The Hegemon's Dilemma.*

Emile Alexandre Marin†
University of Cambridge

November 6, 2021

Please click here for latest version

Abstract

I study the trade-offs faced by a country issuing the dominant currency (dollar) debt in international markets— the *hegemon*. By keeping dollars scarce in international markets, the hegemon earns monopoly rents proportional to its debt position. However, a strong dollar depresses the global demand for its exports and the appreciation leads to losses on its portfolio of foreign assets. Dollar shortages result in macroeconomic externalities not internalized by private agents in the hegemon, who actively trade in dollar assets. Using a standard open macro model with segmented financial markets and focusing on internal objectives, I characterize the mix of monetary, fiscal and macro-prudential policy that can support the constrained optimal allocation for the hegemon. I show that, if macro-prudential policy is not efficiently designed, monetary policy is constrained by private over-borrowing. Dollar swaps, by increasing liquidity in international markets, can improve welfare in the hegemon but only at the cost of eroding monopoly issuance rents. As such, they are an imperfect substitute for macroprudential policy in addressing internal objectives. Considering a two-agent extension where only some households participate in financial markets, I show that the optimal policy trade-offs reflect distributional implications of dollar shortages. A dollar appreciation favours financially active households who earn monopoly issuance rents but hurts inactive households who suffer from an aggregate demand externality.

JEL Codes: E44, E63, F33, F40, G15

*I thank Fernando Alvarez, Charles Brendon, Giancarlo Corsetti, Luca Dedola, Ester Faia (discussant), Simon Lloyd, Xavier Ragot and participants at the Cambridge ADEMU workshop, the ECB DGI seminar, CRETE 2018, CEPR ESSIM 2019, MMF 2019 (LSE), NY Fed, NuCamp Virtual PhD Workshop 2020 and SED 2021 for useful comments and discussions. I acknowledge financial support from the Keynes Fund (JHUK).

†Faculty of Economics, University of Cambridge, Sidgwick Avenue, Cambridge, CB3 9DD, UK. E-mail: eam65@cam.ac.uk

1 Introduction

The centrality of the U.S. in the International Monetary System (IMS) is highlighted during periods of global crisis, such as the 2007-9 Great Financial Crisis (GFC) and the early-stages of the Covid-19 pandemic in March 2020, when capital quickly flows out of other economies– particularly emerging markets– and into dollar markets.[1] During these periods, dollars become scarce resulting in a widening of the spread in the cost of borrowing in dollar debt vis-a-vis foreign currency debt, see Figure 1.[2] Because of the international role of the dollar, dollar shortages and U.S. policy matter disproportionately for the world economy. For instance, an acute shortage of dollar assets can lead to deflationary safety traps (Caballero, Farhi, and Gourinchas (2017)) and a sharp tightening in international financial conditions (Jiang (2021)). Moreover, Kalemli-Ozcan (2019), Miranda-Agrippino and Rey (2020), and Jiang, Krishnamurthy, and Lustig (2020), amongst others, show that U.S. monetary policy shocks have large spillovers in foreign and particularly emerging economies. However, foreign demand for dollars also has stark implications for U.S. domestic outcomes and policy trade-offs, which in turn matter for the international supply of dollars.

This paper considers the domestic consequences of dollar shortages and analyses the policy trade-offs that confront the monopoly issuer of dollar debt. The scarcity of dollars leads to lower borrowing costs for U.S. agents, which can be interpreted as monopoly rents, in line with Farhi and Maggiori (2016). Yet, this transfer of wealth to the U.S. leads to an equilibrium appreciation of the dollar. There are significant costs associated with the dollar appreciation, specifically, depressed export demand and losses on the U.S. portfolio of foreign-currency denominated assets. I show this leads to a policy dilemma. Monetary policy would naturally want to lower interest rates but, in the absence of macro-prudential policies such as a tax on borrowing, the efficacy of monetary policy is compromised by private sector over-borrowing. I show that the direct provision of dollars, by e.g. the FED, can resolve the monetary policy dilemma, in place of a borrowing tax. Allowing for limited financial participation by households, dollar shortages have heterogeneous effects on households. Active households benefit from lower borrowing costs but inactive households suffer from the presence of an aggregate demand externality. Then, policy is driven by distributional incentives.

Moreover, relative to earlier crises, the U.S. has fundamentally changed its international policy stance with the expansion of central bank liquidity swaps. These serve as a direct recognition by the Fed of the role of dollars in the IMS, and its role as a *global* lender of last resort in the spirit of Bagehot, see Bahaj and Reis (2018). Swap lines are agreements according to which the U.S. Federal Reserve lends dollars to a foreign central bank, against good collateral, over short maturities, in exchange for foreign currency. The foreign central bank, in turn, lends dollars to

[1] Farhi and Maggiori (2016) define the International Monetary System (IMS) as: (i) the structure of international markets, the supply and demand of safe assets and the resulting imbalances; (ii) the system of exchange rate regimes and associated monetary policies; (iii) the set of rules and institutions governing capital and trade flows.

[2] Aldasoro et al. (2020) show that banks across the world have a total of \$12.8 trillion of US dollar-denominated borrowing. Maggiori, Neiman, and Schreger (2018) document that the international allocation of capital is increasingly biased towards the U.S.

its domestic financial institutions. By increasing dollar liquidity, swap lines help international financial intermediaries satisfy global demand for dollar debt, and thus moderate the pressure on the dollar exchange rate. To get a sense of how extensively dollar swap lines are used, at the peak of the GFC (2008 Q4), the sum of outstanding dollar swap liabilities amounted to 48% of U.S. GDP. Their expansion is systematically associated with a narrowing of the borrowing spread between the dollars and other currencies (see Figure 1). While existing discussions predominantly consider dollar swaps as an instrument for supporting foreign economic conditions, benefiting the U.S. only by sustaining foreign asset prices and demand, this paper considers the scope for dollar swap lines to address internal policy objectives.[3]

Figure 1 plots the relative cost of borrowing in dollar debt vis-a-vis foreign currency debt, captured by ex-post deviations from the uncovered interest rate parity (UIP). During periods of international financial turmoil (including the GFC, the European Sovereign Debt Crisis, the Taper Tantrum and COVID-19) the cost of borrowing in U.S. dollars consistently falls about $2-6\%$ below the cost of borrowing in a synthetic trade-weighted (against G10 and EM7 currencies) currency denominated bond.[4] Meanwhile, the share of gross liabilities (denominated in dollars) vis-a-vis assets (predominantly denominated in foreign currency) has risen. The U.S. net investment position, calculated as the difference between gross assets and liabilities, deteriorated from about 12% of GDP pre-GFC to almost 70% by 2021 (see Appendix A). As a result, the scope for the U.S. to earn rents from issuing dollar debt has risen significantly since the GFC.

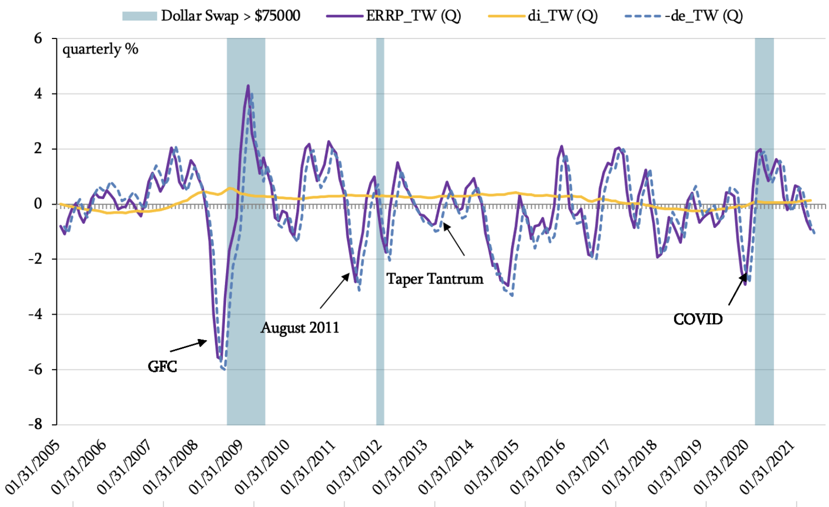


Figure 1: Difference in borrowing cost for dollar debt vs. trade-weighted average of G10 and EM7 currencies (deviations from uncovered interest rate parity) based on 3 month-bonds held to maturity in *p.p.* Decomposition into interest rate differentials ($di > 0$ implies foreign 3-month foreign rates higher) and exchange rate movements ($-de < 0$) implies a dollar appreciation. Moving average based on windows of one quarter. Shaded regions reflect periods when dollar swap facilities exceeded \$75000 million. Source: Global Financial Data, Federal Reserve and author's calculations.

To study how these monopoly rents and the extension of dollar swap lines drive hegemon

[3]The Federal Reserve details its motivation for extending dollar swaps here.

[4]Appendix A details the spread vis-a-vis G10 and EM7 currencies separately. Liao (2020) and Jiang, Krishnamurthy, and Lustig (2020) show that a similar although smaller spread exists for corporate bonds (AAA to AA-) as well, suggesting the private sector in the U.S. also directly benefits from this.

outcomes and optimal policy, I draw on standard open-economy literature, featuring nominal rigidities and financial frictions in international markets. Namely, building on Galí and Monacelli (2005), I specify a global economy consisting of a continuum of small-open economies, assuming that a single country – the hegemon– monopolistically issues dollar debt. All other countries in the continuum issue foreign-currency denominated debt. To model dollar liquidity, I specify a segmented markets framework in the spirit of Gabaix and Maggiori (2015) and Fanelli and Straub (2018), in which dollar and foreign assets are not perfect substitutes. In equilibrium, financial intermediaries satisfy the demand for dollar debt in excess of the supply by U.S. agents, but are subject to participation costs and portfolio limits. Because of this financial friction, for intermediaries to be willing to issue dollar debt, this must trade at a spread over debt in foreign currency. The tighter the intermediaries' portfolio constraint, the lower the level of dollar liquidity in foreign markets, and the larger the spread required for the dollar market to clear. In the model, in line with the empirical evidence, the spread between dollar and foreign currency debt is captured by deviations from (UIP). Intuitively, foreign currencies which tend to contemporaneously depreciate vis-'a-vis the dollar in periods of dollar shortages, systematically appreciate thereafter, therefore the dollar cost of debt repayment rises, even if interest rate differentials are small.

At the crux of the trade-offs arising for the hegemon is a version of the transfer problem, initially debated in Keynes (1929) and Ohlin (1929).[5] While the U.S. benefits from a transfer of monopoly rents (akin to seignorage) from foreign countries, the associated dollar appreciation has large, adverse, secondary effects. In contrast to previous analyses of the transfer problem, I emphasize the resulting macroeconomic externalities not internalized by private agents who trade in financial markets, building on recent theoretical contributions such as Schmitt-Grohé and Uribe (2016), Farhi and Werning (2016), Bianchi and Lorenzoni (2021). I emphasize that the externalities are larger when only a share of agents actively participates in financial markets, see e.g Krishnamurthy and Vissing-Jorgensen (2012) and Aguiar, Bils, and Boar (2020). Moreover, the appreciation is more costly because pass-through to U.S. imports is low (so households do not benefit of much cheaper imports following an appreciation) and because of counter-acting valuation effects since the appreciation lowers the return on foreign-currency denominated assets.

Within this model environment, I highlight three main results for hegemon policy. First, I derive the constrained optimal allocation in the hegemon, that can be implemented using monetary, fiscal and macro-prudential policy instruments, the latter in the form of a time-varying borrowing tax on private agents. I show that macro-prudential policy is required because international dollar shortages cause private U.S. agents to over-borrow. Over-borrowing is the result of two externalities: an aggregate demand externality due to price rigidities, studied in Schmitt-Grohé and Uribe (2016) and Farhi and Werning (2016), and a financial terms of trade

[5]Keynes argued that war reparations paid by Germany to France would impose further costs to the German economy in the form of adverse terms of trade movements, which Ohlin suggested would not materialise if the French spent the reparations on German goods. Relative to the initial debate, as well as the price movements, associated with a transfer, I emphasize the pecuniary externalities which result from them.

externality. The former arises because atomistic households do not internalize the effects of their spending on domestic goods in periods when domestic employment is below optimal. The financial externality arises because atomistic households fail to internalize the efffect of issuing an additional unit of dollar debt on the the price for all other units of debt (both private and public). When macro-prudential policy is not set optimally, over-borrowing will weigh on the trade-offs faced by the other policies, and motivate the introduction of new instruments.

Specifically, I show that the optimal interest rate response to dollar shortages is generally expansionary, but, absent macro-prudential policy, the effectiveness of monetary policy is compromised. The hegemon lowers the interest rate to mitigate the pressure on the exchange rate to appreciate and thus sustain the global demand for U.S. goods and employment. However,since households experience a smaller temporary recession, everything else equal, they borrow less. This makes dollar shortages in international markets more pervasive and persistent, resulting in larger monopoly rents which further strengthen the incentive to over-borrow. With these opposing effects in place, monetary policy cuts interest rates by less than it would in a constrained efficient allocation, where it strikes a compromise between terms of trade manipulation and risk sharing incentives, see e.g. Fanelli (2017), Corsetti, Dedola, and Leduc (2018). This is consistent with the view of a Mundellian Dilemma, as opposed to a Trilemma since the ability of monetary policy in the hegemon to achieve a desired allocation is compromised by capital inflows arising from dollar scarcity. For the case of developing countries, Rey (2015) emphasizes the need for capital controls to preserve the independence monetary policy because of a global cycle in asset prices, whilst Farhi and Werning (2014) emphasize the need for capital controls to smooth the terms of trade in a New-Keynesian model.

Second, I show that, under these conditions, there is scope for direct provision of dollar liquidity by the Federal Reserve in the form of dollar swap lines to improve U.S. household welfare. As already mentioned, swap lines are agreements according to which the Hegemon central bank lends dollars to a foreign central bank in exchange for foreign currency. By increasing dollar liquidity swapping dollars for foreign currency, the hegemon can alleviate the frictions constraining the issuance of dollar debt by financial intermediaries. As a higher dollar debt supply moderates dollar appreciation and reduce the dollar spread, the swaps weaken the incentive for the hegemon residents to borrow. Like the (missing) macro-prudential borrowing tax, dollar swaps allow the hegemon to address inefficient over-borrowing, but, different from the borrowing tax, this is achieved at the cost of eroding monopoly rents from the issuance of dollar debt.

Relatedly, the U.S. government can also satisfy foreign demand for safe dollar asset and stem pressure on the dollar to appreciate by issuing public debt. Yet public debt issuance and dollar swaps are fundamentally different policy instruments in many dimensions. Public debt issuance changes the public sector balance sheet, and is optimally used to smooth spending and taxes, particularly during periods of financial distress. Dollar swaps have little effect on the public sector balance sheet and directly target the spread in dollar vis-a-vis foreign currency borrowing cost and exchange rate appreciation. Their social value is higher when monetary policy is constrained so that the over-borrowing inefficiency is larger, and in the presence of shocks (such as fiscal) which cause the government to issue more/less debt. However, as already stated, dollar swaps are not useful if a macro-prudential tax is available.

Third I demonstrate how the trade-offs facing the hegemon worsen if only a fraction of households actively participate in financial markets in any given period. In the model, I distinguish between households who are financially-active, and thus can trade in dollar debt vis-a-vis financial intermediaries, and inactive households who simply consume their current income. Dollar shortages abroad have heterogenous effects on hegemon households and this can drive the policy response. Financially-active households benefit disproportionately from borrowing at a lower cost whereas all households suffer equally from depressed exports (through lower wages) and from losses on the government's portfolio of assets (through higher taxation and lower spending on public goods). This is so even if, in equilibrium, the financially-active households spend some (but not all) of the rents they earn from issuing dollar debt on domestic goods, resulting in a positive income effect for all households. These considerations are reflected in a higher level of over-borrowing by financially-active households, relative to the representative agent case, increasing the welfare gains achievable by dollar swaps. Consequently, dollar swaps lines play a role in redistributing from financially-active to inactive households. Chien and Morris (2017) show that financial market participation varies by U.S. state even when controlling for household income, dollar shortages introduce a political trade-off in the hegemon and the extension of dollar swap lines can become a political decision.

Finally, I assess these effects quantitatively by calibrating the hegemon economy to the U.S. in 2020Q1. I target empirically relevant values for monopoly rents accruing to the U.S., and weigh these against the cost of depressed exports and capital losses on the U.S. portfolio, reflecting its currency composition, discussed extensively in Gourinchas, Rey, and Govillot (2018). I consider an increase in dollar demand leading to a 5% dollar appreciation and resulting in a 3% negative spread in the cost of borrowing in dollars vis-a-vis foreign currency, when U.S. interest rates do not respond. Monopoly rents amount to about 3.5% of GDP on impact, and dissipate over about 10 quarters; export revenues fall by 1.5%. Losses on the government portfolio are about 4% of GDP but are short lived (5 quarters).

Welfare analysis suggests that, if interest rates are held fixed, both active and inactive households lose out following a rise in dollar shortages—raising the social value of dollar swap lines, as an instrument that can sever the link between dollar shortages and the dollar appreciation. Conversely the optimal monetary policy response cuts interest rates by about 3%. In this case, active households experience a welfare gain, but inactive households lose out. Monetary policy accepts an externally induced overheating of the economy and a level of over-borrowing. Should a borrowing tax have been available, monetary policy cuts interest rates by almost 5% and the average labour wedge is almost perfectly stabilized.

The desirability of dollar swap lines then depends on the Pareto weights the planner assigns to either group of households.

Related Literature. Thematically, this paper belongs to an emerging literature on the role of the U.S. and the dollar in the International Monetary System (IMS). Amongst existing contributions, Maggiori (2017), Gourinchas, Rey, and Govillot (2018), Kekre and Lenel (2020) consider general equilibrium models where the U.S. has a higher capacity to bear risk, earning excess returns outside of crises but facing losses during crises. On the other hand, Farhi and Maggiori (2016) describe a stylized model where a government faces downward sloping demand for its debt, derived from mean-variance investors, and earns monopoly rents. Similarly, Jiang, Krishnamurthy, and Lustig (2020) consider a model where the U.S. earns seignorage rents from issuing debt because foreign investors assign a convenience yield to dollar debt.Relative to these papers, I weigh the seigniorage rents against the costs from a dollar appreciation, emphasizing the externalities which arise and deriving the Ramsey optimal policy.

