Aggregate Productivity and Displacement

The final good at $t+1$ is a CES aggregator over varieties. Using the demand structure, the sectoral price index at $t+1$ becomes:

$$P_{c,t+1} = \frac{\sigma}{\sigma - 1} R_{t+1} \left( \int_0^1 A_{c,t+1}(j)^{\sigma-1} dj \right)^{-1/(\sigma-1)}. \tag{A.52}$$

Define the effective productivity aggregator:

$$\widetilde{A}_{c,t} \equiv \left( \int_0^1 A_{c,t}(j)^{\sigma-1} dj \right)^{\frac{1}{\sigma-1}}. \tag{A.53}$$

Using the updating rule in (A.51), and noting that displacement occurs independently across product lines, we obtain:

$$\begin{aligned} \widetilde{A}_{c,t+1}^{\sigma-1} &= (1 - m_{c,t+1}) \widetilde{A}_{c,t}^{\sigma-1} + m_{c,t+1} e^{\delta(\sigma-1)} \widetilde{A}_{c,t}^{\sigma-1} \\ &= \left[ (1 - m_{c,t+1}) + m_{c,t+1} e^{\delta(\sigma-1)} \right] \widetilde{A}_{c,t}^{\sigma-1}, \end{aligned}$$

so

$$\widetilde{A}_{c,t+1} = \widetilde{A}_{c,t} \left[ (1 - m_{c,t+1}) + m_{c,t+1} e^{\delta(\sigma-1)} \right]^{\frac{1}{\sigma-1}}. \tag{A.54}$$

Taking logs,

$$\Delta \log \widetilde{A}_{c,t+1} = \frac{1}{\sigma - 1} \log \left[ e^{-u_{t+1}^c} + (1 - e^{-u_{t+1}^c}) e^{\delta(\sigma-1)} \right]. \tag{A.55}$$

Since output is proportional to $\widetilde{A}_{c,t}$ and $Z_{c,t}$, we obtain:

$$\Delta \log Y_{c,t+1} = \mu + \varepsilon_{t+1}^c + \frac{1}{\sigma - 1} \log \left[ e^{-u_{t+1}^c} + (1 - e^{-u_{t+1}^c}) e^{\delta(\sigma-1)} \right]. \tag{A.56}$$

For small $u_{c,t+1}$, we have:

$$e^{-u_{t+1}^c} \approx 1 - u_{t+1}^c, \qquad e^{\delta(\sigma-1)} \approx 1 + \delta(\sigma - 1), \tag{A.57}$$

so

$$\Delta \log Y_{c,t+1} \approx \mu + \varepsilon_{t+1}^c + \delta u_{t+1}^c. \tag{A.58}$$

**Summary.** This setup captures how an exogenous displacement shock $u_{c,t+1}$ can simultaneously (i) raise aggregate productivity by $\delta$ for a subset $m_{c,t+1}$ of product lines, and (ii) reallocate profits from incumbents to new entrants.

- **Creative destruction:** The fraction $m_{c,t+1}$ of varieties that is displaced each period embodies Schumpeterian creative destruction. Newer, more productive firms replace old incumbents in exactly those lines.

- **Reallocation:** Ownership of that fraction of product lines switches to new entrants. Old incumbents lose the revenue from those lines; new entrepreneurs gain it.
- **Unspanned risk:** If households *cannot* buy ex ante claims on "who will be the successful innovator," this yields incomplete markets and idiosyncratic risk over who gains or loses in each period's displacement.

## B.3 Full Model

With Epstein-Zin preference, we can construct the representative agent because the aggregation property only depends on the homotheticity of the preference. So in this case, the representative agent constructed above behaves the same as an individual agent in a country but scaled up to the country-level wealth.

### Dynamics of the Consumption Ratio

Denote $W_t^c = W(\hat{C}_t^c, U_{t+1}^c)$ as the utility of the representative agent of country $c$. Denote the partial derivatives with respect to composite consumption and continuation utility as $W_{1,t}^c, W_{2,t}^c$, we have

$$\begin{aligned} \frac{\partial W_t^c}{\partial \bar{C}_t^c} &= \frac{\partial W_t^c}{\partial \hat{C}_t^c}\frac{\partial \hat{C}_t^c}{\partial \bar{C}_t^c} = W_{1,t}^c(\bar{C}_t^c)^{h-1} \\ \frac{\partial W_t^c}{\partial U_{t+1}^c} &= W_{2,t}^c \end{aligned}$$

The intertemporal marginal rate of substitution of representative agent of country $c$ is

$$M_{t,t+1}^c = \frac{\frac{\partial W}{\partial U}{}^c_{t+1}\frac{\partial W}{\partial \bar{C}}{}^c_{t+1}}{\frac{\partial W}{\partial \bar{C}}{}^c_t} = \frac{W_{2,t}^c W_{1,t+1}^c}{W_{1,t}^c}\left(\frac{\bar{C}_{t+1}^c}{\bar{C}_t^c}\right)^{h-1} \tag{A.59}$$

International trade of $Y_H$ good implies that the marginal utilities of good $Y_H$ for $t = 1, 2, \ldots$ in each possible state is

$$\left(\prod_{j=0}^{t-1} W_{2,j}^H\right) W_{1,t}^H \bar{C}_t^H \frac{\alpha}{x_{H,t}^H}(\bar{C}_t^H)^{h-1} = (\bar{C}_t^F)^{h-1}\frac{1-\alpha}{x_{H,t}^F}\bar{C}_t^F W_{1,t}^F\left(\prod_{j=0}^{t-1} W_{2,j}^F\right) \tag{A.60}$$

Define the date-$t$ Pareto weights as

$$\begin{aligned} \Lambda_t^c &= \Lambda_0^c\left(\prod_{j=0}^{t-1} W_{2,j}^c\right) W_{1,t}^c \bar{C}_t^c(\bar{C}_t)^{h-1} \\ &= \Lambda_{t-1}^c W_{2,t-1}^c \frac{W_{1,t}^c}{W_{1,t-1}^c}\left(\frac{\bar{C}_t^c}{\bar{C}_{t-1}^c}\right)^{h-1}\frac{\bar{C}_t^c}{\bar{C}_{t-1}^c} = \Lambda_{t-1}^c M_{t-1,t}^c \exp(\Delta c_t^c) \end{aligned}$$