A new, mostly theoretical, literature on optimal capital controls aims to identify macroeconomic externalities which arise when atomistic agents do not take into account their power in goods markets. Specifically Costinot, Lorenzoni, and Werning (2014), Lloyd and Marin (2020), study the use of capital controls to internalise terms of trade externalities, Schmitt-Grohé and Uribe (2016) and Farhi and Werning (2016) look at aggregate demand externalities and Basu et al. (2020), Bianchi and Lorenzoni (2021) analyze financial externalities. I make three contributions to this literature. First, I emphasize the trade-offs that arise for monetary and fiscal policy because of the absence of a borrowing tax, since capital controls are used less in advanced economies such as the U.S. as opposed to emerging markets. Second, I show that dollar swap lines can be used by the U.S. in place of the borrowing tax but only at the cost of eroding the monopoly rents. Third, I highlight how limited financial market participation, in a two-agent model, can exacerbate these externalities.

This paper also draws on an established literature on optimal policy in open economies. Monetary policy in open economies trades-off terms of trade and risk-sharing incentives, see, e.g. Fanelli (2017) and Corsetti, Dedola, and Leduc (2018). Specifically, the latter analyse the monetary response to inefficient capital inflows in an incomplete markets model. Egorov and Mukhin (2019) and Corsetti, Dedola, and Leduc (2020) study optimal policy when all exports are priced in dollars, see Gopinath et al. (2020) for evidence on dollar pricing. Relative to these papers, I show that the ability of monetary policy to stabilize the economy is compromised by the presence of private over-borrowing, and I highlight the scope for dollar swap lines.

Even though dollar swap lines have been one of the most prominent policies over the past decade, there is comparatively little literature on their effect on macro outcomes.[6] A number of contributions have assessed the efficacy of dollar swaps empirically: Baba and Packer (2009) and Moessner and Allen (2013) analyse the effect of swap lines during the GFC using variation across currency pairs. Bahaj and Reis (2018) use cross-sectional and time series variation to show that dollar swap lines introduce a ceiling on deviations from the covered interest rate parity, reduce portfolio flows into U.S. dollar assets and lower the price of dollar corporate bonds. Aizenman, Ito, and Pasricha (2021) conduct a similar analysis for the aftermath of

[6]McCauley and Schenk (2020) detail the history of liquidity provision policies by the U.S. and other central banks.

COVID-19 and emphasize that the FED selected dollar swap line recipients based on trade and financial closeness.

Of these papers, only Bahaj and Reis (2018) consider a theoretical framework, and their analysis is couched in a three-period model of global banks which later allows for a basic model of production and investment. Eguren-Martin (2020) expands on the macroeconomic consequences of swaps, building on the New-Keynesian model in Akinci and Queraltó (2018), but restricts the analysis to a linear rule for liquidity provision as in Del Negro et al. (2017). Relative to these models, I characterize dollar swap lines as part of the (Ramsey) optimal policy mix, emphasizing the externalities which they can address domestically.

An established literature studies the implications of limited financial market participation on risk-sharing outcomes in closed and open economies, see e.g Alvarez, Atkeson, and Kehoe (2002), Alvarez, Atkeson, and Kehoe (2009), Kollmann (2012) and Cociuba and Ramanarayanan (2017). I contribute to a growing literature studying the interplay between domestic household heterogeneity and capital flows. Fanelli and Straub (2018) derive optimal foreign exchange interventions in a model with segmented international financial markets where hand-to-mouth households are hurt by a pecuniary externality. Ferra, Mitman, and Romei (2019) study the effects of a sudden stop in capital inflows in a small-open economy HANK economy where household debt is partly denominated in foreign currency. Auclert et al. (2021), build on Corsetti and Pesenti (2001), to analyze the effects of household heterogeneity on the costs of an appreciation. Focusing on the U.S., Kim (2020) shows that the role of the U.S. as 'banker of the world' can account for 34-55% of the increase in the top 1% wealth share domestically. In this paper, I emphasize the distributional consequences on U.S. households of dollar shortages, and analyze how limited participation affects the macroeconomic externalities which arise and the scope for monetary policy and dollar swaps.

Section 2 lays out the model. Section C considers a static stylized framework to outline the key trade-offs and illustrate the instruments available. Section 4 considers a dynamic model and solves for welfare maximizing policy. In Section 4.3, I consider the distributional implications for the hegemon in a two-agent version of the model. Section 5 conducts a calibration exercise. Section 6 concludes.

2 Model Setup

There is a continuum of countries $i \in [0, 1]$. I denote the *hegemon* by $i = 0$, and suppress the subscript for domestic variables. The baseline setup builds on a standard open-economy model as in Galí and Monacelli (2005), recently used in, e.g. Farhi and Werning (2017) and Egorov and Mukhin (2019). I extend the model to consider financial market segmentation in the spirit of Gabaix and Maggiori (2015) in order to distinguish between a dollar segment and a foreign currency segment. Households in each segment trade in a non-contingent bond denominated in their own currency, but trade across borders must be intermediated by financiers. The hegemon differs in one important way: it is the monopoly issuer of dollar debt, for which there is excess demand in international markets.

Households. A representative household in country $i = 0$ (Home) has preferences described by the following instantaneous utility function,[7]

$$\mathcal{U}_t = \frac{C_t^{1-\sigma}}{1-\sigma} - \kappa \frac{L_t^{1+\psi}}{1+\psi} + V^G(G_t) \tag{1}$$

where C_t is consumption of private goods, L_t is labour supplied and $V^G(G_t)$ denotes individual utility from the consumption of public goods. Private consumption is an index composed of Home and Foreign good varieties,

$$C_t = [\chi^{\frac{1}{\theta}} C_{H,t}^{\frac{\theta-1}{\theta}} + (1-\chi)^{\frac{1}{\theta}} C_{F,t}^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}} \tag{2}$$

and $C_{H,t}, C_{F,t}$ consists of,

$$C_{H,t} = \left[\int_0^1 C_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}, \tag{3}$$

$$C_{F,t} = \left[\int_0^1 C_{i,t}^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}, \quad C_{i,t} = \left[\int_0^1 C_{i,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}},$$

where j denotes different varieties of the the same good and ϵ is the constant elasticity of substitution between varieties, i denotes countries and θ is the constant (macro) elasticity of substitution between imports from different countries, see e.g Feenstra et al. (2018). The parameter χ reflects the weight of domestic goods in a country's final consumption index, where $\chi > 0.5$ captures home bias.

Households purchase goods, earns wages W_t from providing labour L_t and receive profits $\Pi_t = \Pi_t^g + \Pi_t^f$ from their ownership of goods' and financial firms respectively. Households trade in one-period, non-contingent bonds x_t, denominated in domestic currency, vis-a-vis international financial intermediaries.[8] Households receive a lump-sum rebate from the government T_t in every period. The budget constraint is given by,

$$P_{F,t}C_{F,t} + P_{H,t}C_{H,t} \leq \Pi_t + W_t L_t + \frac{1}{R_t} x_t - x_{t-1} - T_t \tag{4}$$

The household's optimization problem consists of choosing a sequence $\{C_{H,t}, C_{F,t}, L_t, x_t,\}$ to maximize lifetime utility (1) subject to the budget constraint (4), taking initial debt x_0, production $\{Y_{H,t}\}$ and prices $\{W_t, R_t, P_{H,t}, P_{F,t}\}$ as given. The first-order conditions characterizing

[7]Foreign households have analogous preferences. Appendix A presents the model equations for an arbitrary country i.

[8]This is the limiting case of a model where households can take position x_t in domestic currency bonds and $x_{F,t}$ in foreign currency bonds, subject to a constraint $x_{F,t} \in [\underline{x}_F, \overline{x}_F]$ where $\underline{x}_F, \overline{x}_F \to 0$.

the households' optimal allocation are given by,

$$\frac{C_t^{-\sigma}}{P_t} - \beta \mathbb{E}_t \left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}} \right] R_t = 0, \tag{5}$$

$$\kappa L_t^{\psi} \frac{C_{H,t}}{\chi} = \frac{W_t}{P_{H,t}}, \tag{6}$$

$$C_{H,t} = \frac{\chi}{1-\chi} \left(\frac{P_{H,t}}{P_{F,t}} \right)^{-\theta} C_{F,t}, \tag{7}$$

where (5) is the household Euler equation governing the intertemporal allocation of consumption, taking the gross interest rate R_t as given, (6) characterises the optimal labour allocation and (7) determines the allocation of spending between home and foreign good varieties.

Firms. In each country there is a continuum of firms indexed by j, which produce a unique variety of tradable goods and are endowed with linear production technology which uses only labour,

$$Y_{H,t}(j) = A_t L_t(j) \tag{8}$$

where A_t is a Home (aggregate) productivity. Goods are consumed both domestically and exported abroad:

$$Y_{H,t} = C_{H,t} + G_{H,t} + C_{H,t}^{*} \tag{9}$$

where $G_{H,t}$ denotes government expenditure on home varieties and $C_{H,t}^{*}$ denotes foreign demand.

I focus on the case where prices are either perfectly rigid or perfectly flexible.[9] I allow for a constant employment tax τ^L and define the effective wage for firms by $\tilde{W}_t = W_t(1+\tau^L)$. If prices are rigid, I distinguish between two pricing paradigms. Under producer currency pricing (PCP), domestic producers set identical domestic prices for all the goods they produce, regardless of whether they are consumed domestically or exported, as assumed in Galí and Monacelli (2005) and Farhi and Werning (2012). In the data, exported goods are predominantly denominated in dollars.This is referred to as DCP and is documented in Gopinath et al. (2020). I assume the hegemon also issues the dominant currency, consistent with the case of the dollar.[10]

Consider the maximization faced by a firm j in the Home country when prices are perfectly rigid,

$$\max_{P_H(j)} \mathbb{E}_0 \sum_{t=0}^{\infty} \left[P_{H,t}(j) Y_{H,t}(j) - \frac{\tilde{W}_t}{A_t} L_t(j) \right] \tag{10}$$

[9]These assumptions, also used in Egorov and Mukhin (2019) and Basu et al. (2020), allow me to abstract from price dynamics and dispersion. Price dynamics in open economies have been the focus of a large literature on open economy New-Keynesian models, see Galí and Monacelli (2005), Farhi and Werning (2012) and Corsetti, Dedola, and Leduc (2018) amongst others.

[10]Recent literature argues that the dominance of the dollar in financial and goods market is closely connected, see Gopinath and Stein (2018) and Chahrour and Valchev (2021).

In a symmetric equilibrium $P_{H,t}(j) = P_{H,t}$, $Y_{H,t}(j) = Y_{H,t}$. The price is given by,

$$P_{H,t} = \frac{\epsilon}{\epsilon - 1}(1 + \tau^L)\frac{\mathbb{E}_0\left[\sum_{t=0}^{\infty} \Lambda_t \frac{W_t}{A_t} Y_{H,t}\right]}{\mathbb{E}_0\left[\sum_{t=0}^{\infty} \Lambda_t Y_{H,t}\right]}, \tag{11}$$

where $1 + \tau^L = (\epsilon - 1)/\epsilon$ such that the labour subsidy levied by the government eliminates steady state monopolistic distortions. Consistent with the literature, I assume firms set the same price for all export destinations. In contrast, if prices are perfectly flexible, firm j chooses prices such that for each period,

$$\max_{P_{H,t}(j)} P_{H,t}(j)Y_{H,t}(j) - \frac{\tilde{W}_t}{A_t} L_t(j) \tag{12}$$

and in equilibrium,

$$P_{H,t}^{flex} = \frac{\epsilon}{\epsilon - 1}(1 + \tau^L)\frac{W_t}{A_t} \tag{13}$$

such that firms charge a constant mark-up over $\tilde{W}_t/A_t$.

Price indices, exchange rates and foreign variables. The home consumer price index (CPI) is defined as $P_t = [\chi P_{H,t}^{1-\theta} + (1-\chi)P_{F,t}^{1-\theta}]^{\frac{1}{1-\theta}}$. The home producer price index (PPI) is given by $P_{H,t} = (\int P_{H,t}(j)^{1-\epsilon}dj)^{\frac{1}{1-\epsilon}}$. The import price index is given by $P_{F,t} = \left(\int P_{i,t}^{1-\theta}di\right)^{\frac{1}{1-\theta}}$ in dollars, where $P_{i,t} = (\int P_{i,t}(j)^{1-\epsilon}dj)^{\frac{1}{1-\epsilon}}$ is country i's PPI in dollars. I define the world price index $P_t^* = \int (P_{i,t}^{i\ 1-\theta}di)^{\frac{1}{1-\theta}}$ where $P_{i,t}^i$ is the price of good i in country i expressed in domestic currency. I define $\mathcal{E}_t$ as the effective dollar nominal exchange rate, where an increase in $\mathcal{E}_t$ reflects a depreciation of the dollar. Import and export prices for the home country satisfy:

$$P_{H,t}^* = \frac{P_{H,t}}{\mathcal{E}_t^{\lambda}}, \quad P_{F,t} = P_{F,t}^* \mathcal{E}_t^{\lambda^*} \tag{14}$$

where λ is exchange rate pass-through to imports in $i = 0$ and λ^* is exchange rate pass-through on hegemon exports. Under (full) DCP, $\lambda = 0, \lambda^* = 1$.[11] Assuming prices at the border are perfectly rigid, consumer prices are time-varying only if pass-through is non-zero.

To emphasize the distinction between the Home (hegemon) and other countries, I assume all foreign countries are symmetric and I model a single foreign sector consisting of $i \in [0, 1)$ countries. Foreign sector variables are denoted by an asterisk.

Government. Households derive additively separable utility from public goods $V^G(G_t)$ in each period, given by,

$$V^G(G_t) = \omega^G[\chi^G \log(G_{H,t}) + (1 - \chi^G)\log(G_{F,t})] \tag{15}$$

[11] For comparison, $\lambda = \lambda^* = 1$ under PCP where the law of one price holds.

where ω^G captures the relative preference for public spending. A portion χ^G of total public expenditure is spent on domestic varieties and stimulates domestic aggregate demand whereas a portion $1-\chi^G$ is spent on imports. Implicitly, I assume households have an elasticity of substitution of 1 for public spending over time, and across varieties. Specifically,

$$G_{H,t} = \frac{\chi^G}{1-\chi^G}\left(\frac{P_{H,t}}{P_{F,t}}\right)^{-\theta} G_{F,t} \tag{16}$$

The government finances public expenditures by issuing one-period non-contingent bonds B_t at an interest rate R_t and through taxes T_t.[12]

I introduce a parameter κ^G which determines the portion of debt-financing. When $\kappa^G = 0$, public expenditures are entirely debt financed ($T_t = 0$), whereas when $\kappa^G = 1$ the entirety of financing comes from a lump-sum tax ($B_t = 0$). I assume $\kappa^G < 1$, such that Ricardian equivalence fails, otherwise private agents will undo changes in B_t. The government also earns a return on a portfolio of assets $\hat{\Psi}_t(\mathcal{E}_t)$ given by,

$$\hat{\Psi}_t(\mathcal{E}_t) = \Psi_t + \Psi_t^* \mathcal{E}_t \tag{17}$$

where Ψ_t denotes the return on a portfolio of domestic-currency assets and $\Psi_t^*\mathcal{E}_t$ denotes the return, in dollars, on a portfolio of foreign-currency denominated assets. The government budget constraint is given by:

$$\begin{gathered} P_{F,t}G_{F,t} + P_{H,t}G_{H,t} + B_{t-1} - \hat{\Psi}_t \leq \frac{1}{R_t}B_t + T_t \leftrightarrow \\ \left[P_{F,t}G_{F,t} + P_{H,t}G_{H,t} + B_{t-1} - \hat{\Psi}_t\right](1-\kappa^G) \leq \frac{1}{R_t}B_t \end{gathered} \tag{18}$$

where the second line follows from substituting T_t.

2.1 International Financial Markets

Asset markets are incomplete and segmented. Markets are incomplete because households in each country trade in non-contingent bonds denominated in domestic currency. Markets are segmented because households are confined to trade within their own financial market segment only, i.e. they cannot directly trade with households in other countries. For simplicity, I focus on a '*dollar*' and a '*foreign*' market segment only. Figure 2 illustrates the market structure: trade in goods across markets is unrestricted, but trade in assets must be intermediated.

A continuum of financial intermediaries indexed by $k \in [0, \hat{k})$ trade one-period, non-contingent bonds at each time t, across market segments, with agents in the home and foreign segments. Each financier starts with no initial capital, faces a participation cost k and position limits

[12] To derive sharp analytical results, I assume the interest rate on (US) household and government bonds is equal. In practice, there is a sizeable spread between U.S. treasury yields and corporate debt (TED spread), see Krishnamurthy and Vissing-Jorgensen (2012), Valchev (2020) and Liao (2020).

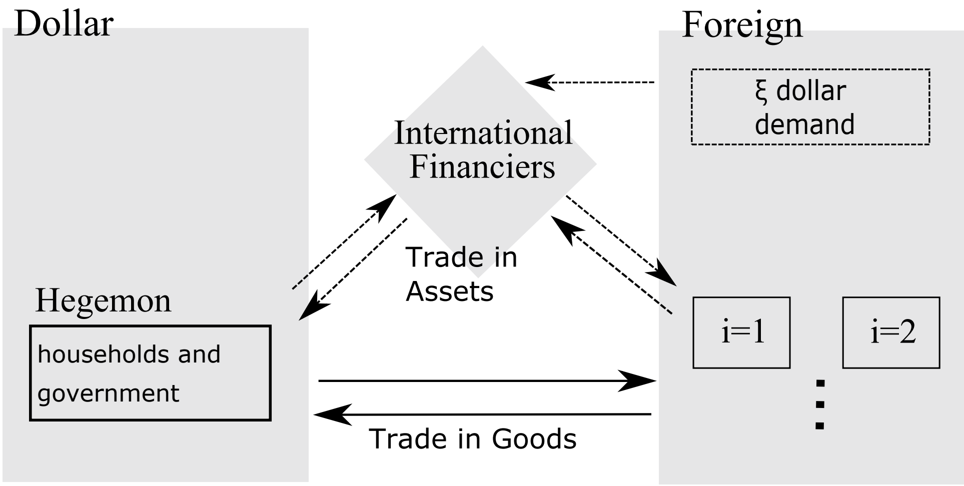


Figure 2: International financial market structure

$\{-\overline{Q}, \overline{Q}\}$.[13] The variable k corresponds to both the financiers' cost of participating and their index. Without loss of generality, I assume financial intermediaries trade in a single foreign bond with the foreign sector at a dollar price $\frac{1}{R_t^*}\mathcal{E}_t$. Since foreign countries are symmetric, $R_{i,t} = R_t^*$ for $i > 0$. Financiers choose a position in dollar bonds $q_t(k)$ to maximize profits earned at t, where $q_t(k) > 0$ denotes a long position, subject to a constraint that they break-even at $t+1$. The problem of an individual financier, indexed by k, at time t can be summarised as,

$$\max_{q_t(k)\in\{-\overline{Q}_t,\ \overline{Q}_t\}} \left(\frac{1}{R_t} - \mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*}\right) q_t(k) - k$$

An individual financial intermediary participates as long as $|\frac{1}{R_t} - \mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*}|\overline{Q}_t > k$. In equilibrium, a measure $\mathbf{k}_t = |\frac{1}{R_t} - \mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*}|\overline{Q}_t$ participate. Then, the total demand for dollars by financiers is given by $Q_t = sign\left(\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*} - \frac{1}{R_t}\right)\overline{Q}_t\ \mathbf{k}_t$. I define $\Gamma_t = \frac{1}{\overline{Q}_t}^2$ as the semi-elasticity of demand for dollar debt.