Since the economy starts with a symmetric setup, $\Lambda_0^H = \Lambda_0^F$. We can rewrite (A.60) as

$$\Lambda_t^H \frac{\alpha}{x_{H,t}^H} = \frac{1-\alpha}{x_{H,t}^F} \Lambda_t^F$$

Denote $\lambda_t = \frac{\Lambda_t^F}{\Lambda_t^H}$ as the ratio of Pareto weights. The optimality condition can be written as

$$\lambda_t = \frac{\alpha x_{H,t}^F}{(1-\alpha) x_{H,t}^H} \tag{A.61}$$

Similar to the log case, note that with Cobb-Douglas preference over different goods, households' consumption expenditure share for each good is fixed. That is, foreign households spend $1-\alpha$ on $Y_H$-good and home households spend $\alpha$ on $Y_H$-good. Therefore, (A.61) shows that $\lambda_t$ is also the consumption expenditure between foreign and home. That is, $\lambda_t = \frac{\mathcal{C}_{F,t}}{\mathcal{C}_{H,t}}$. Also, we have that

$$\lambda_{t+1} = \lambda_t \frac{M_{t,t+1}^F e^{\Delta c_{t+1}^F}}{M_{t,t+1}^H e^{\Delta c_{t+1}^H}} \tag{A.62}$$

**Allocations and Exchange Rate**

Similar to the log case, since the ratio of consumption expenditure is $\lambda_t = \frac{\mathcal{C}_{F,t}}{\mathcal{C}_{H,t}}$, we have

$$x_{H,t}^H = \frac{\alpha \mathcal{C}_{H,t}}{p_{h,t}}, \qquad x_{F,t}^H = \frac{(1-\alpha)\mathcal{C}_{H,t}}{p_{f,t}},$$
$$x_{H,t}^F = \frac{(1-\alpha)\mathcal{C}_{F,t}}{p_{h,t}}, \qquad x_{F,t}^F = \frac{\alpha \mathcal{C}_{F,t}}{p_{f,t}}$$

Substituting these demands into the resource constraints, we get the allocations (A.5), (A.6), (A.7), (A.8). Given these allocations, we can calculate the consumption bundles:

$$\bar{C}_{H,t} = (x_{H,t}^H)^{\alpha} (x_{F,t}^H)^{1-\alpha} \tag{A.63}$$
$$\bar{C}_{F,t} = (x_{H,t}^F)^{1-\alpha} (x_{F,t}^F)^{\alpha} \tag{A.64}$$

We can also compute the price of consumption bundles in home and foreign countries:

$$p_t^H = \frac{p_{h,t} x_{H,t}^H + p_{f,t} x_{F,t}^H}{\mathcal{C}_{H,t}} \tag{A.65}$$
$$p_t^F = \frac{p_{h,t} x_{H,t}^F + p_{f,t} x_{F,t}^F}{\mathcal{C}_{F,t}} \tag{A.66}$$

Note that the relative price of good $Y_F$ in terms of good $Y_H$ is

$$p_t = \frac{Y_{H,t}}{Y_{F,t}} \frac{1-\alpha+\alpha\lambda_t}{\alpha+(1-\alpha)\lambda_t} \tag{A.67}$$

By definition, the exchange rate is the ratio of prices of consumption bundles:

$$E_t = \frac{p_t^H}{p_t^F} = \frac{\bar{C}_{F,t}}{\bar{C}_{H,t}} \frac{1}{\lambda_t} \tag{A.68}$$

The exchange rate growth is

$$\frac{E_{t+1}}{E_t} = \frac{\lambda_{t+1}}{\lambda_t} \frac{\bar{C}_{F,t+1}/\bar{C}_{F,t}}{\bar{C}_{H,t+1}/\bar{C}_{H,t}} \tag{A.69}$$

Note that (A.62) and (A.69) show that in our model exchange rate growth is equal to the growth of SDF, as the model has integrated financial markets.

**SDF**

Let us focus on the home country. The derivation for foreign country is similar. Since preference is homothetic, consumption is proportional to wealth. To calculate the SDF of the representative agent, we need to consider two groups of population: the population that receive the new firms in the current period (with measure $\pi$, denote as N); and the population that does not receive the new firms in the current period (with measure $1 - \pi$, denote as O).

To this end, first note that $b_{i,t+1}$ is the fraction of wealth account for by the cohort that does not receive profitable projects from period $t$ to $t + 1$ in country $i$. The wealth shares of these two groups within the home country are

$$b_{H,t}(1 - \pi), b_{H,t}\pi + 1 - b_{H,t}$$

The consumption growth and relative consumption growth for group O are $\frac{\bar{C}_{t+1}}{\bar{C}_t} b_{H,t+1}$ and $b_{H,t+1}$. And the consumption growth and relative consumption growth for group O are $\frac{b_{H,t+1}\pi+1-b_{H,t+1}}{\pi} \frac{\bar{C}_{t+1}}{\bar{C}}$ and $\frac{b_{H,t+1}\pi+1-b_{H,t+1}}{\pi}$. Therefore, the growth in the composite consumption for two groups {O, N} is (we omit the country index $H$ from now on)

$$\begin{aligned}
\frac{\hat{C}_{t+1}}{\hat{C}_t}_O &= \left( \frac{\bar{C}_{t+1} b_{t+1}}{\bar{C}_t} \right)^h (b_{t+1})^{1-h} = \frac{\bar{C}_{t+1}^h}{\bar{C}_t^h} b_{t+1} \\
\frac{\hat{C}_{t+1}}{\hat{C}_t}_N &= \left( \frac{\bar{C}_{t+1}}{\bar{C}_t} \frac{b_{t+1}\pi + 1 - b_{t+1}}{\pi} \right)^h \left(\frac{b_{t+1}\pi + 1 - b_{t+1}}{\pi}\right)^{1-h} \\
&= \left(\frac{\bar{C}_{t+1}}{\bar{C}_t}\right)^h \frac{b_{t+1}\pi + 1 - b_{t+1}}{\pi}
\end{aligned}$$