In equilibrium, because of non-zero entry costs and position limits, financial intermediaries require excess returns when there are dollar imbalances in international markets ($Q_t \neq 0$), leading to deviations from UIP:

$$\left(\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*} - \frac{1}{R_t}\right) = \Gamma_t Q_t \tag{19}$$

Suppose there is a shortage of dollars. Then, in equilibrium, intermediaries borrow in dollars, i.e they issue a claim to dollars which they sell in foreign currency. The LHS of (19) reflects the required compensation to intermediate dollar shortages $Q_t < 0$ for a given level of (inverse)

[13]Position limits are motivated by collateral constraints, see e.g Gromb and Vayanos (2002), Gromb and Vayanos (2010) or value at risk constraints, see Adrian and Shin (2014). The timing of the intermediation problem follows Alvarez, Atkeson, and Kehoe (2002) and Cociuba and Ramanarayanan (2017).

dollar liquidity Γ_t.[14] In periods of low liquidity, when financiers are more constrained (i.e $\overline{Q}_t$ is low and Γ_t is high) a larger spread is required for a given Q_t. As a result, the dollar price of dollar debt exceeds that of foreign-currency denominated debt. In the limit where dollar liquidity is abundant ($\Gamma_t = 0$) the spread does not depend on Q_t.

Furthermore, I assume there is a separate group of non-optimizing, unconstrained agents belonging to the foreign sector who have inelastic demand $\xi_t \geq 0$ for dollar debt, which they finance by taking a position $-\xi_t/\mathcal{E}_t$ in foreign currency debt. Market clearing in the dollar segment requires,

$$Q_t = x_t + B_t - \xi_t, \tag{20}$$

where x_t is dollar debt issued by households, B_t is dollar debt issued by the hegemon government, and ξ_t is inelastic demand for dollar debt from foreign agents. For markets to clear, the financiers' position in dollar debt (Q_t) is equal to the supply of dollar debt ($x_t + B_t$) minus the demand for dollar debt ξ_t. Equations (19) and (20) summarise the dollar market equilibrium.

Financial intermediaries are non-U.S. entities issuing dollar debt at a cost. Relatedly, Jiang, Krishnamurthy, and Lustig (2020) study a model where foreign firms are able to produce dollar debt at the cost of balance sheet mismatch. Evidence of issuance of U.S. debt by non-U.S. is presented in Bruno and Shin (2017) and Maggiori, Neiman, and Schreger (2018).

Multipolar World. To highlight the specialness of the hegemon in the model, consider the case when there are N competing issuers within a segment, and for notational clarity, consider the dollar segment. Market clearing is then given by,

$$Q_t = x_t + B_t + \sum_{i>0}^{N-1} (x_t^i + B_t^i) - \xi_t, \tag{21}$$

where x_t^i and B_t^i are the issuance of dollar assets by issuer $i > 0$ households and government respectively. If foreign issuers of close-substitute debt respond to changes in ξ_t (which lead to a fall in R_t) by a factor $\epsilon > 0$, as the number of issuers becomes large, shortages cannot arise in the market segment.[15]

2.2 Dollar Swap Lines

A key institutional innovation in the IMS in recent years has been the (re-)establishment of dollar swap lines. As part of a swap line agreement, the U.S. Federal Reserve lends dollars

[14]The distinction between deviations in the covered (CIP) and uncovered (UIP) interest rate parities depends on risk. In particular, deviations in the covered interest rate parity arise in the absence of risk (i.e when financiers fully hedge exchange rate risk using swaps) and translate 1:1 to deviations in the covered and uncovered interest rate parity. The model is silent on this distinction, but UIP deviations tend to be an order of magnitude greater than their CIP counterparts.

[15]In Appendix **??**, I show within a stylized model that if N symmetric governments compete a la Cournot when issuing substitutable varieties of debt, dollar shortages in international markets go to zero, as do rents from issuance.

to a foreign central bank at an interest rate set at a spread above the overnight indexed swap (OIS) rate, at short maturity. The foreign central bank, in turn, lends dollars to their domestic financial institutions– in this instance, the financial intermediation sector. The Fed receives a foreign currency deposit as collateral and at the end of the loan, the FED gets its currency back at the original exchange rate. Therefore, the operation carries minimal risk for the FED which does not take up exchange rate risk. In the model, I abstract from the foreign central bank and assume the FED swaps dollars directly with financial intermediaries. As a result of the liquidity provision by the U.S., position limits faced by financiers expand. I derive a relationship between dollar-swap up-take, equilibrium dollar shortages, and the resulting spread in borrowing costs. At the end of this section, I contrast dollar swaps, direct FX interventions and capital controls in the model. For further details on the contract underlying dollar swap lines see Bahaj and Reis (2018).

Previously, I assumed each financier could promise a to deliver a maximum $\overline{Q}_t$ dollars tomorrow, limiting the size of dollar shortages that can be intermediated in equilibrium. When dollar swaps are available, I assume the financier can draw Q^s from the swap facility, swapping foreign currency for dollars. Financiers will choose to do so as long as the currency-adjusted interest rate differential is greater than the participation cot and the cost of taking up dollar-swaps. Specifically, when dollar swap lines are available, a financier indexed by k faces the following maximization:

$$\max_{\substack{q_t(k)\in\{-\overline{Q}_t,\overline{Q}_t\}\\ q_t^s(k)\in\{-Q^s,0\}}} \left\{\left(\frac{1}{R_t}-\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*}\right)(q_t(k)+q_t^s(k))-\tau^s q_t^s(k)-k\right\}$$

where $q_t^s(k)$ reflects the financier's position in dollars, backed by dollar swaps. The cost of drawing $q_t^s(k)$ from the dollar swap line is $q_t^s(k)\tau^s$. Financiers' enter with a position $\overline{Q}+Q^s$ as long as,

$$\left(\frac{1}{R_t}-\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*}\right)(\overline{Q}+Q^s)-\tau^s(\overline{Q}+Q^s)\frac{Q^s}{(\overline{Q}+Q^s)}\geq k \tag{22}$$

I redefine $\Gamma=\frac{1}{\overline{Q}+Q^s}^2$ as the new semi- elasticity of demand. In equilibrium,

$$\left(\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}-\frac{1}{R_t}\right]\frac{1}{R_t^*}\right)-\tau^s\frac{Q^s}{(\overline{Q}+Q^s)}=\Gamma_t Q_t \tag{23}$$

The next lemma summarise the effect of dollar swaps on the equilibrium UIP deviations.

Lemma 1 (Dollar Swaps)

If $\tau^s=0$ (no spread on dollar swaps), then, the model is isomorphic to the baseline with UIP *deviations given by* (19)*, except the semi-elasticity of demand is now given by:*

$$\Gamma_t = \left(\frac{1}{\overline{Q} + Q^s}\right)^2 < \left(\frac{1}{\overline{Q}}\right)^2 \tag{24}$$

Total up-take of dollar swaps in the model is given by:

$$\mathbf{k}_t Q^s = -Q_t \frac{Q^s}{\overline{Q} + Q^s} \geq 0 \tag{25}$$

Equation (25) maps directly to the data on dollar swap up-take in Figure 3, which in turn provides evidence on the level of dollar shortages Q_t. In the limit $\overline{Q} \to 0$, dollar swaps up-take must satisfy the entirety of dollar shortages. Away from this limit, up-take is proportional to the total size of dollar shortages. . I restrict attention to the limit where $\tau^s = 0$, since this provides simplicity at little cost to economics.[16]

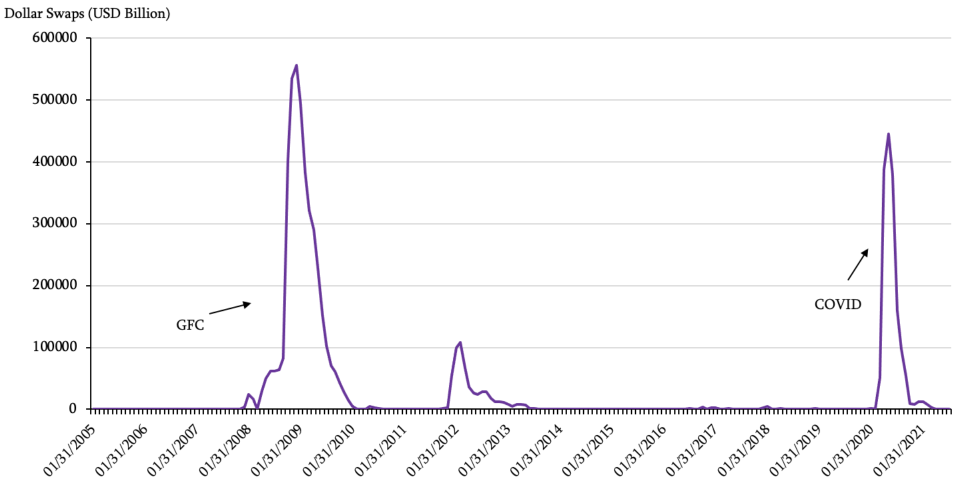


Figure 3: Weekly outstanding dollar swaps (Wednesday level). Source: Federal Reserve

2.3 Equilibrium and Macroeconomic Implications of Dollar Shortages

Simplifying assumptions. To maintain the tractability of the model and isolate the mechanisms of interest I make the following assumptions.

A.1 (World Interest Rates) *Foreign sector monetary policy is fully characterised by a constant R^* policy.*

[16]The model can be generalised to the case where the Fed earns a positive spread $\tau^s > 0$. In this case, an individual financier can choose to take position $\overline{Q}$ or $\overline{Q} + Q^s$. In the limit where all financiers take a position $\overline{Q} + Q^s$ and dollar swap lines are large $\frac{Q^s}{\overline{Q}+Q^s} \to 1$, the semi-elasticity of demand is $\Gamma_t = {\frac{1}{\overline{Q}+Q^s}}^2$, the relevant spread is $\frac{1}{R_t} - \frac{1}{R^*}\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} - \tau^s$ and the hegemon earns $\tau^s \overline{Q}^s \boldsymbol{\kappa}$ rents from extending the dollar swap.

A.2 (Cole-Obstfeld) *Unitary elasticity of substitution, unitary macro elasticity* $\sigma = \theta = 1$.

A.1 isolates the incentive of the hegemon to manipulate dollar imbalances, from the incentive to manipulate foreign prices. Generally, there are three channels through which the home country can manipulate its interest rate R_t: its size in financial markets, its size in goods markets and as a result of dominant currency pricing. This paper focuses on the first, rules out the second by assuming the hegemon is a small in goods markets and $A.1$ rules out the third channel.[17] A.2. is a utility specification frequently used in the literature since Cole and Obstfeld (1991), that lends tractability to the model but I relax this assumption in Section 5.

The next lemma summarises the condition required for an equilibrium. Note that for $\kappa^G < 1$, household and government budget constraints cannot be consolidated, breaking Ricardian equivalence, therefore (18) must be satisfied in addition to (4).

Lemma 2 (Implementability)
Given $\{\xi_t, \overline{Q}_t\}$*, a household allocation* $\{C_{H,t}, C_{F,t}, x_t, L_t\}$ *and a government allocation* $\{G_{H,t}, G_{F,t}, B_t, Q_t^s\}$ *with prices* $\{\mathcal{E}_t, R_t, W_t, P_{H,t}\}$*, taking* $\{C_t^*, R_t^*, P_{F,t}^*\}$ *as given, constitute part of equilibrium if and only if conditions* (5),(7), (9), (16), (18) *and* (23) *hold.*

Following the tradition in public finance, building on Lucas and Stokey (1983), I try to summarise the equilibrium using a small number of equations. Substituting Π_t and T_t into (4), using 9, the expression for T_t and (23) yields the consolidated household budget constraint:[18]

$$C_{F,t} \leq \mathcal{E}_t^{-\lambda}\Bigg\{\zeta\mathcal{E}_t^{\eta} + \mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R^*}x_t \quad \underbrace{-\Gamma_t Q_t(\xi_t - B_t)}_{\text{(a) Monopoly issuance rents (+ve)}} \quad \underbrace{-\Gamma_t Q_t^2(1-\omega)}_{\text{(b) Cost of segmentation } (-ve)}$$
$$-(x_{t-1} + \kappa^G B_{t-1}) + \left(\frac{\chi^G - \kappa^G}{1-\chi^G}\mathcal{E}_t^{\lambda} G_{F,t} + \kappa^G \hat{\Psi}_t(\mathcal{E}_t)\right)\Bigg\} \tag{27}$$

The first term on the right-hand side reflects total revenues earned from the export of goods. In a standard small-open economy model with frictionless markets, households earn $\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R^*}x_t$ from issuing new debt. Then, both terms (a) and (b) are zero since $Q_t = 0$. Instead, if there are dollar shortages, $Q_t < 0$, term (a) captures the positive rents from issuing dollar assets. Term (b) is a cost from segmentation that is positive as long as $\omega < 1$, i.e. profits from financiers

[17] For a recent analysis of (goods market) terms of trade manipulation see Costinot, Lorenzoni, and Werning (2014), and Lloyd and Marin, 2019 for an extension with trade taxes. Egorov and Mukhin (2019) show the U.S. can manipulate foreign prices and the foreign SDF, even if it is a SOE, under DCP and Corsetti, Dedola, and Leduc (2020) investigate optimal policy in large open economy with DCP.

[18] From (19), we can derive total profits accruing to the financial intermediation sector,

$$\Pi_t^f = \left(\frac{1}{R_t} - \mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*}\right)Q_t = \Gamma_t Q_t^2 \geq 0 \tag{26}$$

do not fully accrue to the hegemon country.[19] The final terms reflect the cost of repaying debt coming due, as well as income effects from public spending and a lump-sum rebate of due to the government portfolio of assets.

Using (16), the government budget constraint (18) can be rewritten as:

$$\frac{1-\kappa^G}{1-\chi^G}G_{F,t} \leq \mathcal{E}_t^{-\lambda}\left\{\frac{1}{R^*}\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}B_t - \Gamma_t Q_t B_t - (1-\kappa^G)(B_{t-1}-\hat{\Psi}_t)\right\}, \tag{28}$$

where $-\Gamma_t Q_t B_t$ reflects monopoly rents from issuance of government dollar debt. In the limit $\kappa^G = 1$, government spending is entirely tax financed, $B_t = 0$ and Ricardian equivalence holds.

Rents from issuance of dollar debt arise from both a dollar appreciation and a fall in the hegemon interest rate, as per (19). The relative adjustment of interest rates and the dollar is governed by monetary policy. If there is a dollar appreciation, this depresses export revenues $\zeta\mathcal{E}_t^\eta$ and leads to portfolio losses on foreign-currency denominated assets $\Psi_t^*\mathcal{E}_t$. In principle, there can be positive rents from dollar issuance without an appreciation of the dollar if interest rates adjust sufficiently. However, as I detail in Section 4, considering a dynamic environment, changes in R_t can lead to an inefficient allocation of resources over time for private agents (over-borrowing). Because of this, the monetary policy response does not efficiently stabilize the economy when faced with dollar shortages, leaving scope for dollar swaps.

2.4 Monopoly Rents, Monetary Policy and the Transfer Problem.

The hegemon benefits from a transfer of monopoly rents (akin to seignorage). Equations (27) and (28) show that the transfer of wealth from the rest of the world to the hegemon is $-\Gamma_t Q_t \xi_t - \Gamma_t Q_t^2(1-\omega)$ and $-\Gamma_t Q_t B_t$ accrues to the government. As the demand for dollars (ξ_t) rises, the borrowing cost spread grows (see (19)), contributing to larger rents. However, these rents are at least in part associated with an appreciation of the dollar which can have large adverse, secondary effects. At the crux of the trade-off is a version of the transfer problem, initially debated in Keynes (1929) and Ohlin (1929).[20]

Holding the level of borrowing $x_t + B_t$ constant, the size of monopoly rents does not depend on the monetary policy stance, i.e. the extent of the interest rate cut and dollar appreciation. Generally, however, interest rates only partly adjust, and the exchange rate appreciation (implied by (19)) leads to lower export revenues ($\frac{d\zeta\mathcal{E}_t^\eta}{d\mathcal{E}_t} > 0$) and losses on the portfolio of assets $\frac{d\hat{\Psi}_t}{d\mathcal{E}_t} > 0$. Next, in Section 3 I illustrate the trade-off between monopoly rents and the dollar appreciation for a given monetary policy stance. I show how public debt issuance and the extension of dollar swaps can be used to manage this. In Section 4, I show that because of private

[19] Similar terms appear in Fanelli and Straub (2018), who consider a real model and focus on FX interventions. Term (a) in Fanelli and Straub (2018) is an exogenous UIP (price) shock, whereas in my framework, it is the result of non-fundamental demand for dollar debt by foreign agents. They show that term (b) incentivizes the planner to pursue a policy path which smooths over interest rate differentials.

[20] Keynes argued that war reparations paid by Germany to France would impose further costs to the German economy in the form of adverse terms of trade movements, which Ohlin suggested would not materialise if the French spent the reparations on German goods. Relative to the initial debate, as well as the price movements, associated with a transfer, I emphasize the pecuniary externalities which result from them.

sector over-borrowing, the cut in interest rates is itself may not be optimal. Absent an optimal borrowing tax, second-best effects compromise the ability of monetary policy to balance the incentives above.

3 Analytical Hegemon's Dilemma

I first focus on a stylized, two-period version of the model. The aim of this section is to: (i) trace the channels through which dollar shortages matter for hegemon outcomes for a given monetary stance (ii) describe the instruments available, specifically public debt issuance and dollar swaps, and discuss why they are effective.

Setup. Consider a two-period version $t = \{0, 1\}$ of the model described in Section 2. I assume there is no issuance of new government debt in period 1 ($B_2 = 0$) and that the monetary authority credibly commits to an exchange rate $\mathcal{E}_2 = \overline{\mathcal{E}}$ in period 2. I further take private issuance of dollar debt as given.[21] At time 0, I normalize dollar supply, demand and imbalances to zero ($B_0 = \xi_0 = Q_0 = 0$) and $\Gamma_0 = \overline{Q}^{-2}$.

Monetary policy plays a key role in the mode of transmission of dollar shortages to hegemon allocations. To keep the analytical model simple, I define the monetary instrument $\mu_t = P_{F,t}C_{F,t} + P_H C_{H,t} = \mathcal{E}_t^{\lambda} C_{F,t} \frac{1}{1-\chi}$ such that $\frac{1}{R_1} = \beta \frac{\mu_1}{\overline{\mu}}$ as in, e.g, Corsetti and Pesenti (2001).[22] I allow μ_1 to depend on Γ_1 and Q_1 as follows:

$$\mu = \overline{\mu}(1 - s) + s\overline{\mu} \left(\frac{\beta^*}{\beta} - \frac{\Gamma_1 Q_1}{\beta} \right) \tag{29}$$

Rearranging (19) and substituting (29), the exchange rate in the model is expressed as:

$$\mathcal{E}_1 = \overline{\mathcal{E}} \left(\frac{\beta}{\beta^*} \frac{\mu_1}{\overline{\mu}} + \frac{\Gamma_1}{\beta^*} [B_1 + x_1 - \xi_1] \right) \tag{30}$$

The parameter s governs the responsiveness of monetary policy. Consider two extreme cases: (i) if $s = 0$, monetary policy maintains a constant interest rate and the adjustment happens entirely through a dollar appreciation (ii) if $s = 1$, monetary policy targets an exchange rate $\hat{\mathcal{E}}_t$ and the adjustment happens entirely through a cut in interest rates.

Objective function. I posit the hegemon planner optimizes over two main incentives, employment stabilization and maximization of monopoly rents.[23] Define the period-1 labour wedge τ_1 as,

$$\tau_1 = 1 - \frac{1}{A_1} \frac{\kappa}{\chi} C_{H,1} L_1^{\psi}, \tag{31}$$

[21] Private issuance can be allowed to take any value. I assume the level and responsiveness of x_t to be the outcome of a borrowing tax.

[22] In Appendix B, I show that μ is the return on a perpetual bond.

[23] This modelling choice is made for clarity and I make no claim that it maps to welfare optimization. However, when I solve for the welfare maximizing allocation in Section 4, I show that stabilization of the labour wedge is attained in the constrained optimal allocation.

The labour wedge is frequently considered in the literature as a measure of the output gap, see e.g. Chari, Kehoe, and McGrattan (2007), Farhi and Werning (2016), amongst others, and is equal to zero if prices are flexible such that (6) holds but is generally non-zero if prices are rigid. I define periods where $\tau_t > 0$ to be periods of *recession*, since there is involuntary unemployment in the economy and conversely periods where $\tau_t < 0$ as *boom* periods. Dollar shortages transmit to the labour wedge through two channels. First, the dollar appreciation reduces demand for exports leading to a fall in employment ($L_1 \downarrow$). Second, the monetary policy responds by cutting interest rates ($\mu_1 \uparrow$) according to the parameter $s > 0$ which stimulates domestic consumption ($C_{H,1} \uparrow$).

Next, define Ω_1^M as the *excess* revenue from issuance of dollar debt, adjusted for the hegemon's share of intermediaries' profits and returns on the government portfolio. The total revenue from debt issuance for the hegemon is $\frac{1}{R_1}B_1$. The revenue earned by a foreign country when issuing B_1 units of foreign-currency debt is $\frac{1}{R_1^*}B_1$ and, in dollar terms, is equal to $\frac{1}{R_1^*}\frac{\mathcal{E}_1}{\overline{E}}B_1$. From (19), the excess revenue from issuance of dollar debt, corrected for the profits from ownership of financiers is given by:

$$\Omega_1^M = -\Gamma_1 Q_1 B_1 + \omega \Gamma_1 Q_1^2 \tag{32}$$

As in Farhi and Maggiori (2016), I interpret the excess revenue as monopoly rents, which are an increasing function of foreign demand for dollar debt.

I posit the hegemon chooses public debt issuance in period 1 B_1 and the level of dollar liquidity $\Gamma = \frac{1}{\overline{Q}+Q_1^s}^2$, via issuance of dollar swaps Q_1^s, to maximize a convex combination over the two incentives:

$$\max_{\{B_1,\Gamma_1 \leq \overline{Q}^{-2}\}} \left\{ w^S \; |\overline{\tau} - \tau_1(B_1, \Gamma_1, \xi_1,)| + (1-w^S)\; \Omega_1^M(B_1, \Gamma_1, \xi_1) \right\} \tag{HD1}$$

where I make explicit the dependence of the period 1 labour wedge and monopoly rents on the supply of dollar debt B_1, (inverse) dollar liquidity Γ_1 and dollar demand ξ_1. The first term in (HD1) captures the incentive to stabilize the domestic economy at a target labour wedge $\overline{\tau}$. The second term in (HD1) reflects the incentive to maximize revenues from public debt issuance, ownership of financial intermediaries and returns on the government portfolio. The parameter w^S captures the preference for stabilization.

The first-order conditions for (HD1), with respect to B_1 and Γ_1 respectively (when the constraint does not bind), are given by,

$$\omega^S \text{sign}(\overline{\tau} - \tau_1)\frac{d\tau_1}{dB_1} + (1-\omega^S)\frac{d\Omega_1^M}{dB_1} = 0, \tag{33}$$

$$\omega^S \text{sign}(\overline{\tau} - \tau_1)\frac{d\tau_1}{d\Gamma_1} + (1-\omega^S)\frac{d\Omega_1^M}{d\Gamma_1} = 0, \tag{34}$$

where $\frac{d\tau_1}{dB_1}, \frac{d\Omega_1^M}{dB_1}, \frac{d\tau_1}{d\Gamma_1}, \frac{d\Omega_1^M}{d\Gamma_1}$ are reported in (91)-(94) in Appendix C.

Proposition 1 (Analytical Hegemon's Dilemma)
(i) Assume G_H is fixed. If monetary policy is sufficiently unresponsive ($0 < s < \overline{s}$), an increase in dollar shortages $Q_1 < 0$ widens the labour wedge and increases monopoly rents.
(ii) Consider the limit $w^S = 1$. The hegemon supplies dollar debt to satisfy demand $B_1 = \xi_1$ or extends dollar swaps such that $\Gamma_1 \to 0$ to perfectly stabilize employment. If $w^s = 0$, the hegemon chooses B_1 at the top of an issuance 'Laffer' curve and dollar swaps are not used $\Gamma_1 = \overline{Q}^{-2}$.
Proof. From (91) in Appendix C , the labour wedge is constant in dollar shortages if:

$$\overline{s} = \frac{\frac{\mu_1}{\mu}\zeta\eta\mathcal{E}^{\eta-1}\overline{\mathcal{E}}}{L_1^{\psi} + \mu_1\frac{\chi}{p_H} + \frac{\mu_1}{\mu}\zeta\eta\mathcal{E}^{\eta-1}\overline{\mathcal{E}}}$$

For $s < \overline{s}$ ($s \in [0,1]$) , i.e if monetary policy is less responsive, the labour wedge becomes positive if shortages arise $dQ < 0$. On the other hand, monopoly rents are strictly increasing in Q_1, see (93) as long as $s > 0$. Full proof in Appendix C. □

A surge in capital inflows results in an appreciation of the dollar as long as $s < 1$. Proposition 1 isolates two key channels which drive policy and academic debate –macroeconomic stabilization and monopoly (financial) rent extraction. Consider the case where the hegemon is only concerned with closing the labour wedge gap ($w^S = 1$), i.e a '*stabilization*' strategy. Following a rise in dollar demand $\xi_1 > 0$, when G_H is held constant (e.g. $\chi^G = 0$), this can be achieved using either instrument. The hegemon can choose public debt issuance B_1 such that for any level of dollar demand ξ_1, dollar shortages are zero $Q_1 = 0$ or the hegemon extends sufficient dollar swaps such that $\Gamma_1 \to 0$ and shortages do not imply any movement in the exchange rate.

However, the '*stabilization*' strategy comes at the cost of a lower price for dollar debt and lower monopoly rents. Suppose instead that $w^S = 0$, corresponding to a '*monopolist*' strategy. In this case, the hegemon issues dollar debt at the top of a Laffer curve $0 < B_1 < \xi_1$, detailed in Appendix C and targets a level of dollar shortages $Q_1 < 0$. Monopoly rents are strictly decreasing in dollar liquidity Γ_1 as long as there are dollar shortages $Q_1 < 0$ therefore dollar swaps are not used. For intermediate values of ω^S, the hegemon compromises between the two strategies. Figure 3 illustrates the locus of B_1, Γ_1 which maximize the hegemon's objective function in each of the two corner cases.

Finally, I use the stylized model to present two extensions which are important in the general framework – stabilizing effects from government spending and valuation effects.

Fiscal stabilization Proposition 1 assumes G_H is fixed, therefore fiscal spending cannot stabilize domestic employment. In this case, public debt issuance serves a purely macro-prudential role for domestic stabilization by satisfying dollar shortages. Next, consider the case where (16) such that $G_{H,1} = \chi^G[\frac{1}{R_1}B_1 - B_0]$.Then, Proposition 1 (i) still applies but $\overline{s}$ is replaced by:

$$\overline{s}' = \frac{\frac{\mu_1}{\mu}\zeta\eta\mathcal{E}^{\eta-1}\overline{\mathcal{E}}}{L_1^{\psi} + \mu_1\frac{\chi}{p_H} + \frac{\mu_1}{\mu}\zeta\eta\mathcal{E}^{\eta-1}\overline{\mathcal{E}} + \psi L^{\psi-1}\frac{\mu}{\mu}\frac{1}{p_H}\frac{\chi^G}{1-\chi^G}B_1}$$

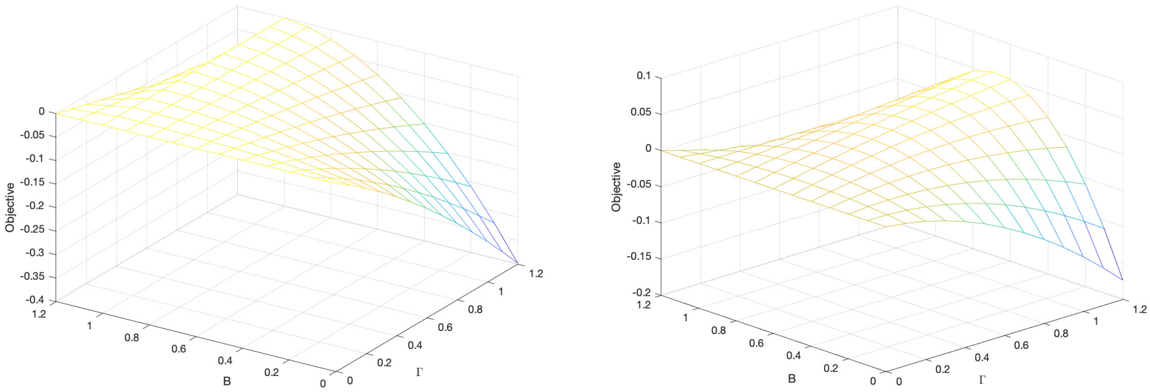


Figure 4: Left panel: $w^S = 1$ Stabilization strategy optimal. Right panel: $w^S = 0$ Monopolist strategy optimal. Parametrization: $s = 0.2, \kappa = \overline{\mu} = \overline{\mathcal{E}} = \zeta = \eta = \psi = 1$, $\chi = 0.6, \chi^G = 0, \beta = \beta^* = 0.99$.

where $\overline{s}' < \overline{s}$. Reconsider the *stabilization* strategy ($\omega^S = 1$). Relative to before, an additional unit of debt contributes to a larger increase in aggregate demand ($\frac{d\tau_1}{dB_1} < 0$ is larger in absolute value), as long as the hegemon is on the increasing part of the Laffer curve (see Appendix C). As a result, the level of debt issuance consistent with stabilization is lower than before $(B_1 < \xi_1)$ and a non-zero level of dollar shortages is desirable.

Exorbitant privilege vs. valuation effects. Monopoly rents represent a wealth inflow to the U.S. during crises, when demand for dollars is high. However, as emphasized by Gourinchas and Rey (2005), the return on the U.S. portfolio of assets falls during crises, leadfing to wealth outflows, due to a fall in the return of foreign (risky) assets and a dollar which undermines the dollar return on foreign-currency denominated assets. To consider both sides of the debate, the model encompasses valuation effects by assuming returns on an exogenous portfolio $\hat{\Psi}_1$, given by (17), which enters Ω_1^M. Allowing for $\chi^G > 0$, valuation effects matter for both stabilization and monopolistic motives. Proposition 1 (i) holds for $s \in (\underline{s}, \overline{s}'')$ where these quantities are reported in Appendix C. For all values of w^S, the hegemon has an incentive to depreciate the dollar, either by issuing debt or extending dollar swaps, since the a weaker dollar implies higher dollar earnings on the portfolio of foreign currency denominated assets.

The stylized model has a number of shortcomings. First, while it highlights a key role for the monetary policy rule, it does not pin it down. Moreover, (HD1) assumes that private issuance is constant, but in practice household debt contributes to dollar balances. In a dynamic model, Inefficient levels of private dollar debt issuance will constrain the ability of monetary policy to stabilize the economy, giving scope for dollar swap lines to improve welfare.

4 Constrained Optimal Allocation

I next consider the trade-offs which arise in the dynamic model and I derive welfare maximizing policy. I derive the constrained optimal allocation, attained when the hegemon is able to set monetary, fiscal and macroprudential policy optimally, where macroprudential policy takes the form of a time-varying tax on private borrowing.[24] The hegemon planner chooses allocations and prices to maximize *domestic household welfare only*, subject to the equilibrium conditions detailed in Lemma 2. I assume the planner is endowed with perfect commitment and I restrict the analysis to one-off unanticipated shocks.

The planning problem for the hegemon can be summarised as follows:[25]

$$\max_{\{C_{F,t}, x_{t+1}, \mathcal{E}_t, G_{F,t}, B_t\}_{t\geq 0}} \sum_{t=0}^{\infty} \beta^t V(C_{F,t}, G_{F,t}, \mathcal{E}_t) \tag{HD2}$$

$$\text{s.t:} \quad (27), (28)$$

I attach multipliers η_t^C and η_t^G respectively to the household and government constraints respectively. If the borrowing tax is not available, the planner also faces households' Euler (5) as a constraint, to which I attach multiplier η_t^E. The indirect utility function $V(C_{F,t}, G_{F,t}, \mathcal{E}_t)$ is given by,

$$\begin{aligned} V(C_{F,t}, G_{F,t}, \mathcal{E}_t) = \chi \log\left(\frac{\chi}{1-\chi}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H} C_{F,t}\right) + (1-\chi)\log(C_{F,t}) + \\ \omega^G \left[\chi^G \log\left(\tfrac{\chi^G}{1-\chi^G}\mathcal{E}_t^\lambda G_{F,t}\right) + (1-\chi^G)\log(G_{F,t})\right] - \\ \frac{1}{1+\psi}\left(\frac{1}{A_t}\left[\frac{\chi}{1-\chi}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H} C_{F,t} + \frac{\chi^G}{1-\chi^G}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H}(1-\chi)\tfrac{\zeta}{\overline{P}_H}\mathcal{E}_t^\eta\right]\right)^{1+\psi} \end{aligned} \tag{35}$$

I assume that the planning problem is convex in the region of interest such that the first-order conditions characterise the equilibrium allocation. Following Farhi and Werning (2016), I characterize the planner's preferred allocation as a function of partial derivatives of the indirect utility with respect to $C_{F,t}$ and $\mathcal{E}_t$ and $G_{F,t}$, denoted by $V_{C_{F,t}}, V_{E_t}, V_{G_{F,t}}$ respectively, and wedges.

I begin the analysis by defining a measure of over-borrowing by private households in the economy. To do so, I combine the first order conditiosn for the planner with respect to x_t and $C_{F,t}$, with the expression for $V_{C_{F,t}}$ detailed in Appendix D, and the Euler equation (5), in order to derive the optimal borrowing tax τ_t^x,

$$\tau_t^x = 1 - \frac{1 + \frac{\chi}{1-\chi}\tau_{t+1}}{1 + \frac{\chi}{1-\chi}\tau_t}(1 + \tau_t^\Omega) \tag{36}$$

[24] I distinguish between capital controls and a macroprudential borrowing tax, by assuming that the former would enter as a wedge in the UIP equation. Therefore, capital controls in the model would correspond to a tax on financiers.

[25] The full derivation of both the indirect utility function and the implementation constraints is presented in 4.

where $\tau_t^x < 0$ denotes a tax on household borrowing. By analogy to the labour wedge τ_t defined in (31), τ_t^Ω is the issuance wedge:

$$\tau_t^\Gamma = \frac{1}{R_t}\left[\frac{1}{R_t} - \Gamma_t x_t + 2\omega\Gamma_t Q_t\right]^{-1} - 1, \tag{37}$$

which captures the failure of atomistic private households to internalize the effect of their savings decision on the price of dollar debt. If $x_t > 0$, τ_t^Ω is positive as long as $\Gamma_t > 0$. The issuance wedge is decreasing in the share of financiers' profits accruing to the hegemon (ω), since dollar shortages lead to intermediation profits.