Similarly, we can derive the growth in continuation utility for these two groups. Since the consumption to utility ratio are equalized across two groups, we have

$$\frac{\left( \frac{U_{O,t+1}^{1-\gamma}}{\mathrm{E}_t(U_{t+1}^{1-\gamma})} \right)}{\left( \frac{U_{N,t+1}^{1-\gamma}}{\mathrm{E}_t(U_{t+1}^{1-\gamma})} \right)} = \frac{b_{t+1}}{\frac{b_{t+1}\pi+1-b_{t+1}}{\pi}} \tag{A.70}$$

The growth of the SDF of these two groups can be written as ($M_{x,t,t+1} = \frac{M_{x,t+1}}{M_{x,t}}, x \in \{O, N\}$)

$$M_{O,t,t+1} = \frac{M_{O,t+1}}{M_{O,t}} = \beta(\frac{\hat{C}_{t+1}}{\hat{C}_t})_O^{-\frac{1}{\psi}}(\frac{\bar{C}_{t+1}}{\bar{C}_t})^{h-1}\left(\frac{U_{O,t+1}^{1-\gamma}}{\mathrm{E}_t(U_{t+1}^{1-\gamma})}\right)^{\frac{1/\psi-\gamma}{1-\gamma}}$$

$$M_{N,t,t+1} = \frac{M_{N,t+1}}{M_{N,t}} = \beta(\frac{\hat{C}_{t+1}}{\hat{C}_t})_N^{-\frac{1}{\psi}}(\frac{\bar{C}_{t+1}}{\bar{C}_t})^{h-1}\left(\frac{U_{N,t+1}^{1-\gamma}}{\mathrm{E}_t(U_{t+1}^{1-\gamma})}\right)^{\frac{1/\psi-\gamma}{1-\gamma}}$$

Note that the time $t+1$ state used to define the intertemporal marginal rates of substitution above includes the investor type, N or O, which is idiosyncratic and becomes known only at time $t+1$. Because each agent is assigned new projects in proportion to their current wealth level and becoming an innovator in each period is independent of all other shocks in the economy, the equilibrium SDF in this economy (which prices claims contingent on aggregate states) can be expressed as the conditional expectation of the inter-temporal marginal rate of substitution of any agent, which is conditioned on the aggregate state at time $t+1$. Hence the cross-sectional average of investors' inter-temporal marginal rates of substitution is a stochastic discount factor. That is,

$$\begin{aligned} M_{t,t+1} = \frac{M_{t+1}}{M_t} &= (1-\pi)M_{O,t,t+1} + \pi M_{N,t,t+1} \\ &= \beta\left(\frac{\bar{C}_{t+1}}{\bar{C}_t}\right)^{-\frac{h}{\psi}+h-1}\left(\pi\left(\frac{b_{t+1}\pi+1-b_{t+1}}{\pi}\right)^{-\frac{1}{\psi}}\left(\frac{U_{N,t+1}^{1-\gamma}}{\mathrm{E}_t[U_{t+1}^{1-\gamma}]}\right)^{\frac{1/\psi-\gamma}{1-\gamma}} + (1-\pi)b_{t+1}^{-\frac{1}{\psi}}\left(\frac{U_{O,t+1}^{1-\gamma}}{\mathrm{E}_t[U_{t+1}^{1-\gamma}]}\right)^{\frac{1/\psi-\gamma}{1-\gamma}}\right) \end{aligned}$$

Combining with (A.70), we have (44).

**Wealth ratio**

First, note that the marginal utility of consumption of the representative agent in each country is

$$\frac{\partial\tilde{U}}{\partial C} = (1-\tilde{\beta})\tilde{U}^{\frac{1}{\psi}}\hat{C}^{-\frac{1}{\psi}}\bar{C}^{h-1}$$

we can compute the wealth of households who didn't receive projects at $t$, in units of local consumption bundles:

$$\begin{aligned} \hat{W}_H &= \frac{\tilde{U}}{\frac{\partial\tilde{U}}{\partial C_H}} \\ &= \frac{1}{1-\beta}(\tilde{U})^{1-1/\psi}(\hat{C}_{H,t})^{\frac{1}{\psi}}\bar{C}_{H,t}^{1-h} \\ &= \frac{1}{1-\beta}(\frac{\tilde{U}_{H,t}}{\hat{C}_{H,t}})^{1-1/\psi}\hat{C}_{H,t}\bar{C}_{H,t}^{1-h} \\ &= \frac{1}{1-\beta}(\frac{\tilde{U}_{H,t}}{\hat{C}_{H,t}})^{1-1/\psi}\bar{C}_{H,t} \end{aligned}$$

Similarly we can derive the wealth for foreign country,

$$\hat{W}_F = \frac{1}{1-\beta}\tilde{U}_{F,t}^{1-1/\psi}\hat{C}_{F,t}^{1/\psi}\bar{C}_{F,t}^{1-h} = \frac{1}{1-\beta}\left(\frac{\tilde{U}_{F},t}{\hat{C}_{F,t}}\right)^{1-1/\psi}\bar{C}_{F,t} \tag{A.71}$$

Note that the wealth above are calculated in the units of local consumption bundles, so the ratio of two countries' wealth should be adjusted by the price of their respective consumption bundles

$$\frac{W_F}{W_H} = \frac{\hat{W}_F}{\hat{W}_H}\frac{p_F}{p_H} = \left(\frac{\frac{U_{F,t}}{\hat{C}_{F,t}}}{\frac{U_{H,t}}{\hat{C}_{H,t}}}\right)^{1-1/\psi}\lambda_t \tag{A.72}$$

The second equation comes from the fact that $\lambda = \frac{p_F\bar{C}_F}{p_H\bar{C}_H}$ (Recall (A.61)).

**Asset Prices**

Similar to the log case, for the stock market we have

$$\begin{aligned}
S_t^H &= p_{h,t}Y_{H,t} + \mathrm{E}_t\left[\frac{M_{t+1}^H}{M_t^H}S_{t+1}^H\right] \\
pd_t^H &= \mathrm{E}_t\left[\frac{M_{t+1}^H}{M_t^H}\frac{p_{h,t+1}Y_{H,t+1}}{p_{h,t}Y_{H,t}}(1+pd_{t+1}^H)(1-(1-e^{-u_{t+1}^H})\eta)\right] \\
S_t^F &= p_{f,t}Y_{F,t} + \mathrm{E}_t\left[\frac{M_{t+1}^F}{M_t^F}S_{t+1}^F\right] \\
pd_t^F &= \mathrm{E}_t\left[\frac{M_{t+1}^F}{M_t^F}\frac{p_{f,t+1}Y_{F,t+1}}{p_{f,t}Y_{F,t}}(1+pd_{t+1}^F)(1-(1-e^{-u_{t+1}^F})\eta)\right]
\end{aligned}$$

When $\eta < 1$, new projects are allocated not only to the inventors but also to the existing firms. Assume there are two types of firms: those that can receive these new projects and those that cannot. The former type trades at a higher valuation multiple in equilibrium, and we denote such firms by $H$–"growth". We denote the type that cannot receive projects as $L$–"value". Firms can transit between these two states according to the following transition probability:

$$\Sigma = \begin{bmatrix} 1-p_s & p_s \\ q_s & 1-q_s \end{bmatrix}. \tag{A.73}$$

Suppose that the fraction of new projects that go to $H$ type is $\omega$, so the $L$ type gets $1-\omega$ of the total $1-\eta$ projects. In our case, $\omega = 1$ and value firms do not receive projects. Among all the firms, a fraction of $m_H$ is the $H$ type, and the remaining fraction $1-m_H$ is the $L$ type. In the steady state, we have

$$\begin{aligned}
m_H(1-p_s) + q_s(1-m_H) &= m_H \\
p_s m_H + (1-q_s)(1-m_H) &= 1-m_H
\end{aligned}$$

Solving the system, we obtain:

$$m_H = \frac{q_s}{p_s + q_s}, \qquad 1 - m_H = \frac{p_s}{p_s + q_s}. \tag{A.74}$$

**Assets in Place and Growth Opportunities** Assets in place and growth opportunities, expressed as a multiple of dividends, satisfy

$$pd^c_{AP,t} = \mathrm{E}_t\Big(M^c_{t,t+1}\frac{p_{c,t+1}Y_{c,t+1}}{p_{c,t}Y_{c,t}}(1 + pd^c_{AP,t+1})e^{-u^c_{t+1}}\Big), \tag{A.75}$$

$$G^c_{H,t} = \mathrm{E}_t\Big(M^c_{t,t+1}\frac{p_{c,t+1}Y_{c,t+1}}{p_{c,t}Y_{c,t}}\Big[\frac{(1 - e^{-u^c_{t+1}})(1-\eta)}{m_H}(1 + pd^c_{t+1}) + e^{-u^c_{t+1}}\big[(1-p_s)G^c_{H,t+1} + p_s G^c_{L,t+1}\big]\Big]\Big), \tag{A.76}$$

$$G^c_{L,t} = \mathrm{E}_t\Big(M^c_{t,t+1}\frac{p_{c,t+1}Y_{c,t+1}}{p_{c,t}Y_{c,t}}e^{-u^c_{t+1}}\big[q_s G^c_{H,t+1} + (1-q_s)G^c_{L,t+1}\big]\Big). \tag{A.77}$$

**Trade and Capital Flows**

The net export as a fraction of total output is

$$\frac{NX^H_t}{Y_{H,t}} = \frac{p_{h,t}Y_{H,t} - p_{h,t}x^H_{H,t} - p_{f,t}x^H_{F,t}}{p_{h,t}Y_{H,t}} = 1 - \frac{1}{\alpha + (1-\alpha)\lambda_t} \tag{A.78}$$

$$\frac{NX^F_t}{Y_{F,t}} = \frac{p_{f,t}Y_{F,t} - p_{f,t}x^F_{F,t} - p_{h,t}x^F_{H,t}}{p_{f,t}Y_{F,t}} = 1 - \frac{\lambda_t}{1 - \alpha + \alpha\lambda_t} \tag{A.79}$$

The net international investment position scaled by country's wealth is

$$\frac{A^H_t}{W^H_t} = \frac{W^H_t - S^H_t}{W^H_t} \tag{A.80}$$

$$\frac{A^F_t}{W^F_t} = \frac{W^F_t - S^F_t}{W^F_t} \tag{A.81}$$

## B.4 Numerical Procedure

Here, we briefly describe the numerical procedure for solving the model.

The equilibrium is obtained by jointly solving the set of non-linear equations that describe the equilibrium conditions: (9), (11), (16), (20), (35), (A.5), (A.6), (A.7), (A.8), (A.72), (44). We put all the equations here, as below:

On the aggregate level, we have

$$d\log Y_{H,t} = \mu + \delta u_{H,t} + \varepsilon_{H,t}$$
$$d\log Y_{F,t} = \mu + \delta u_{F,t} + \varepsilon_{F,t}$$

For each country's allocation we have (A.5)-(A.8).

$$x^H_{H,t} = \frac{\alpha}{\alpha + (1-\alpha)\lambda_t} Y_{H,t} \tag{A.82}$$

$$x^F_{H,t} = \frac{(1-\alpha)\lambda_t}{\alpha + (1-\alpha)\lambda_t} Y_{H,t} \tag{A.83}$$

$$x^H_{F,t} = \frac{1-\alpha}{1-\alpha+\alpha\lambda_t} Y_{F,t} \tag{A.84}$$

$$x^F_{F,t} = \frac{\alpha\lambda_t}{1-\alpha+\alpha\lambda_t} Y_{F,t} \tag{A.85}$$

The displacement effect:

$$b_{H,t+1} = 1 - \frac{(1+pd_{H,t+1})(1-e^{-u_{H,t+1}})\eta}{\left(1+pd_{H,t+1} + (1+pd_{F,t+1})\frac{p_{f,t+1}Y_{F,t+1}}{p_{h,t+1}Y_{H,t+1}}\right)\frac{1}{1+w_{t+1}}} \tag{A.86}$$

$$b_{F,t+1} = 1 - \frac{(1+pd_{F,t+1})(1-e^{-u_{F,t+1}})\eta}{\left((1+pd_{H,t+1})\frac{p_{h,t+1}Y_{H,t+1}}{p_{f,t+1}Y_{F,t+1}} + (1+pd_{F,t+1})\right)\frac{w_{t+1}}{1+w_{t+1}}} \tag{A.87}$$

where the dividend ratio is

$$\frac{p_{f,t}Y_{F,t}}{p_{h,t}Y_{H,t}} = \frac{1-\alpha+\alpha\lambda_t}{\alpha+(1-\alpha)\lambda_t}$$