Proposition 2 (Over-borrowing by private agents)
Households over-borrow in dollar debt as long as:

$$1 - \tau^x = \frac{1 + \frac{\chi}{1-\chi}\tau_{t+1}}{1 + \frac{\chi}{1-\chi}\tau_t}(1 + \tau_t^\Omega) > 1 \tag{38}$$

and under-issue otherwise, where $\tau_t^x < 0$ denotes a borrowing tax.
Proof. See Appendix D. □

The optimal level of borrowing by hegemon households is determined by the interaction of two key frictions in the model– nominal rigidities and market segmentation. Consider first the case where prices are flexible or monetary policy finds it optimal to target the flexible allocation, such that the labour wedge is zero ($\tau_t = \tau_{t+1} = 0$). In this case, if $\tau_t^\Omega > 0$, households are over-borrowing only because of the issuance externality arising from market segmentation.

Suppose further that prices are rigid and the monetary authority responds to dollar shortages by lowering the interest rate sufficiently such that $\tau_t \leq \tau_{t+1} < 0$. Then, in addition to the issuance externality, private households are over-borrowing because they fail to internalize that the social value of a unit of $C_{F,t}$ tomorrow is higher due to its effects on employment. Notice that the two externalities which underlie the over-borrowing are dynamic versions of the incentives detailed in (HD1).

Over-borrowing matters in the conomy because it compromises the ability of other policy instruments to stabilize the economy. To measure this, consider the multiplier on the Euler equation denoted by η_t^E,

$$\eta_t^E = \left\{\Gamma_t \frac{1}{\mathcal{E}_t^\lambda C_{F,t}}\right\}^{-1}\left\{\beta\eta_{t+1}^C\mathcal{E}_{t+1}^{-\lambda} - \eta_t^C\mathcal{E}_t^{-\lambda}\left[\frac{1}{R_t} - \Gamma_t x_t + 2\omega\Gamma_t Q_t\right] + \eta_t^G\mathcal{E}_t^{-\lambda}\Gamma_t B_t\right\} \tag{39}$$

derived from the first-order condition of (36) with respect to x_t. The multiplier is greater than zero whenever households are over-borrowing ((38) holds). Intuitively, the multiplier on the Euler is positive ($\eta_t^E > 0$) when the value of a unit of consumption tomorrow (η_{t+1}^C) is relatively high because the level of consumption tomorrow is relatively low.

Monetary policy. In open economies, monetary policy faces a well-understood trade-off between macroeconomic stabilisation and risk sharing incentives. With flexible exchange rates monetary policy can target the flexible price allocation ($\tau_t = 0$). Generally, however, when markets are incomplete, monetary policy does not target $\tau_t = 0$ because of the incentive to depreciate to lower the burden of debt (in which case $\tau_t < 0$), see e.g Farhi and Werning (2016). The planner also has an incentive to appreciate the exchange rate such that the price of imports per unit of labour falls (in which case $\tau_t > 0$).

Combining the first-order conditions with respect to $\mathcal{E}_t$ and $C_{F,t}$ with $V_{\mathcal{E}_t}$ yields a targeting rule for monetary policy,

$$V_{\mathcal{E}_t} + \eta_t^C \frac{dC^*_{H,t}}{d\mathcal{E}_t} + \left\{\eta_t^C \frac{dF_t}{d\mathcal{E}_t} + \eta_{t-1}^C \frac{dF_{t-1}}{d\mathcal{E}_t}\right\} + \left\{\eta_t^G \frac{dF_t^G}{d\mathcal{E}_t} + \eta_{t-1}^G \frac{dF_{t-1}^G}{d\mathcal{E}_t}\right\} + \left\{\eta_t^E \frac{d\mathcal{R}_t}{d\mathcal{E}_t}\right\} + \left\{\eta_{t-1}^E \frac{d\mathcal{R}_{t-1}}{d\mathcal{E}_t}\right\} = 0, \tag{40}$$

where $C^*_{H,t}$ denotes foreign demand for exports, F_t denotes the households' financial position, F_t^G denotes the government's financial position and $\mathcal{R}_t$ is the implicit formulation of the Euler equation (5).[26] Each term is detailed in Appendix D.

When macro-prudential policy is available ($\eta_t^E = \eta_{t-1}^E = 0$), the monetary policy targetting rule faces familiar trade-offs. The partial derivative $V_{\mathcal{E}_t}$ captures the increase in utility from a depreciation, which balances the positive effect of an increase in consumption for home goods as they become relatively cheaper, and the negative effect that households work relatively more. The remaining terms reflect the costs of a depreciation captured by the constraints faced by the planner. The first term ($\frac{dC^*_{H,t}}{d\mathcal{E}_t} > 0$) captures the rise in export revenue expressed in terms of imports. The risk sharing incentive of monetary policy depends on the level of issuance $\{x_t, B_t\}$ and the level of dollar demand $\{\xi_t\}$. If pass-through to import prices is non-zero ($\lambda > 0$), monetary policy has an incentive to depreciate debt coming due ($\frac{dF_t}{d\mathcal{E}_t}$), although this effect is anticipated by investors, captured by the ($\frac{dF_{t-1}}{d\mathcal{E}_t}$) term.

The term $\frac{dF_t}{d\mathcal{E}_t}$ also accounts for the effect of a exchange rate movements on the monopoly issuance rents and the returns on the government portfolio of assets. Since issuance rents are denominated in dollars an appreciation increased the amount of imports they can buy. However, the appreciation lowers the return on the government portfolio of foreign-currency denominated assets, therefore monetary policy must strike a balance. The terms ($\frac{dF_t^G}{d\mathcal{E}_t}$) and ($\frac{dF_{t-1}^G}{d\mathcal{E}_t}$) deal with the same portfolio incentives, but on the government portfolio.

Absent macro-prudential policy, the ability of monetary policy to stabilize the economy when there are dollar shortages is compromised.When there is over-borrowing in the economy as reflected by$\eta_t^E > 0$, hegemon monetary policy faces an additional incentive to raise interest rates to encourage households to borrow less– partly internalizing the over-issuance. Intuitively, the appreciated exchange rate tries to shift consumption to the future by driving the relative

[26] Specifically,

$$\mathcal{R}_t = \beta R_t \mathcal{E}_{t+1}^{-\lambda} C_{F,t+1}^{-1} - \mathcal{E}_t^{-\lambda} C_{F,t}^{-1}. \tag{41}$$

cost of current consumption R_t up, captured by $\frac{d\mathcal{R}_t}{d\mathcal{E}_t} < 0$.[27] However, this appreciation further depresses export demand and lowers the dollar return on foreign currency assets.

4.1 Hegemon's Dilemma Revisited

Given the optimal monetary policy, and having defined a measure of over-borrowing in the economy, I revisit the choice of the hegemon to extend dollar swaps and issue debt.

Dollar Swaps. I now endow the hegemon with the ability to extend dollar swap lines $Q^s > 0$ to financial intermediaries, easing portfolio constraints and increasing dollar liquidity in international markets ($\Gamma = (\overline{Q} + Q^s)^{-2} < \overline{Q}^{-2}$). In practice, the hegemon establishes dollar swap lines (with a high or no ceiling) *in anticipation* of dollar shortages, and their up-take is determined by financial intermediaries according to (25). To illustrate the mechanisms driving the hegemon's policy choice, in this section, I assume the hegemon can indirectly choose the level of liquidity period by period.

Consider the first order condition of (HD2) with respect to Γ_t :

$$\underbrace{-\eta_t^C \mathcal{E}_t^{-\lambda}(Q_t x_t + 2\omega Q_t^2) - \eta_t^G \mathcal{E}_t^{-\lambda} B_t Q_t}_{\text{cost of foregone issuance rents}} \quad = \quad \underbrace{\eta_t^E \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}} Q_t}_{\text{cost of over-borrowing}} \tag{42}$$

The left hand side of (42) represents the marginal cost of increasing liquidity by one unit. Suppose there are dollar shortages ($Q_t < 0$). Increasing dollar liquidity erodes monopoly rents from issuance of dollar debt by households and the government, since intermediaries can now issue dollars at a lower cost.

The right hand side of (42) captures the marginal (social) benefit of increasing liquidity by one unit. Dollar swaps affect the interest rate and therefore the allocation of private sector borrowing over time. Increasing liquidity by one unit, when there are dollar shortages, raises the cost of borrowing through a lower exchange rate premium ($|\Gamma_t Q_t|$ falls), improving welfare when private agents are over-borrowing ($\eta_t^E > 0$). Instead, if the optimal borrowing tax were available, private borrowing would be at an optimal and $\eta_t^E = 0$. In that case, the net marginal benefit of issuing dollar swaps is the model is negative and the constraint $Q^s \geq 0$ binds.

Proposition 3 (Dollar Swaps)
Suppose there are dollar shortages and the hegemon is borrowing. Dollar swaps address over-borrowing in the economy at the cost of lower monopoly rents from issuance. Dollar swaps are never used if an optimal borrowing tax is available.

While dollar swaps are an imperfect substitute to macro-prudential taxation for adressing internal objectives in the hegemon, the two policies lead to very different outcomes interna-

[27] This mechanism extends the 'insurance channel' of monetary policy discussed in Caballero and Krishnamurthy (2004), Fanelli (2017) and Wang (2019).

tionally. While the optimal borrowing tax restricts private sector issuance resulting in larger dollar shortages and a wider spread in borrowing costs, the provision of dollar swaps narrows the spread in borrowing costs for any level of shortages. In the special case where the only shocks in the economy are shocks to dollar demand ξ_t, extending dollar swap lines is sufficient to achieve full stabilization if $Q^s \to \infty$.

Public debt issuance. I next investigate whether fiscal policy can be used in place of dollar swaps, as in the simple example (HD1). Consider first the optimal level of debt issuance by the hegemon, described by the FOC with respect to B_t:

$$\eta_t^G \mathcal{E}_t^{-\lambda} \frac{1}{R_t} = \beta \eta_{t+1}^G \mathcal{E}_{t+1}^{-\lambda}(1-\kappa^G) + \beta \eta_{t+1}^C \mathcal{E}_{t+1}^{-\lambda} \kappa^G + \tag{43}$$
$$\Gamma_t \left\{ \eta_t^G \mathcal{E}_t^{-\lambda} B_t + \eta_t^C \mathcal{E}_t^{-\lambda}(x_t + 2\omega Q_t) \right\} - \eta_t^E \Gamma_t \frac{1}{\mathcal{E}_t^{-\lambda} C_{F,t}}$$

The first line of (43) compares the benefit of a unit of debt issued today (LHS) against the cost of a foregone unit of government spending and taxation tomorrow (RHS). The optimality condition determines level of public debt issuance which trades-off stabilization incentives (smoothing government spending and aggregate demand) and monopolist incentives (manipulating the price of dollar debt). The incentive to smooth spending is captured by the path of $\{\eta_t^G\}$, given by,

$$\eta_t^G \frac{1-\kappa^G}{1-\chi^G} = V_{G_{F,t}} - \eta_t^C \frac{\kappa^G - \chi^G}{1-\chi^G} \tag{44}$$

whereas the incentive to smooth taxation is reflected by the marginal value of private consumption η_{t+1}^C. The novel part of the analysis is the incentive to manipulate dollar imbalances using public debt, captured by the second line. Consider the limit ($\chi^G = \kappa^G = \omega^G = 0$), in which case $V_{G_{F,t}} = 0$ and dollar debt issuance is not driven by fiscal motives. Rearranging (43) yields:

$$\eta_t^E \Gamma_t \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}} = \Gamma_t \left\{ \eta_t^C \mathcal{E}_t^{-\lambda}(x_t + 2\omega Q_t) \right\} \tag{45}$$

If the optimal borrowing tax is available, $\eta_t^E = 0$. Optimal public debt issuance targets the same allocation, but must additionally account for the reaction of private issuance x_t, and its effect on financiers profits. In this case, fiscal policy can be used as an alternative to dollar swaps and macro-prudential taxation.

However, away from this limit, optimal public debt issuance trades off fiscal incentives and financial terms of trade manipulation. In particular, $V_{G_{F,t}}$ will rise in periods where the government balance sheet worsens (such as domestic downturns), dominating the incentive to issue debt monopolistically. Consequently, the hegemon will be unable to manipulate dollar shortages directly without a large cost. This leaves scope for dollar swaps, which affect the level of dollar liquidity, to become a key instrument during crises.

4.2 Policy Constraints.

Monetary and macro-prudential policies can be very effective in mitigating the trade-offs faced by the hegemon and minimizing the need for dollar swap lines. In practice, however, these instruments are often unavailable or constrained. Throughout this section, I have maintained that optimal macro-prudential taxation is not generally available. In addition to this, over the past decade, interest rates have hovered around the zero lower bound (ZLB) and have therefore been largely unresponsive to shocks. To model unresponsive monetary policy, suppose,

$$\mathcal{E}_t^{\lambda} C_{F,t} = \mu_t(1-\chi), \tag{46}$$

where μ_t is a synthetic monetary instrument, detailed in Appendix A. When μ grows at a constant rate, (46) ensures nominal interest rates R_t are constant in the absence of macro-prudential policy. I attach multiplier η_t^{μ} to the monetary policy constraint (46) and define a corresponding monetary wedge:

$$\tau_t^{\mu} = \frac{C_{F,t}^{-\sigma} + \eta_t^{\mu}}{C_{F,t}^{-\sigma}} - 1 \tag{47}$$

If monetary policy is constrained, the dollar appreciation leads to a recession today ($\tau_t < \tau_{t+1}$). While a high level of issuance today, ceteris-paribus, increases $C_{F,t}$ and stimulates domestic demand when it is depressed, each additional unit of $C_{F,t}$ is associated with a dollar appreciation which further depresses domestic demand for $H-$ type goods. The latter channel becomes stronger if pass-through to U.S. imports (λ) is low. An adjusted version of Proposition 2 applies which shows that the efficient level of borrowing in the economy falls if monetary constraints are sufficiently binding. Private agents over-issue dollar debt if:

$$\frac{1 + \frac{\chi}{1-\chi}\tau_{t+1} - \tau_{t+1}^{\mu}}{1 + \frac{\chi}{1-\chi}\tau_t - \tau_t^{\mu}}(1 + \tau_{t+1}^{\Gamma}) > 1, \tag{48}$$

and under-issue otherwise. Specifically, if $C_{F,t} > C_{F,t+1}$ because of monopoly issuance rents, then $\tau_t^{\mu} > \tau_{t+1}^{\mu}$ and η_t^{E} will be higher. In this case, the marginal social benefit of increasing dollar swaps rises.

Lemma 3 (Dollar swaps when monetary policy is constrained)
The level of over-borrowing in the economy rises if monetary policy is constrained and $C_{F,t} > C_{F,t+1}$. The social value of dollar swaps rise.

4.3 Limited Financial Market Participation

In this section, I extend the model to allow for limited financial market participation. I show that if a share of households does not participate in financial markets, dollar shortages in international markets have distributional consequences for in the hegemon.

Extending the basic model. There are to types of households. Financially-active households trade in a domestic currency, non-contingent bond with financial intermediaries. I denote active household quantities by an $'A'$ superscript and the measure of financially active households is exogenously given by $\mathbf{a}_t$. Financially inactive households, have allocations denoted by an $'NA'$ superscript, and consume their wages and profits in every period.[28] I make the following assumptions to extend the basic model to the case of limited financial market participation.

A.3 (Limited Financial Market Participation)

(*i.*) Labour is rationed equally when the economy is demand constrained: $L_t^A = L_t^{NA}$.

(*ii.*) Profits from goods' firms Π_t^g and lump-sum tax rebates T_t accrue equally amongst all households

(*iii.*) Profits from ownership of financial firms Π_t^f are rebated exclusively to active households.

A full exposition of the model is delegated to Appendix E. Here, I detail some key features of the model. Financially active households trade in complete markets domestically, therefore:

$$\frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}^A} = \beta R_t \frac{1}{\mathcal{E}_{t+1}^{\lambda} C_{F,t+1}^A}, \tag{49}$$

Only active household allocations appear in the Euler condition. Inactive households consume their wages in each period, and a representative inactive household can be considered because of the absence of idiosyncratic risks. Goods market clearing is given by $Y_{H,t} = \mathbf{a}_t C_{H,t}^A + (1-\mathbf{a}_t) C_{H,t}^{NA} + C_{H,t}^*$. Individual households' consumption depends on the measure of active households through prices R_t and $\mathcal{E}_t$ because dollar shortages are given by,

$$Q_t = \alpha_t x_t + B_t - \xi_t \tag{50}$$

Moreover, since $\mathbf{a}_t$ determines the size of the country in financial markets, the financial externality, measured by τ^{Ω}, is increasing with $\mathbf{a}_t$.

Proposition 5 (Dollar Shortages and Redistribution)

[28] In the literature, these households are often referred to as *hand-to-mouth*, see Aguiar et al. (2015) for an empirical investigation. Alvarez, Atkeson, and Kehoe (2002) and Alvarez, Atkeson, and Kehoe (2009) study models of endogenous financial market segmentation based on fixed costs, analogous to the problems faced by financial intermediaries in Section 3 Kollmann (2012) and Cociuba and Ramanarayanan (2017) study limited financial market participation in open economies.

Consumptions of individual active and inactive households are given by,

$$C^A_{F,t} \leq \mathcal{E}_t^{-\lambda}\Bigg[\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G - \kappa^G}{1-\chi^G}P_{F,t}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}) \tag{51}$$

$$+(1-(1-\mathbf{a}_t)\chi)\left(\frac{1}{R^*}\frac{\mathcal{E}_t}{\mathbb{E}_t[\mathcal{E}_{t+1}]}x_t - x_{t-1} - \Gamma_t Q_t x_t + \frac{\omega}{\mathbf{a}_t}\Gamma_t Q_t^2\right)\Bigg],$$

$$C^{NA}_{F,t} \leq \mathcal{E}_t^{-\lambda}\Bigg[\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G - \kappa^G}{1-\chi^G}P_{F,t}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}) \tag{52}$$

$$+\mathbf{a}_t\chi\left(\frac{1}{R^*}\frac{\mathcal{E}_t}{\mathbb{E}_t[\mathcal{E}_{t+1}]}x_t - x_{t-1} - \Gamma_t Q_t x_t + \frac{\omega}{\mathbf{a}_t}\Gamma_t Q_t^2\right)\Bigg],$$

respectively. Labour, rationed equally across households, is given by,

$$L_t = \frac{1}{A_t}\frac{1}{P_{H,t}}\frac{\chi}{1-\chi}\left\{\zeta\mathcal{E}^{\eta-\lambda} + \frac{\chi^G - \kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}) + \mathbf{a}_t\left(\frac{1}{R_t}x_t - x_{t-1} + \tfrac{\omega}{\mathbf{a}_t}\Gamma_t Q_t^2\right)\right\} \tag{53}$$

In equilibrium, monopoly issuance rents accrue disproportionately to active households if $\chi < 1$.