Post-Dividend price-dividend ratios are given by

$$pd^H_t = \mathrm{E}_t\left[\frac{M^H_{t+1}}{M^H_t}\frac{p_{h,t+1}Y_{H,t+1}}{p_{h,t}Y_{H,t}}(1+pd^H_{t+1})(1-(1-e^{-u^H_{t+1}})\eta)\right] \tag{A.88}$$

$$pd^F_t = \mathrm{E}_t\left[\frac{M^F_{t+1}}{M^F_t}\frac{p_{f,t+1}Y_{F,t+1}}{p_{f,t}Y_{F,t}}(1+pd^F_{t+1})(1-(1-e^{-u^F_{t+1}})\eta)\right] \tag{A.89}$$

Aggregate consumption is given by

$$\bar{C}^H_t = (x^H_{H,t})^{\alpha}(x^H_{F,t})^{1-\alpha} \tag{A.90}$$

$$\bar{C}^F_t = (x^F_{H,t})^{1-\alpha}(x^F_{F,t})^{\alpha} \tag{A.91}$$

The two SDFs are given by (44),

$$\frac{M^c_{t+1}}{M^c_t}_o = \beta\left(\frac{\bar{C}_{c,t+1}}{\bar{C}_{c,t}}\right)^{-\frac{h}{\psi}+h-1} b_{o,c,t+1}^{-\frac{1}{\psi}}\left(\frac{U^{1-\gamma}_{o,c,t+1}}{\mathrm{E}_t[U^{1-\gamma}_{c,t+1}]}\right)^{\frac{1/\psi-\gamma}{1-\gamma}} \tag{A.92}$$

$$\frac{M^c_{t+1}}{M^c_t}_n = \beta\left(\frac{\bar{C}_{c,t+1}}{\bar{C}_{c,t}}\right)^{-\frac{h}{\psi}+h-1} b_{n,c,t+1}^{-\frac{1}{\psi}}\left(\frac{U^{1-\gamma}_{n,c,t+1}}{\mathrm{E}_t[U^{1-\gamma}_{c,t+1}]}\right)^{\frac{1/\psi-\gamma}{1-\gamma}} \tag{A.93}$$

where

$$b_n = \frac{b\pi + 1 - b}{\pi}$$
$$b_o = b$$
$$\frac{U_{n,t+1}}{C_t} = \frac{U_{n,t+1}}{C_{n,t+1}} \frac{\bar{C}_{t+1}}{\bar{C}_t} \left( \frac{b\pi + 1 - b}{\pi} \right)$$
$$\frac{U_{o,t+1}}{C_t} = \frac{U_{o,t+1}}{C_{o,t+1}} \frac{\bar{C}_{t+1}}{\bar{C}_t} b$$

We use cross-sectional average as the aggregate SDF:

$$\frac{M_{t+1}}{M_t} = \beta \left( \frac{\bar{C}_{c,t+1}}{\bar{C}_{c,t}} \right)^{-\frac{h}{\psi}+h-1} \left( \pi \left( \frac{b_{c,t+1}\pi + 1 - b_{c,t+1}}{\pi} \right)^{-\frac{1}{\psi}+\frac{1/\psi-\gamma}{1-\gamma}} + (1-\pi) b_{c,t+1}^{-\frac{1}{\psi}+\frac{1/\psi-\gamma}{1-\gamma}} \right) \left( \frac{\bar{U}_{c,t+1}^{1-\gamma}}{\mathrm{E}_t[U_{c,t+1}^{1-\gamma}]} \right)^{\frac{1/\psi-\gamma}{1-\gamma}}$$

and the wealth ratio is given by (A.72) and the lambda ratio by (A.62).

## B.5 Calibration Details

The model has a total of 19 parameters. We choose the probability of household death $\xi = 1/40$, which corresponds to an average working life of 40 years. We calibrate firms' transition probabilities $p_s$ and $q_s$ using U.S. data. Specifically, each year, we sort U.S. firms into growth and value categories based on the median book-to-market breakpoint. Then we estimate the transition probability over the sample period, which yields $p_s = 0.267, q_s = 0.224$.

We put two restrictions on the dynamics of $u$ shocks to reduce the number of parameters. First, we assume that $u_1 = u_2$. Hence, a transition from $u_1$ to $u_2$ only affects the future distribution of $u$ (as the transition probabilities change) rather than the current level of displacement. Second, we assume that the matrix $T$ corresponds to transition matrix of a discretized AR(1) process, so that it could be parameterized by only two parameters—the corresponding autocorrelation parameter $p$ and $q$. Specifically, we assume that the transition matrix has the following form

$$T = \begin{bmatrix} p^2 & 2p(1-p) & (1-p)^2 \\ p(1-q) & pq + (1-p)(1-q) & q(1-p) \\ (1-q)^2 & 2q(1-q) & q^2 \end{bmatrix} \tag{A.94}$$

Where $p^2$ is the probability of staying in the lowest state once already there and $q^2$ is the probability of staying in the highest state once there. We estimate the remaining parameters of the model using a simulated minimum distance method Lee and Ingram (1991). Specifically, given a vector of $X$ of target statistics in the data, we obtain parameter estimates by

$$\hat{p} = \arg\min_{p \in \mathcal{P}} \left( X - \frac{1}{S} \sum_{i=1}^{S} \hat{X}_i(p) \right)' W \left( X - \frac{1}{S} \sum_{i=1}^{S} \hat{X}_i(p) \right) \tag{A.95}$$

Where $\hat{X}_i(p)$ is the vector of statistics computed in one simulation of the model. Our choice of weighting matrix $W = diag(XX')^{-1} I_W$ penalizes proportional deviations of the model statistics from their empirical counterparts. $I_W$ is a diagonal matrix that adjusts for the relative importance of the statistics in our estimation. We apply a factor of 10 on the equity risk premium, the volatility of exchange rate and the UIP slope. The rest elements on the diagonal of $I_W$ are normalized to one.

We use different weights on the diagonal of $I_W$ to reflect the relative importance of the following moments: equity risk premium, the volatility of exchange rate and the UIP slope. We do this because the magnitude of these moments are relatively well documented in the literature, and also speaks directly to the model's mechanism.

Our calibration targets are reported in the first column of Table 8. They include a combination of first and second moments of aggregate quantities, asset prices and exchange rates. They are defined as follows:

1. **Consumption, output and net export.** Output is gross domestic product. Consumption is households and NPISHs final consumption expenditure (private consumption). Net export is the exports of goods and services minus the imports of good and services.

2. **Standard deviation of aggregate quantities.** We first calculate the standard deviation for each US-foreign country pair, and then we take the average and use that as our target.

3. **Bilateral correlations between aggregate quantities.** Similar to the standard deviation, we first calculate the correlation for each US-foreign country pair, and then we take the average and use that as our target.

4. **Real exchange rate.** Inflation rates are calculated using Consumer Price Index (CPI) from World Bank. The real exchange rates are calculated by adjusting nominal exchange rates by the relative CPI index of the corresponding country.

5. **Risk free rate and Stock market returns.** Risk free rate is constructed using three-month T-bill yield, adjusting for realized inflation using annual changes in CPI. Stock market returns are obtained using MSCI indexes from Datastream.

6. **UIP coefficient.** for each US-foreign country pair, we regress the exchange rate growth from $t$ to $t+1$ on the interest rate differentials at $t$:

$$\Delta e_{US,F,t,t+1} = \alpha_F + \beta_{UIP,F}(r_{F,t} - r_{US,t}) + \varepsilon_{F,t}$$

   Then we take an average of the estimated $\beta_{UIP,F}$ across all countries $F$ in our sample.

7. **Inequality, wealth and the coefficients in regression.** Income inequality and wealth data is from World Inequality Database, the top 1% income share including capital income. We use the estimated coefficients of the panel regression with country fixed effects, as in Table 4 and Table 7. In these regressions, independent variables are standardized using unconditional moments.

8. **Dollar and U.S displacement.** The correlation between the equal-weighted dollar index and the proxy for U.S. displacement as described in section 2.6.

9. **U.S. displacement and wealth ratios.** The correlation between the proxy for U.S. displacement and the growth of wealth ratios.

10. **Coefficients of bi-variate regressions.** The regression slopes that correspond to the bi-variate regression in Table 4.

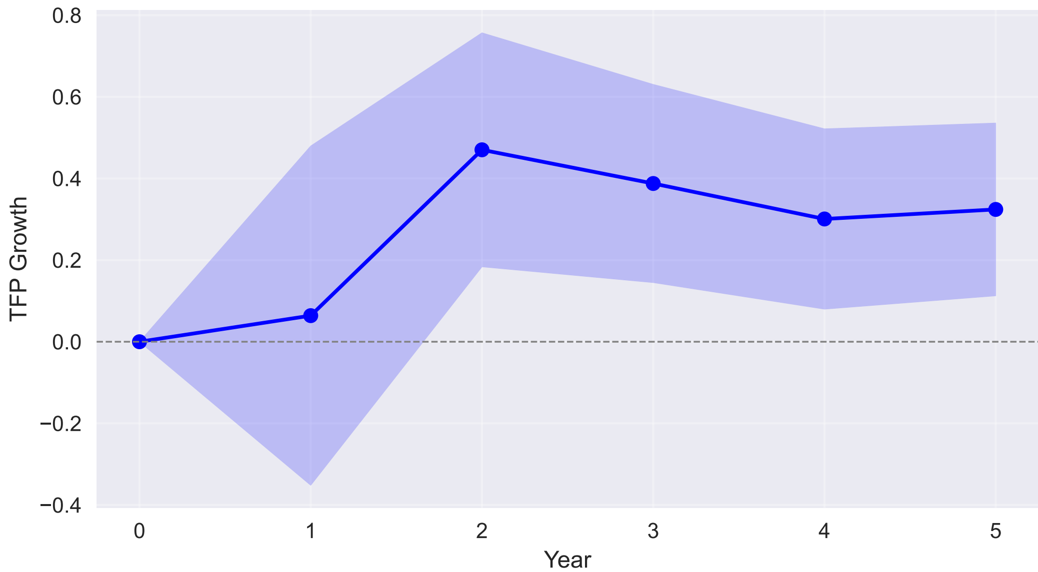
In addition to these standard international moments in the literature, we also target a set of correlations. The neutral shock and displacement shock have different implications for the cyclicality of the exchange rates. Thus, the set of correlation between exchanges rates and consumption, output and stock market, together with the set of bilateral correlations, are informative about the relative magnitude of these two shocks. We also target the estimated coefficients of regressions (41).

We simulate the model at annual frequency. For each simulation, we first simulate 100 years data as burn-in, to remove the samples' dependencies on the initial condition. Then, we simulate the data for 50 years – the same length as our empirical sample. The simulation starts with the symmetric steady state where the displacement shocks are at the middle state and $\lambda = 1$. In each iteration we simulate 10000 samples, and simulate pseudo-random variables using the same seed in each iteration.

Solving each iteration of the model is costly, and thus computing the minimum (A.95) using standard methods is infeasible. We therefore use the Radial Basis Function (RBF) algorithm in Björkman and Holmström (2000). The Björkman and Holmström (2000) algorithm first fits a response surface to data by evaluating the objective function at a few points. Then, it searches for a minimum by balancing between local and global search in an iterative fashion. We use a commercial implementation of the RBF algorithm that is available through the TOMLAB optimization package.