Under $A.3(i)$, export revenues contribute equally to both active and inactive households' consumption, but monopoly rents disproportionally accrue to financially-active households as long as $\chi < 1$, i.e. active households spend a share of their rents abroad.Active households partly spend monopoly rents on domestic goods, contributing to domestic demand and boosting inactive household consumption but less than one to one. The set-up above resembles a two agent model as in Bilbiie (2020) and Auclert et al. (2021). In these models a spending multiplier arises, equal to $\frac{1}{1-(1-\alpha)}$, where $1-\alpha$ is the measure of hand-to-mouth households. In open economies, financially active households spend a share $1-\chi$ income on foreign goods, so the multiplier becomes $\frac{1}{1-(1-\alpha)\chi} < \frac{1}{1-(1-\alpha)}$. These distributional effects arise because markets are incomplete domestically. Allowing for redistributive taxes (ruled out by A.3 (iii)) or domestically complete markets ($\mathbf{a} = 1$), then $C^A_{F,t} = C^{NA}_{F,t}$.

Optimal policy with limited financial market participation. I denote the indirect utility function with limited financial market participation by $V(C^A_{F,t}, C^{NA}_{F,t}, G_{F,t}, \mathcal{E}_t; \boldsymbol{\lambda}, \mathbf{a}_t)$, where $\boldsymbol{\lambda} = [\lambda^A\ \lambda^{NA}]$ are Pareto weights with $\mathbf{a}_t\lambda^A + (1-\mathbf{a}_t)\lambda^{NA} = 1$. The planning problem is given by,

$$\max_{\{C^A_{F,t}, C^{NA}_{F,t}, \mathcal{E}_t, G_{F,t}, B_t, x_t\}} \mathbb{E}_t \sum_{t=0}^{\infty} V(C^A_{F,t}, C^{NA}_{F,t}, G_{F,t}, \mathcal{E}_t; \boldsymbol{\lambda}, \mathbf{a}_t)$$

$$\text{s.t.} \qquad (28), (51), (52), (18)$$

I detail the indirect utility function, the conditions governing the planner's allocation in Appendix E. Here, I summarise the key implication of limited financial market participation in the hegemon. When a measure of households does not actively participate in financial markets, the optimal borrowing tax is given by:[29]

$$1 - \tau_t^x = \frac{1 + \frac{\chi}{1-\chi}\tau_{t+1}^A + \delta_{t+1}^{NA}}{1 + \frac{\chi}{1-\chi}\tau_t^A + \delta_t^{NA}} \tag{54}$$

where $\delta_t^{NA} = \frac{(1-\mathbf{a})\chi}{1-(1-\mathbf{a})\chi}\left(1 + \frac{\chi}{1-\chi}\tau_t^{NA}\right)\frac{C_{F,t+1}^A}{C_{F,t+1}^{NA}}$. Since inactive households cannot smooth their consumption using financial assets, the inactive labour wedge rises by more, on impact, following an appreciation ($\tau^N A_t > \tau_t^A$), in part because inactive consumption falls by more $C_{F,t}^{NA} > C_{F,t}^A$. Consequently, the amount each active household over-borrows is higher when there is limited financial market participation.

5 Numerical Exercise

In this section I calibrate the model in steady state to key features of the U.S. economy in 2008Q1. I then simulate a realistic shock to dollar shortages and trace its macroeconomic effects. First, I assess the effectiveness of monetary policy, with and without an optimal borrowing tax. Then, I evaluate the welfare outcomes for active and inactive households, highlighting the distributional consequences of dollar shortages and the policy dilemma they present. Finally, I investigate the driving forces in the model: how large are the monopoly rents earned from issuance of dollar debt, by how much do export revenues fall and how large are the losses on a portfolio of foreign assets.

Calibration. The calibration is quarterly. I choose $\beta = \beta^* = 0.99$ based on an annual natural interest rate of about 4%. I choose a CRRA coefficient $\sigma = 1.5$ and an elasticities of substitution across domestic and imported goods θ of 2.5 consistent with RBC literatature estimates. Similarly, I set the Frisch elasticity ψ of substitution to 2.5 and choose κ to target a steady-state labour supply of two-thirds.[30] I choose $\chi = \chi^G = 0.8$ and $\omega^G = 0.5$ such that government spending to GDP $PG/P_H Y_H = 0.3$ and $P_H C_H^*/P_H Y_H = 0.15$, consistent with data from the Bureau of Economic Analysis. I choose an export demand elasticity $\eta = 2.5$.

To generate realistic values for monopoly rents in the U.S. economy, I target both the outstanding size of debt and the conditional response of the borrowing cost spread during crises. I choose steady-state demand for dollars ($\bar{\xi} = 0.8$) to match a net foreign asset position of 10% of U.S. GDP, see Appendix A.[31]I choose $\frac{1}{Q}^2 = 0.14$, based on an internal calibration such that a 1% change in dollar shortages to U.S. GDP on impact, leads to about a 2% appreciation for the dollar holding R_t constant. This is consistent with evidence of FX dollar swaps vis-a-vis Brazil as identified in Kohlscheen and Andrade (2014) and is comparable to the calibration in Fanelli and Straub (2018).[32] Finally, to target the size of the losses on the U.S. portfolio arising

[29]The derivation follows the proof to Proposition 1, using (51) and (52).

[30]See e.g Valchev (2020), Eichenbaum, Johannsen, and Rebelo (2020).

[31]Note that dollar shortages are always zero in steady-state (consistent with low unconditional ERRP (about 0.5% in the data over the sample) and so steady state values for monopoly rents in the model are zero.

[32]This is a calibration for dollar liquidity in times of crises, and Γ is likely to be lower outside of crises.

due to a dollar appreciation valuation effects, I calibrate the exogenous government portfolio Ψ to be consist of 140% GDP in domestic currency liabilities which carry a retun of 4% and 140% of foreign-currency denominated assets also yielding 4%, consistent with data from the BEA.

Parameter	**Value**	**Description**	Target
$\beta = \beta^*$	0.99	Discount factor, quarterly calibration	4% annual interest
σ	1.5	Coefficient of relative of risk aversion (A.1)	RBC
θ	2.5	Macro elasticity of substitution (A.1)	RBC
ψ	2.5	Frisch elasticity of labour supply	RBC
ζ	1	Size of foreign economy	Normalisation
η	2.5	Elasticity of export demand	RBC
κ	6	Disutility from labour	RBC
$P_F^* = 1$	1	Price of foreign goods	Normalisation
$\omega = 0$	0	Home ownership of financiers	
κ^G	0.9	Share of tax- financing	
$\chi = \chi^G$	0.85	Share of Home goods	$\frac{X}{Y} = 13\%$
ω^G	0.5	Share of utility from public goods	$\frac{G}{Y} = 30\%$
λ	0.2	Pass-through for U.S. imports	Matarazzi et al. (2019)
$\overline{\xi}$	1	Mean demand shock	10% nfa
$\overline{\Gamma}$	0.14	Elasticity of financiers' demand	$\frac{d\mathcal{E}}{dQ} = 2$
$\Psi = \Psi^*$	0.45	Government portfolio	BEA
α	0.3	Share of inactive households	SCF

Table 1: Benchmark Model Calibration. RBC refers to a standard parameter value taken from the literature.

5.1 Dollar demand shock.

The analysis focuses on a shock to dollar demand by foreign agents ξ_t. I assume the dollar shock follows an AR(1) process with quarterly persistence 0.85, such that dollar shortages last about 4 quarter, see Fig. 5 (left panel). This is consistent with the experience of the U.S. during the GFC. Furthermore, I choose the size of the dollar demand shock ξ to result in an exchange rate appreciation (on impact) of about 7% if interest rates are held constant, see Fig. 5 (right panel). The implied size of the dollar demand shock is about 7% of U.S. GDP.[33]

Monetary Policy. Figure 6 contrasts the effects of a dollar demand shock on allocations and prices in the hegemon, and shortages abroad, if interest rates are held constant (46) and if monetary policy is set optimally according to (41). In both cases, the demand shock $\xi_t > 0$ leads to an excess demand for dollars ($Q_t < 0$). The middle panel illustrates exchange rate and interest rate movements under the two monetary regimes, expanding on Fig. 5. The hegemon

[33]McGuire and Peter (2009) find that European bank's dollar shortfall (the biggest counterparty for the U.S. in terms of dollar swap lines) at the onset of the GFC was about $1 - 1.2$ trillion, or roughly 7-8% of U.S. GDP in 2007, so the size of the dollar shock implied by the model is resonable. Adrian and Xie (2020) show that the dollar asset share of non-U.S. banks is a good proxy for dollar demand, and co-moves with the dollar.

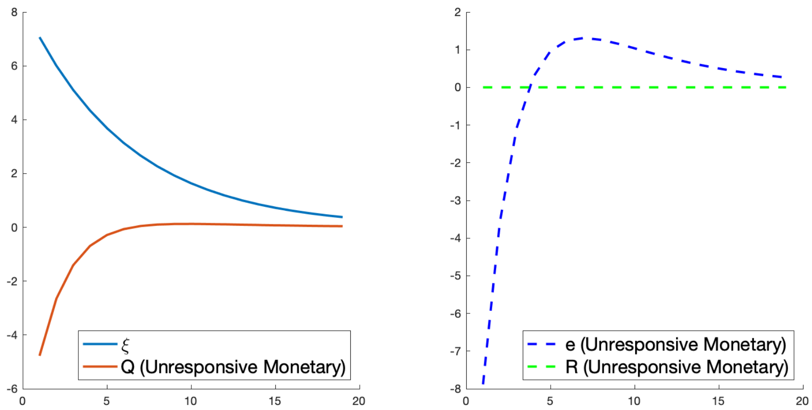


Figure 5: Impulse response to dollar demand shock ξ_t. Left panel: Dollar demand shock dollar shortages expressed in % of U.S. GDP. Right panel: Exchange rate appreciation in % deviations from steady state.

optimally lowers interest rates such that a smaller dollar appreciation is required to satisfy financiers' optimality condition (19), mitigating the trade-offs discussed extensively in Sections 2.4 and 3.

The right panel illustrates the response of the average labour wedge. If when interest rates are held constant, the demand shock leads to a domestic recession ($\tau_t > 0$). This outcome is driven by a fall in the demand for exported goods and a fall in public spending due to portfolio losses, both driven by the dollar appreciation. Instead,if interest rates respond optimally, the hegemon experiences a temporary boom ($\tau_t < 0$), although a recession follows after about 6 quarters.[34] As reflected in the monetary policy targeting rule (107), absent a borrowing tax, the monetary authority accepts a degree of externally induced employment volatility and private sector over-borrowing.[35]

Finally, notice that dollar shortages are more prevalent and more persistent when monetary policy is optimally set. This is because households face a smaller recession (or boom) and therefore borrow less in foreign markets. The spread in the cost of borrowing in dollars as opposed to foreign currency amounts to $4-5\%$ on impact, plotted in Appendix F, consistent with the quarterly average of the fall in borrowing costs of the U.S. during periods of global distress.

Since only a measure $\mathbf{a} < 1$ of households in the hegemon participate in financial markets in any given period, dollar shortages have heterogeneous effects on the two groups of households within the hegemon. Building on the Section 4.3, Fig. 7 contrasts the impulse response of the labour wedge for financially active and inactive households when monetary policy is set optimally and when interest rates are held constant. Under both regimes, inactive households experience involuntary unemployment, but the effect is significantly stronger when interest rates

[34]Kekre and Lenel (2020) study a fully fledged New-Keynesian model where monetary policy follows a Taylor rule. In their calibration, the U.S. experiences a recession following a capital inflow shock.

[35]Appendix F illustrates the impulse response for the multiplier η_t^E on the Euler, where as positive value reflects private sector over-borrowing, see Proposition 1.

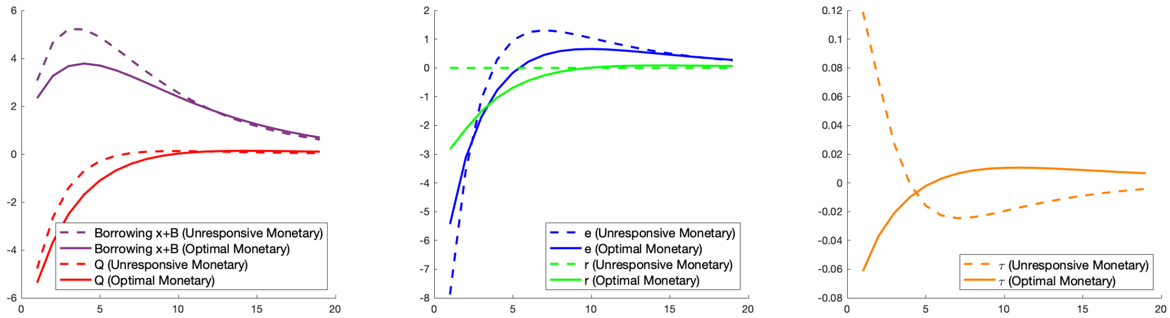


Figure 6: Impulse response to dollar demand shock ξ_t Comparison of optimal monetary (solid line) policy vs. passive monetary policy (dashed line). Left Panel: Sum of private and public borrowing expressed as % GDP in deviations from steady state. Middle panel: Exchange rate and interest rate movements expressed in % deviations from steady state. Right panel: Labour wedge deviations.

are constant. On the other hand, active households experience involuntary unemployment only if interest rates are held constant, and are overworked otherwise.[36]

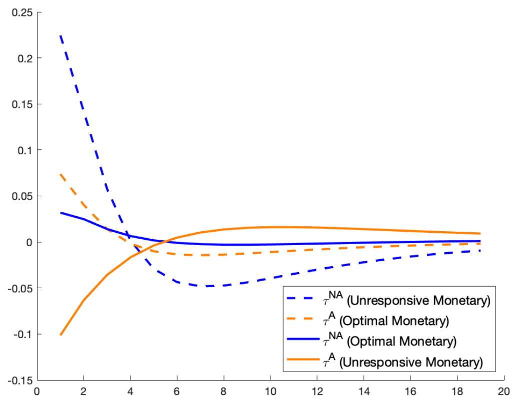


Figure 7: Impulse response to dollar demand shock ξ_t. Labour wedge deviations.

Constrained Optimal Allocation and Monetary Policy Trade-offs. Consider now the constrained optimal allocation which is achieved by the combination of monetary policy and a borrowing tax. At the constrained optimum allocation, the interest rate cut is larger (5% vs. 3%), lowering the pressure on the exchange rate to appreciate, as illustrated in Fig. 8 (middle panel).

Monetary policy is able to achieve this because the borrowing tax addresses private sector over-borrowing. The left panel shows that total borrowing falls and, as a result, dollar shortages are larger and more persistent. Yet the exchange rate appreciation on impact is smaller because

[36]Since by assumption A.3(i), labour is rationed uniformly, this result reflects that active households consumption rises whereas inactive households' consumption falls. See Appendix F.

of the interest rate cut. Together, these effects imply the aggregate labour wedge is almost fully stabilized, there is no temporary boom followed by a future recession. At the constrained optimal, the planner no longer accepts externally induced employment instability.[37]

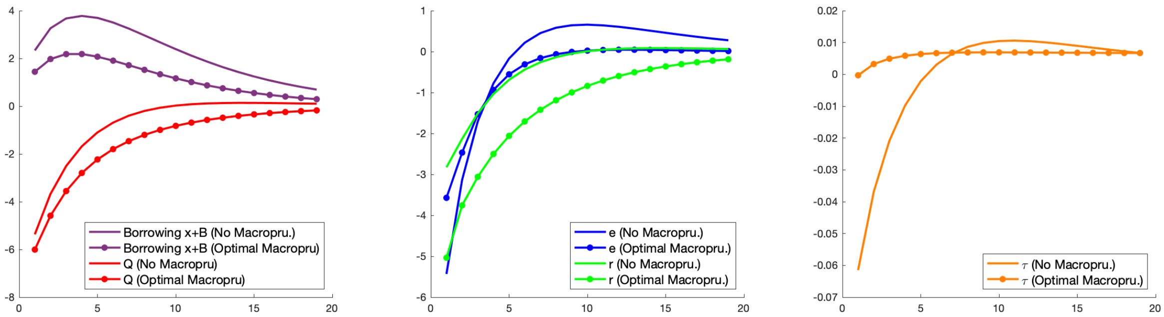


Figure 8: Impulse response to $\xi^* > 0$. Comparison of optimal macropru (rivetted line) vs. no macropru.(solid line). Left Panel: Sum of private and public borrowing expressed as % GDP in deviations from steady state. Middle panel: Exchange rate and interest rate movements expressed in % deviations from steady state. Right panel: Labour wedge deviations.

5.2 Driving mechanisms.

Recapping the main mechanisms in the paper: dollar shortages abroad lead to a dollar appreciation and a fall in interest rates in the U.S. This has three key implications driving the macroeconomic outcomes and trade-offs in the model. First, a dollar appreciation depresses demand for exports and leads to involuntary unemployment in the presence of nominal rigidities. Second, the combination of an appreciation and a lower U.S. interest rate results in a lower cost when borrowing in dollars, giving rise to monopoly rents from issuance. Third, a dollar appreciation leads to large wealth transfers from the U.S. to the rest of the world due to the currency composition of the U.S. portfolio.

The calibration does a good job capturing the transfer of wealth from the hegemon, to the foreign sector due to valuation effects, which amount to $6-8\%$, entirely due to an exchange rate appreciation and are negative for about 5 quarters. Gourinchas, Rey, and Truempler (2011) calculate that during the GFC there was a 17% of U.S. GDP transfer of wealth from the U.S. to foreign countries, of which about one third was due to exchange rate movements and two-thirds were due to a fall in returns on risky assets.[38] Monopoly rents on impact are 3.5% of U.S. GDP, rents are positive for over 10 quarters. The model predicts that the in export rents attributable to the dollar appreciation amounts to $1.5-2\%$ of GDP.

Optimal monetary policy stems the appreciation mitigating the fall in export revenues and valuation effects. Furthermore, if monetary policy is optimally set, total dollar debt issuance in

[37] Decomposing the aggregate labour wedge into a labour wedge for financially active and inactive households shows that even at the constrained optimal active households experience a boom and inactive households experience a bust. This is illustrated in Appendix F.

[38] The international loss of wealth reflected 12% of the total wealth loss in the United States. In the model, the fall in returns on risky assets can be modelled by a negative shock to Ψ_t^*.

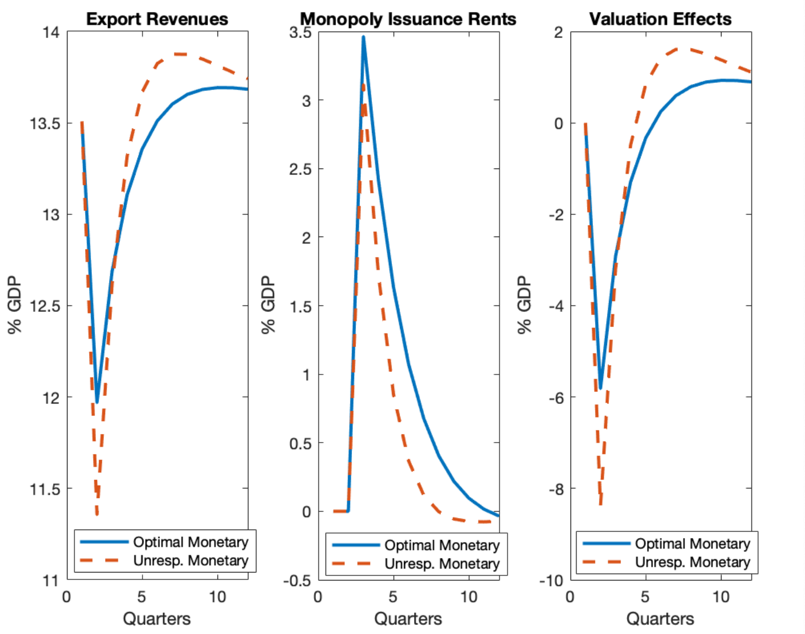


Figure 9: Impulse response to $\xi > 0$. Comparison of export revenues, monopoly rents from issuance and valuation effects, as % of GDP, under the optimal and unresponsive monetary regimes.

the hegemon is lower, exacerbating imbalances and increasing monopoly rents from issuance.

5.3 Welfare and Dollar Swap Lines

To assess the welfare implications of a rise in dollar shortages for the hegemon, I define the present discounted value of welfare following a dollar demand shock $\{\xi_t\} > 0$ when dollar liquidity is Γ by,

$$\mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\Gamma, \xi_t\}) \tag{55}$$

where I make explicit the dependence of welfare on policy. Consider the Hicksian equivalent variation for consumption,

$$\sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^i (1+\nu^i)^{1-\sigma}}{1-\sigma} - \kappa \frac{L_t^{1+\psi}}{1+\psi} + V(G_t) \right] = \mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \Gamma, 0), \tag{56}$$

where ν^i is a time-invariant proportional consumption transfer such that household $i \in \{A, NA\}$ is equally well-off whether or not the dollar demand shock occurs.[39] A positive transfer $\nu > 0$ suggests that a one-off unexpected increase in dollar shortages is costly to the household, i.e $\mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \Gamma, 0) > \mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\Gamma, \xi_t\})$. Table 2 details the welfare outcomes from a one-off dollar demand shock for the calibration discussed above:
[use heterogeneous notation.]

[39] Such consumption transfers are used Lucas (2003) to evaluate the welfare costs of business cycles.

	Active	Inactive	Aggregate
Unresponsive monetary (no macropru.)	0.017%	0.032%	0.022%
Optimal monetary (no macropru.)	-0.057%	0.016%	-0.035%
Constrained Optimal	-0.16%	0.031%	-0.1%

Table 2: Hicksian welfare transfers under different policy regimes, in response to a one-off, unanticipated dollar-asset demand shock.

When interest rates are held constant (first row of Table 2), rising dollar shortages lead to a sharp dollar appreciation depressing aggregate demand and causing large losses due to valuation effects. This leads to welfare losses for both active and inactive households, although the latter suffer disproportionately more as they benefit less from the monopoly rents, see Proposition 5. Instead, if monetary policy cuts interest rates optimally (second row),welfare outcomes are starkly different for financially active and inactive households. Active households are better off as they benefit from lower borrowing costs, and the extent of the dollar appreciation is moderated. On the other hand, inactive households experience welfare losses because they suffer disproportionately from the aggregate demand externality. The final row in the table details welfare at the constrained optimal allocation, achieved via a combination of optimal monetary policy and the optimal borrowing tax. While aggregate welfare is rises, this is achieved at the expense of inactive household welfare. The borrowing tax exacerbates dollar shortages, disproportionately benefiting active households, while the interest rate cut keeps employment high due to a depreciation, so inactive households are working disproportionately hard.

Revisiting Dollar Swaps. In practice, dollar swap lines are extended by the Federal Reserve at a time t, and their take-up in future periods is determined by the demand of foreign central banks. Therefore, the U.S. makes a one-off decision to extend dollar swaps if:

$$\mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\frac{1}{Q+Q^s}^2, \xi_t\}) > \mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\frac{1}{Q}^2, \xi_t\}) \tag{57}$$

Dollar demand shocks have no macroeconomic consequences for the hegemon in the limit where dollar liquidity is very high. Therefore, dollar swaps are optimal when dollar demand shocks lead to welfare losses.Specifically for the case of dollar demand shocks, no other instrument is required to completely offset the shock.Appendix D details the role of dollar swaps as part of the optimal policy mix, in the face of productivity shocks, and shocks to the return on foreign assets.

Dollar swaps have only become a prominent part of policy since the GFC, yet the U.S. has been experiencing capital inflows which appreciate the dollar since the 1930s, see Corsetti and Marin (2020). My analysis emphasizes three reasons why the welfare value of dollar swaps may have increased in recent years. First, Table 2 shows that the welfare costs from dollar shortages are larger for all households if interest rates do not fall. Since at least the GFC, interest rates in the U.S. have been at or near the zero lower bound and have likely responded less to appreciationary inflows than they otherwise would have. In the policy problem, this is reflected by a higher level of over-borrowing (see Lemma 3). Since I have shown that dollar swaps are useful as a substitute to a borrowing tax (42), it follow that dollar swaps are more desirable when monetary policy does not respond, as is the case near the zero lower bound.

Secondly, in the calibration, financially inactive households incur losses from dollar shortages across all policy regimes. Indeed, financially inactive households will incur larger losses (or smaller gains) for any reasonable calibration, in the absence of redistributive fiscal policy.Assigning Pareto weights $\{\lambda^A, \lambda^{NA}\}$ to financially active and inactive household welfare respectively, where $\alpha\lambda^A + (1-\alpha)\lambda^{NA} = 1$, dollar swaps become more desirable as λ^{NA} rises, i.e. when the planner cares disproportionately above inactive household outcomes. The decision to extend dollar swaps can therefore be driven by a desire to insure inactive households during periods of large dollar shortages.

Third, evidence in Figure 1 shows that dollar shortages do not occur in isolation but coincide with large, international crises. Consider again the role for public debt issuance (135). Public debt issuance trades off fiscal incentives with macroprudential incentives. If there is a large fall in fiscal revenues (e.g Ψ falls), the government prioritises smoothing spending and over-borrowing in the economy rises (e.g. η^E rises). From (42), we can see that the returns to dollar swaps rise. I analyse the effects of a shock to Ψ in Appendix **??**. Similar trade-offs arise if there is a fall to the return from foreign assets Ψ^*, documented in Gourinchas, Rey, and Govillot, 2018.

Dollar Currency Pricing and the cost of Dollar Shortages. The exchange rate pass-through to imports in the hegemon partly determines the costs of a dollar appreciation. For any given level of monopoly rents $-\Gamma_t Q_t(\mathbf{a}_t x_t + B_t)$, the quantity of imports they can buy is $-P_F^{*\,-1}\mathcal{E}^{-\lambda}\Gamma_t Q_t(\mathbf{a}_t x_t + B_t)$. Following an appreciation, the price of imports falls by more if λ is higher. Therefor, for a given level of dollar demand, DCP contributes to higher welfare costs from the resulting appreciation due to the presence of real income effects, see e.g Corsetti and Pesenti (2001), Auclert et al. (2021). The welfare outcomes under different policy regimes, for a higher level of exchange rate pass-through are reported in Appendix **??**.[40]

6 Conclusion

Dollar shortages in international markets have stark macroeconomic implications for the issuer of dollar assets– the hegemon– and result in a trade-off: because dollars are scarce, the hegemon households and government earn monopoly rents from issuance of dollar debt, but face costs due to an appreciated dollar. In particular, the dollar appreciation depresses demand for exports and leads to losses on a portfolio of foreign currency-denominated assets.

[40]However, as noted in Farhi and Maggiori (2016), the extent of demand for dollar assets and the associated safety premium is likely to be endogenous to the international pricing paradigm. Farhi and Maggiori (2016) look at a dollarized economy and argue that dollar debt, if not defaulted upon outright, becomes safe in real terms since devaluations on behalf of the US would not reduce the amount of goods foreigners can purchase.

I show that monetary policy can stabilize the hegemon economy, but its effectiveness is limited by private sector over-borrowing, if a borrowing tax is not available. This arises due to a combination of nominal rigidities and atomistic households failing to internalize their size in dollar markets. Dollar swaps can address domestic over-borrowing but only at the cost of eroding monopoly rents. The social value of dollar swaps in response to a dollar demand shock is higher if interest rates are held constant, if there is a simultaneous fall in government fiscal revenues, or if a measure of households not active in financial markets.Relatedly, I show that the costs associated with a dollar appreciation are higher when exchange rate pass-through is low (consistent with dollar currency pricing).

References

[1] Tobias Adrian and Hyun Song Shin. “Procyclical Leverage and Value-at-Risk”. In: *Review of Financial Studies* 27.2 (2014), pp. 373–403.

[2] Tobias Adrian and Peichu Xie. *The Non-U.S. Bank Demand for U.S. Dollar Assets*. CEPR Discussion Papers 14437. C.E.P.R. Discussion Papers, 2020.

[3] Mark Aguiar, Manuel Amador, Hugo A Hopenhayn, and Ivan Werning. “Equilibrium Default”. 2015.

[4] Mark Aguiar, Mark Bils, and Corina Boar. *Who are the Hand-to-Mouth?* 2020.

[5] Joshua Aizenman, Hiro Ito, and Gurnain Kaur Pasricha. *Central Bank Swap Arrangements in the COVID-19 Crisis*. Working Paper 28585. National Bureau of Economic Research, 2021.

[6] Ozge Akinci and Albert Queraltó. *Exchange rate dynamics and monetary spillovers with imperfect financial markets*. Staff Reports 849. Federal Reserve Bank of New York, 2018.

[7] Iñaki Aldasoro, Torsten Ehlers, Patrick McGuire, and Goetz von Peter. *Global banks' dollar funding needs and central bank swap lines*. BIS Bulletins 27. Bank for International Settlements, 2020.

[8] Fernando Alvarez, Andrew Atkeson, and Patrick J Kehoe. “Money, Interest Rates, and Exchange Rates with Endogenously Segmented Markets”. In: *Journal of Political Economy* 110.1 (2002), pp. 73–112.

[9] Fernando Alvarez, Andrew Atkeson, and Patrick J Kehoe. “Time-Varying Risk, Interest Rates, and Exchange Rates in General Equilibrium”. In: *The Review of Economic Studies* 76.3 (2009), pp. 851–878. ISSN: 00346527, 1467937X.

[10] Adrien Auclert, Matthew Rognlie, Martin Souchier, and Ludwig Straub. *Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel*. Working Paper 28872. National Bureau of Economic Research, 2021.

[11] Naohiko Baba and Frank Packer. *From turmoil to crisis: dislocations in the FX swap market before and after the failure of Lehman Brothers*. BIS Working Papers 285. Bank for International Settlements, 2009.

[12] Saleem Bahaj and Ricardo Reis. *Central Bank Swap Lines*. Discussion Papers 1816. Centre for Macroeconomics (CFM), 2018.

[13] Suman Basu, Emine Boz, Gita Gopinath, Francisco Roch, and Filiz Unsal. “A Conceptual Model for the Integrated Policy Framework”. In: *IMF Working Papers* 20 (2020).

[14] Javier Bianchi and Guido Lorenzoni. “The Prudential Use of Capital Controls and Foreign Currency Reserves”. In: (2021).

[15] Florin O Bilbiie. “The New Keynesian cross”. In: *Journal of Monetary Economics* 114.C (2020), pp. 90–108.

[16] Valentina Bruno and Hyun Song Shin. "Global Dollar Credit and Carry Trades: A Firm-Level Analysis". In: *The Review of Financial Studies* 30.3 (2017), pp. 703–749. ISSN: 0893-9454.

[17] Ricardo J Caballero, Emmanuel Farhi, and Pierre-Olivier Gourinchas. "The Safe Assets Shortage Conundrum". In: *Journal of Economic Perspectives* 31.3 (2017), pp. 29–46.

[18] Ricardo J Caballero and Arvind Krishnamurthy. "Smoothing sudden stops". In: *Journal of Economic Theory* 119.1 (2004), pp. 104–127.

[19] Ryan Chahrour and Rosen Valchev. "Trade Finance and the Durability of the Dollar". In: *The Review of Economic Studies* (2021). ISSN: 0034-6527.

[20] V V Chari, Patrick J Kehoe, and Ellen R McGrattan. "Business Cycle Accounting". In: *Econometrica* 75.3 (2007), pp. 781–836.

[21] YiLi Chien and Paul Morris. "Household Participation in Stock Market Varies Widely by State". In: *Federal Reserve Bank of St. Louis* 3rd quarte (2017).

[22] Simona E Cociuba and Ananth Ramanarayanan. *International Risk Sharing with Endogenously Segmented Asset Markets*. Tech. rep. 2017.

[23] Harold L Cole and Maurice Obstfeld. "Commodity trade and international risk sharing: How much do financial markets matter?" In: *Journal of Monetary Economics* 28.1 (1991), pp. 3–24. ISSN: 0304-3932.

[24] Giancarlo Corsetti, Luca Dedola, and Sylvain Leduc. *Exchange Rate Misalignment, Capital Flows, and Optimal Monetary Policy Trade-off*. Discussion Papers 1806. Centre for Macroeconomics (CFM), 2018.

[25] Giancarlo Corsetti, Luca Dedola, and Sylvain Leduc. *Global inflation and exchange rate stabilization under a dominant currency*. Tech. rep. Mimeo, 2020.

[26] Giancarlo Corsetti, Simon Lloyd, and Emile Marin. "Emerging market currency risk around 'global disasters': Evidence from the Global Financial Crisis and the COVID-19 crisis". In: *CEPR ebook "Economics in the Time of COVID-19"* (2020).

[27] Giancarlo Corsetti and Emile Marin. "A Century of Arbitrage and Disaster Risk Pricing in Foreign Exchange Markets". In: *CFM Working Paper* (2020).

[28] Giancarlo Corsetti and Paolo Pesenti. "Welfare and Macroeconomic Interdependence". In: *The Quarterly Journal of Economics* 116.2 (2001), pp. 421–445.

[29] Giancarlo Corsetti, Paolo Pesenti, Richard Clarida, and Jeffrey Frankel. "The Simple Geometry of Transmission and Stabilization in Closed and Open Economies [with Comments]". In: *NBER International Seminar on Macroeconomics* (2007), pp. 65–129. ISSN: 19328796.

[30] Arnaud Costinot, Guido Lorenzoni, and Iván Werning. "A Theory of Capital Controls as Dynamic Terms-of-Trade Manipulation". In: *Journal of Political Economy* 122.1 (2014), pp. 77–128.

[31] Marco Del Negro, Gauti Eggertsson, Andrea Ferrero, and Nobuhiro Kiyotaki. "The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities". In: *American Economic Review* 107.3 (2017), pp. 824–857.

[32] Konstantin Egorov and Dmitry Mukhin. *Optimal Monetary Policy under Dollar Pricing*. Tech. rep. 2019.

[33] Fernando Eguren-Martin. *Dollar shortages and central bank swap lines*. Bank of England working papers 879. Bank of England, 2020.

[34] M S Eichenbaum, B K Johannsen, and S T Rebelo. "Monetary Policy and the Predictability of Nominal Exchange Rates". In: *The Review of Economic Studies* 88.1 (2020), pp. 192–228. ISSN: 0034-6527.

[35] Sebastian Fanelli. *Optimal Monetary Policy and Portfolio Choice*. Tech. rep. 2017.

[36] Sebastian Fanelli and Ludwig Straub. *A Theory of Foreign Exchange Interventions*. Tech. rep. 2018.

[37] Emmanuel Farhi and Matteo Maggiori. "A Model of the International Monetary System". Working Paper. 2016.

[38] Emmanuel Farhi and Ivan Werning. "A Theory of Macroprudential Policies in the Presence of Nominal Rigidities". In: *Econometrica* 84.5 (2016), pp. 1645–1704.

[39] Emmanuel Farhi and Ivan Werning. *Dealing with the Trilemma: Optimal Capital Controls with Fixed Exchange Rates*. 2012.

[40] Emmanuel Farhi and Ivan Werning. "Dilemma not Trilemma? Capital Controls and Exchange Rates with Volatile Capital Flows". In: *IMF Economic Review (Special Volume in Honor of Stanley Fischer)* 62 (2014), pp. 569–605.

[41] Emmanuel Farhi and Ivan Werning. "Fiscal Unions". In: *American Economic Review* 107.12 (2017), pp. 3788–3834.

[42] Robert C Feenstra, Philip Luck, Maurice Obstfeld, and Katheryn N Russ. "In Search of the Armington Elasticity". In: *The Review of Economics and Statistics* 100.1 (2018), pp. 135–150.

[43] Sergio de Ferra, Kurt Mitman, and Federica Romei. *Household Heterogeneity and the Transmission of Foreign Shocks*. Working Paper 26402. National Bureau of Economic Research, 2019.

[44] Xavier Gabaix and Matteo Maggiori. "International Liquidity and Exchange Rate Dynamics". In: *Quarterly Journal of Economics* 130.3 (2015), pp. 1369–1420.

[45] Jordi Galí and Tommaso Monacelli. "Monetary Policy and Exchange Rate Volatility in a Small Open Economy". In: *Review of Economic Studies* 72.3 (2005), pp. 707–734.