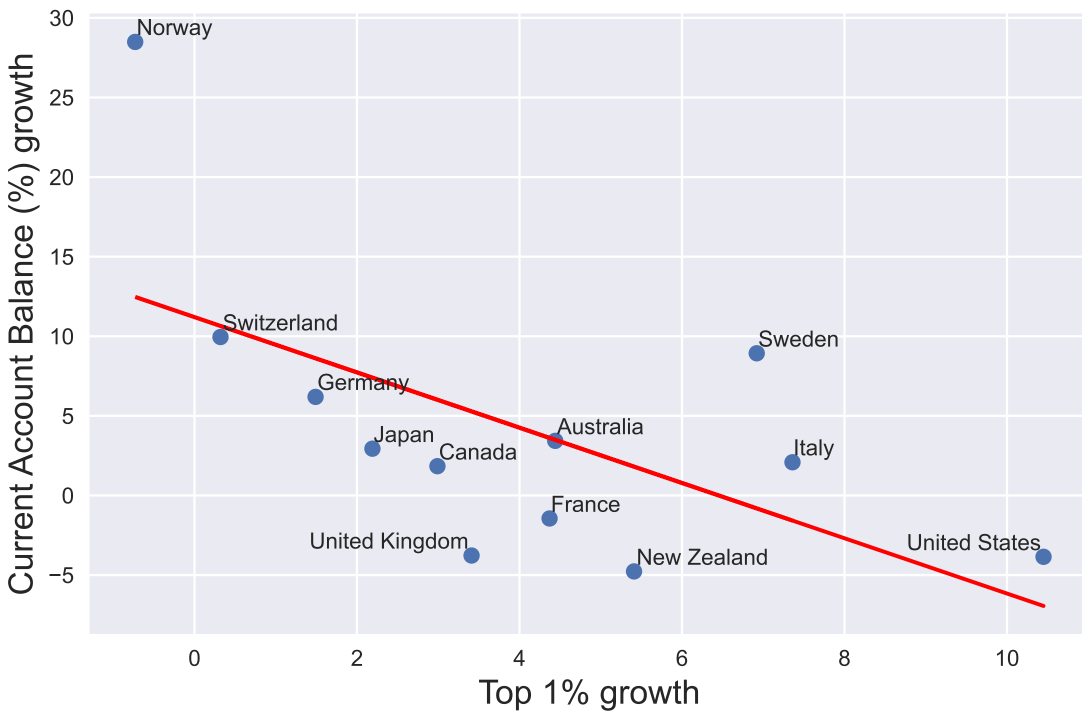
# Appendix Tables and Figures

**Figure A.1:** Innovation and Total Factor Productivity




**Note:** This figure plots the coefficients $\beta_s$ (for $s = 1, 2, 3, 4, 5$) from the following specification, $\Delta A_{t,t+s} = \alpha + \beta_s\, Inno_{t+1} + \beta_c\, X_t + \varepsilon_{t+s}$ US innovation is measured as the log of the ratio of the total value of patents each year from Kogan et al. (2017) to the total market value. TFP growth is based on annual utilization-adjusted US TFP from Fernald (2014). Vector of controls includes the lagged level of TFP and lagged level of innovation.

**Figure A.2:** Cross-country Differences in Inequality Growth vs Trade Deficit




**Note:** This figure plots the changes in top 1% income share and current account balance (%) from 1980-2022. Income inequality data are from the World Inequality Database, and the current account balance data is from the World Economic Outlook Database.

**Table A.1:** Dollar Index Growth and U.S. Innovation

Time Series Estimate (TW Dollar Index)

| | 1-Year | 1-Year | 1-Year | 3-Year | 3-Year | 3-Year |
|---|---|---|---|---|---|---|
| KPSS/MKT | 0.018* | 0.024* | 0.027** | 0.042** | 0.047** | 0.058*** |
| | (0.009) | (0.014) | (0.012) | (0.018) | (0.019) | (0.019) |
| Lagged Output growth | YES | YES | YES | YES | YES | YES |
| Lagged Dollar Index | YES | NO | YES | YES | NO | YES |
| Lagged Innovation | NO | YES | YES | NO | YES | YES |
| Observations | 49 | 49 | 49 | 47 | 47 | 47 |
| R2 | 0.127 | 0.080 | 0.146 | 0.404 | 0.253 | 0.479 |

**Notes:** The table reports regression results of the growth of log dollar index on U.S. innovation:

$$\Delta \log e_{t,t+s}^{USD} = \alpha + \beta_1 Inno_{US,t,t+s} + \beta_2 X_t + \varepsilon_t$$

The sample period is 1974-2022, with $s = 1, 3$. U.S. innovation is measured by the log of the ratio of the total value of patents each year (Kogan et al. (2017)) to the total market value. The dollar Index is a trade-weighted average real value of the US dollar index, obtained from the Fed. Control variable $X_t$ includes lagged innovation, lagged output growth and lagged Dollar Index level at $t$. Both series are in logs. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table A.2:** Dollar Index Growth and U.S. Innovation

Dependent Variable = Dollar Index Growth

| | 1-Year | 1-Year | 1-Year | 3-Year | 3-Year | 3-Year |
|---|---|---|---|---|---|---|
| KPSS(avg) | 0.028** | 0.038 | 0.031 | 0.051** | 0.114*** | 0.106*** |
| | (0.012) | (0.025) | (0.023) | (0.022) | (0.021) | (0.017) |
| Lagged Dollar Index | YES | NO | YES | YES | NO | YES |
| Lagged Innovation | NO | YES | YES | NO | YES | YES |
| Observations | 49 | 49 | 49 | 47 | 47 | 47 |
| R-squared | 0.188 | 0.053 | 0.188 | 0.493 | 0.239 | 0.581 |

**Notes:** The table reports regression results of the growth of log dollar index on U.S. innovation:

$$\Delta \log e^{USD}_{t,t+s} = \alpha + \beta_1 Inno_{US,t,t+s} + \beta_2 X_t + \varepsilon_{t+s}$$

The sample period is 1974-2022. U.S. innovation is measured as the log of the ratio of the average real value of patents each year (Kogan et al. (2017)) . The dollar Index is computed as an equal weighted average real value of the US dollar against the group of currencies in our sample. Control variable $X_t$ includes lagged innovation and lagged dollar Index level at $t$. Both series are in logs. The sample consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. Independent variables are standardized to unit standard deviation using unconditional moments. Standard errors (in parentheses) are obtained using Newey-West with one/three period lag. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table A.3:** Exchange Rate Growth and U.S. Innovation

| | Panel | AUS | CAN | CHE | DEU | FRA | GBR | ITA | JPN | NOR | NZL | SWE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Displacement | 0.039*** | 0.047*** | 0.030** | 0.029* | 0.038 | 0.051* | 0.034* | 0.042 | 0.031 | 0.050*** | 0.057*** | 0.063*** |
| | (0.011) | (0.017) | (0.011) | (0.017) | (0.028) | (0.026) | (0.018) | (0.026) | (0.021) | (0.016) | (0.019) | (0.019) |
| Observations | 467 | 49 | 49 | 49 | 25 | 25 | 49 | 25 | 49 | 49 | 49 | 49 |
| R2 | 0.194 | 0.297 | 0.248 | 0.286 | 0.250 | 0.297 | 0.222 | 0.262 | 0.105 | 0.237 | 0.278 | 0.230 |

**Notes:** The table reports regression results of the growth of log exchange rate on displacement shocks:

$$\Delta \log e_{t+1} = \alpha + \beta_1 Displacement_t + \beta_2 X_t + \varepsilon_t$$

The sample period is 1974-2022. U.S. displacement is measured as described in section 2.6. The unbalanced panel consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. The vector of controls $X_t$ includes lagged displacement and lagged exchange rate at $t$. Independent variables are standardized to unit standard deviation using unconditional moments. In individual country regressions, standard errors (in parentheses) are obtained using Newey-West with one period lag. The Panel regressions include country fixed effects, and we report Driscoll and Kraay (1998) standard errors in parentheses. Exchange rate, consumption and GDP data are from the World Bank and the IMF. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table A.4:** Exchange Rate Growth and U.S. Innovation

Dependent Variable = FX Growth

| | AUS | CAN | CHE | DEU | FRA | GBR | ITA | JPN | NOR | NZL | SWE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| KPSS/MKT | 0.046** | 0.041*** | 0.017 | 0.019 | 0.003 | 0.030 | 0.012 | 0.002 | 0.045** | 0.061** | 0.049* |
| | (0.020) | (0.014) | (0.023) | (0.040) | (0.041) | (0.022) | (0.041) | (0.025) | (0.022) | (0.025) | (0.026) |
| Observations | 49 | 49 | 41 | 25 | 25 | 49 | 25 | 49 | 49 | 44 | 49 |
| R-squared | 0.277 | 0.271 | 0.205 | 0.223 | 0.234 | 0.221 | 0.266 | 0.112 | 0.160 | 0.250 | 0.138 |

**Notes:** The table reports regression results of the growth of log dollar exchange rate on U.S. innovation:

$$\log e_{t+1} - \log e_t = \alpha + \beta_1 Inno_{US,t+1} + \beta_2 X_t + \varepsilon_{t+1}$$

The sample period is 1974-2022. U.S. innovation is measured as the log of the ratio of the total value of patents each year (Kogan et al. (2017)) to the total market value. $X_t$ accounts for lagged exchange rate, lagged U.S. innovation, and the lagged growth of the output ratio between the U.S. and each foreign country. The sample consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. Control variable $X_t$ includes lagged innovation and lagged exchange rate at $t$. Independent variables are standardized to unit standard deviation using unconditional moments. In individual country regressions, standard errors (in parentheses) are obtained using Newey-West with one period lag. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table A.5:** Inequality Growth and Exchange Rates

*Panel A. Exchange rate and inequality growth*

| | Panel | AUS | CAN | CHE | DEU | FRA | GBR | ITA | JPN | NOR | NZL | SWE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inequality growth | 0.019*** | 0.056*** | -0.010 | 0.023 | 0.049 | 0.043 | 0.039** | 0.097** | 0.025 | -0.002 | 0.013 | 0.010 |
| | (0.005) | (0.017) | (0.017) | (0.025) | (0.062) | (0.028) | (0.017) | (0.040) | (0.023) | (0.014) | (0.013) | (0.017) |
| Observations | 418 | 49 | 49 | 42 | 18 | 25 | 42 | 18 | 42 | 42 | 49 | 42 |
| R2 | 0.131 | 0.399 | 0.132 | 0.203 | 0.188 | 0.233 | 0.303 | 0.405 | 0.084 | 0.093 | 0.152 | 0.122 |

*Panel B. Wealth change and inequality growth*

| | Panel | AUS | CAN | CHE | DEU | FRA | GBR | ITA | JPN | NOR | NZL | SWE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inequality growth | 0.022*** | 0.064*** | -0.013 | 0.016 | 0.035 | 0.070** | 0.037* | 0.069 | 0.045* | 0.002 | 0.019 | 0.003 |
| | (0.006) | (0.018) | (0.019) | (0.027) | (0.057) | (0.030) | (0.019) | (0.046) | (0.025) | (0.015) | (0.020) | (0.020) |
| Observations | 396 | 49 | 49 | 42 | 18 | 25 | 42 | 18 | 42 | 42 | 27 | 42 |
| R2 | 0.107 | 0.416 | 0.124 | 0.108 | 0.164 | 0.355 | 0.142 | 0.331 | 0.198 | 0.154 | 0.122 | 0.112 |

**Notes:** Panel A of the table reports regression results of the growth of log exchange rate on log income inequality growth ratio.

$$\log e_{t+1} - \log e_t = \alpha + \beta \Delta \log I_{t+1} + \gamma X_t + \varepsilon_{t+1}$$

where $\Delta \log I_{t+1}$ is the growth of the ratio of top 0.1% income share. The sample period is 1974-2022. The unbalanced panel consists of Australia, Canada, Switzerland, Germany, France, United Kingdom, Italy, Japan, Norway, New Zealand and Sweden. Independent variables are standardized to unit standard deviation using unconditional moments. In individual country regressions, standard errors (in parentheses) are obtained using Newey-West with one period lag. The Panel regressions include country fixed effects, and we report Driscoll and Kraay (1998) standard errors in parentheses. Panel B repeats the analysis with the dependent variable equal to the growth of wealth ratios. Data on income inequality and wealth are from World Inequality Database. Exchange rate, consumption and GDP data are from the World Bank and the IMF. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.