[46] Gita Gopinath, Emine Boz, Camila Casas, Federico J Díez, Pierre-Olivier Gourinchas, and Mikkel Plagborg-Møller. "Dominant Currency Paradigm". In: *American Economic Review* 110.3 (2020), pp. 677–719.

[47] Gita Gopinath and Jeremy C Stein. "Banking, Trade and the Making of a Dominant Currency". 2018.

[48] Pierre-Olivier Gourinchas and Hélène Rey. *From World Banker to World Venture Capitalist: US External Adjustment and the Exorbitant Privilege*. Working Paper 11563. National Bureau of Economic Research, 2005.

[49] Pierre-Olivier Gourinchas, Helene Rey, and Nicolas Govillot. *Exorbitant Privilege and Exorbitant Duty*. Tech. rep. mimeo, 2018.

[50] Pierre-Olivier Gourinchas, Hélène Rey, and Kai Truempler. *The Financial Crisis and The Geography of Wealth Transfers*. Working Paper 17353. National Bureau of Economic Research, 2011.

[51] Denis Gromb and Dimitri Vayanos. "Equilibrium and welfare in markets with financially constrained arbitrageurs". In: *Journal of Financial Economics* 66.2 (2002), pp. 361–407. ISSN: 0304-405X.

[52] Denis Gromb and Dimitri Vayanos. "Limits of Arbitrage". In: *Annual Review of Financial Economics* 2.1 (2010), pp. 251–275.

[53] Zhengyang Jiang. *US Fiscal Cycle and the Dollar*. Working Paper 27682. National Bureau of Economic Research, 2021.

[54] Zhengyang Jiang, Arvind Krishnamurthy, and Hanno Lustig. *Dollar Safety and the Global Financial Cycle*. Working Paper 27682. National Bureau of Economic Research, 2020.

[55] Sebnem Kalemli-Ozcan. *U.S. Monetary Policy and International Risk Spillovers*. Working Paper 26297. National Bureau of Economic Research, 2019.

[56] Rohan Kekre and Moritz Lenel. "The Dollar and the Global Price of Risk". In: *Mimeo* (2020).

[57] J M Keynes. "The Reparation Problem: A Discussion". In: *The Economic Journal* 39.154 (1929), pp. 172–182. ISSN: 00130133, 14680297.

[58] Taehoon Kim. "The World's Banker: On the Rise in U.S. Wealth Inequality". In: 2020.

[59] Emanuel Kohlscheen and Sandro C Andrade. "Official FX interventions through derivatives". In: *Journal of International Money and Finance* 47 (2014), pp. 202–216. ISSN: 0261-5606.

[60] Robert Kollmann. "Limited asset market participation and the consumption-real exchange rate anomaly". In: *Canadian Journal of Economics* 45.2 (2012), pp. 566–584.

[61] Arvind Krishnamurthy and Annette Vissing-Jorgensen. "The Aggregate Demand for Treasury Debt". In: *Journal of Political Economy* 120.2 (2012), pp. 233–267.

[62] Gordon Y Liao. "Credit migration and covered interest rate parity". In: *Journal of Financial Economics* 138.2 (2020), pp. 504–525. ISSN: 0304-405X.

[63] Simon Lloyd and Emile Marin. *Capital Controls and Free Trade Agreements*. Working Paper. Mimeo, 2020.

[64] Simon P Lloyd and Emile A Marin. “Exchange Rate Risk and Business Cycles”. In: *Cambridge Working Paper* (2019).

[65] Robert E Lucas. “Macroeconomic Priorities”. In: *American Economic Review* 93.1 (2003), pp. 1–14.

[66] Robert E Lucas and Nancy L Stokey. “Optimal fiscal and monetary policy in an economy without capital”. In: *Journal of Monetary Economics* 12.1 (1983), pp. 55–93.

[67] Matteo Maggiori. “Financial Intermediation, International Risk Sharing, and Reserve Currencies”. In: *American Economic Review* (2017).

[68] Matteo Maggiori, Brent Neiman, and Jesse Schreger. *International Currencies and Capital Allocation.* Tech. rep. 2018.

[69] Robert N McCauley and Catherine R Schenk. *Central bank swaps then and now: swaps and dollar liquidity in the 1960s.* BIS Working Papers 851. Bank for International Settlements, 2020.

[70] Patrick McGuire and Goetz von Peter. *The US dollar shortage in global banking and the international policy response.* BIS Working Papers 291. Bank for International Settlements, 2009.

[71] Richard A Meese and Kenneth Rogoff. “Empirical exchange rate models of the seventies: Do they fit out of sample?” In: *Journal of International Economics* 14.1 (1983), pp. 3–24. ISSN: 0022-1996.

[72] Silvia Miranda-Agrippino and Hélène Rey. “U.S. Monetary Policy and the Global Financial Cycle”. In: *The Review of Economic Studies* 87.6 (2020), pp. 2754–2776. ISSN: 0034-6527.

[73] Richhild Moessner and William Allen. “Central bank swap line effectiveness during the euro area sovereign debt crisis”. In: *Journal of International Money and Finance* 35.C (2013), pp. 167–178.

[74] Bertil Ohlin. “The reparation problem: a discussion”. In: *The Economic Journal* 39.154 (1929), pp. 172–182.

[75] Hélène Rey. “Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence”. In: *Proceedings - Economic Policy Symposium - Jackson Hole* (2015).

[76] Stephanie Schmitt-Grohé and Martín Uribe. “Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment”. In: *Journal of Political Economy* 124.5 (2016), pp. 1466–1514.

[77] Rosen Valchev. “Bond Convenience Yields and Exchange Rate Dynamics”. In: *American Economic Journal: Macroeconomics* 12.2 (2020), pp. 124–166.

[78] Olivier Wang. “Exchange Rate Pass-Through, Capital Flows, and Monetary Autonomy”. In: *Mimeo* (2019).

A Additional Empirical Evidence.

Evidence on deviations from the Uncovered Interest Parity and Monopoly Rents. Figure 10 below considers tthe decomposition of ERRP between G10 and EM7 currencies. Two points are noteworthy: first both G10 and EM7 currencies are subject to the spread during currencies. The spread for EM7 currencies is wider, and significantly so in the most recent COVID-19 episode.

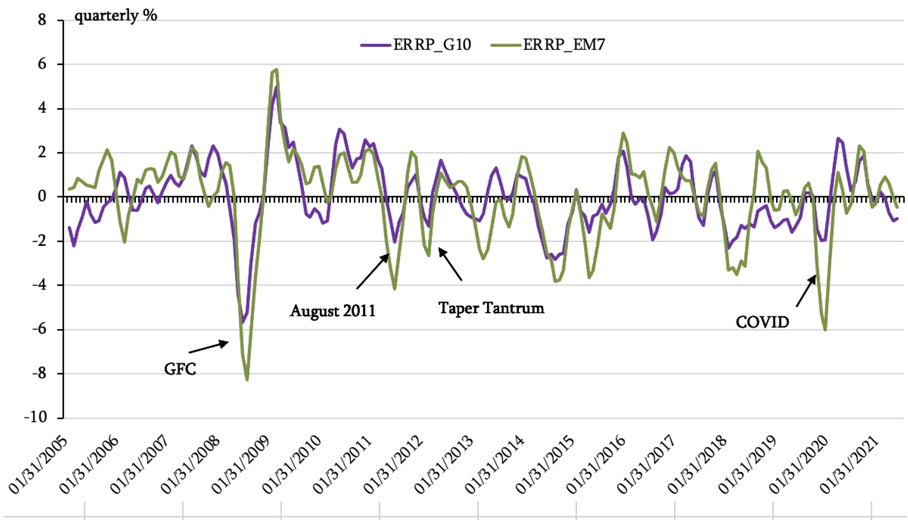


Figure 10: Source: Federal Reserve

Evidence on the deteriorating U.S. position. Figure 11 plots the net investment position of the U.S., as a % of GDP, from 2006Q1 to 2021Q4. This is calculated as the difference in gross assets and liabilities, and has rapidly worsened over time.

The next figure, from the BEA, illustrates the size of gross assets and liabilities held by the

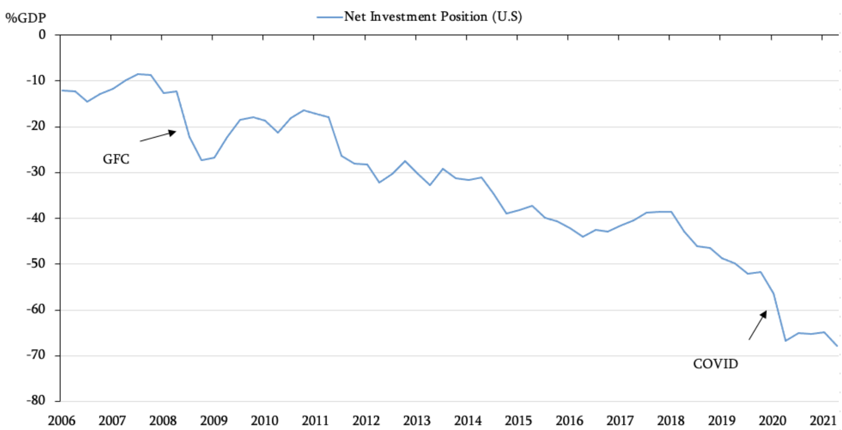


Figure 11: Net Investment Position for the United States as % of U.S. GDP. Source: BEA and authors calculations.

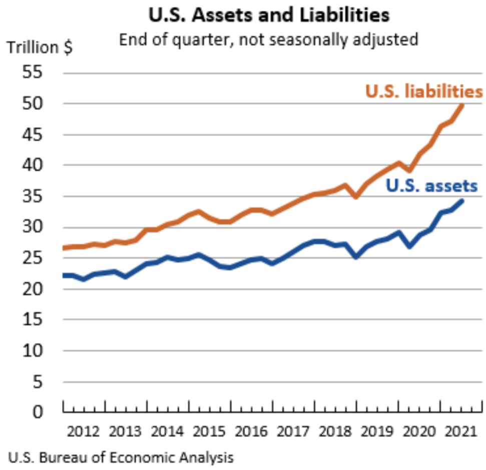


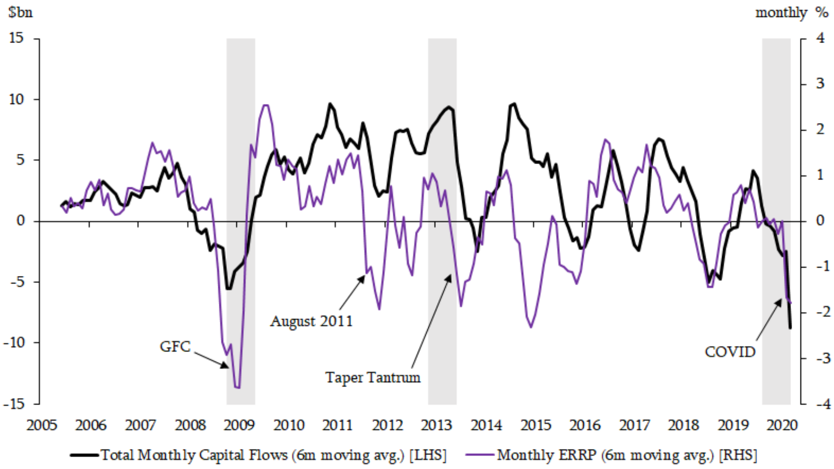
Figure 12: Left Panel: Net Investment Position for the United States in \$ Right panel: Gross assets and liabilities in \$. Source: BEA.

U.S., and is used in 5 to calibrate the U.S. portfolio of foreign assets.

Evidence on Correlation of Capital Flows and Exchange Rates. Figure 13, from Corsetti, Lloyd, and Marin (2020), plots emerging market capital flows and exchange rate risk premia as 6-month moving averages. While the correlation of these two variables is close to zero when calculated over the whole period, it becomes strongly positive around periods of significant financial distress and low liquidity. Over a 2005:01-2020:03 sample, the correlation between non-resident portfolio flows to EMs and the EM PPP-weighted exchange rate risk premium, at monthly frequency, is just 0.08– consistent with a Γ_t close to zero. This result is often highlighted by the literature on the 'exchange rate disconnect', stressing the apparent weak relationship between currency valuation and economic fundamentals, including capital flows, see Meese and Rogoff (1983). However, a rolling correlation between these series over a 6-month window highlights that this correlation rises to above 0.75 during periods of financial distress: the Great Financial Crisis, the 2013 Taper Tantrum and the recent COVID crisis—all of which are characterised by large capital movements and low international liquidity. In these periods, the data suggests a Γ_t that is substantially positive.

Evidence of Wealth Inflows to the U.S. during the GFC The next figure contrasts the calculation of the U.S. net foreign asset position around the GFC by Maggiori (2017) and Jiang, Krishnamurthy, and Lustig (2020). The latter consider a more general formulation and find evidence of a net transfer to the U.S. from abroad, even though the position deteriorated in absolute value. Specifically, they consider equities, bonds, and deposits issued in the U.S. , held by both U.S. and non-U.S. agents,plotted by the black-dashed line. The red line measures the same quantity for Canada, Germany, France, Great Britain and Japan.

Figure 13: Capital flows and *ex post* exchange rate risk premia for EMs



Note: 6-month moving average of: non-resident portfolio flows to EMs, and 1-month *ex post* EM exchange rate risk premia vis-à-vis US dollar (PPP-weighted). Capital flows cumulated over each calendar month, with negative value implying an outflow from EMs. Moving averages plotted at end-date of period. Shaded areas denote periods in which 6-month rolling correlation of raw capital flows and exchange rate risk premia exceed 0.75. Unconditional correlation of raw series equal to 0.08 over the sample. *Dates*: January 2005 to March 2020. *Data Sources*: Datastream, IIF, IMF International Financial Statistics.

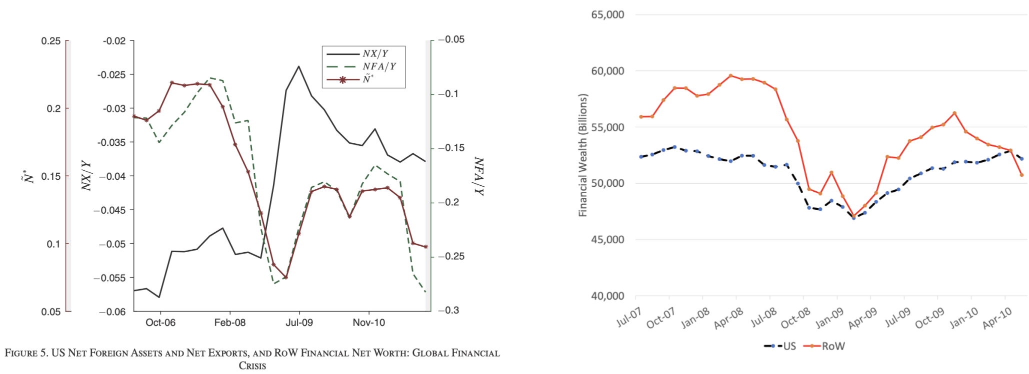


Figure 14: Left panel: Figure 5 from Maggiori (2017). Right panel: Figure 5 from Jiang, Krishnamurthy, and Lustig (2020).

Next, to motivate the interest in limited financial market participation, Figure 15, shows that proxies for financial market participation suggest a significant fall following the financial crisis.

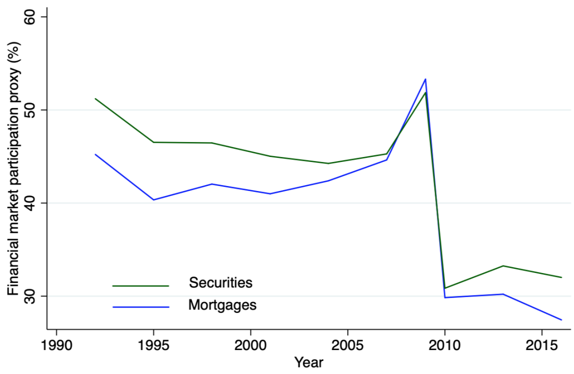


Figure 15: Triennial Survey of Consumer Finances and authors' calculation. Proxy for security holdings constructed using percentage of households which own at least one of bonds, publicly listed stock or mutual funds.

B General Model

In this Appendix I detail the equilibrium conditions for the global model for a country $i > 0$ under dollar currency pricing, where country $i = 0$ is the issuer of dollars. I detail the model for an arbitrary utility function, CES aggregator and market structure and specialize to derive the desired results.

Model Setup. The consumption basket for country i is given by,

$$C_{i,t} = \left[\chi C_{ii,t}^{\frac{\theta-1}{\theta}} + (1-\chi) C_{i,t}^{*\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, \tag{58}$$

where $C^*_{i,t} = \int_j C_{ji,t} dj$ denotes the import good bundle and $C_{ji,t}$ denotes country i's consumption of goods produced in country j. In turn,

$$C_{ji,t} = \left(\int_\omega C_{ji,t}(\omega)^{\frac{\epsilon-1}{\epsilon}} d\omega\right)^{\frac{\epsilon}{\epsilon-1}} \tag{59}$$

The country i consumer-price index is given by,

$$P_{i,t} = \left[\chi P_{ii,t}^{1-\theta} + (1-\chi)\int_j P_{ji,t}^{1-\theta} dj)\right]^{\frac{1}{1-\theta}}, \tag{60}$$

where prices are expressed in the currency of destination, $P_{ii,t}$ denotes country i prices of domestic goods and $P_{ji,t}$ is the price of goods produced in j and consumed in i. The demand for home and foreign goods respectively is given by,

$$C_{ii,t} = \chi \left(\frac{P_{ii,t}}{P_{i,t}}\right)^{-\theta} C_{i,t}, \quad C_{ji,t} = (1-\chi)\left(\frac{P_{ji,t}}{P_{i,t}}\right)^{-\theta} C_{i,t}, \tag{61}$$

I define the real exchange rate $Q_{i,t}$, the terms of trade $S_{i,t}$ and deviations from the law of one price $\Phi_{i,t}$ as follows,

$$Q_{i,t} = \frac{\mathcal{E}_{i,t} P_t^*}{P_{i,t}}, \quad S_{i,t} = \frac{P_t^*}{P_{i,t}}, \quad \Phi_{i,t} = \frac{\mathcal{E}_{i,t} P_{i,t}^*}{P_{ii,t}} \tag{62}$$

where, from (61),

$$Q_{i,t}^{\theta-1} = \chi + (1-\chi)(S_{i,t}\Phi_{i,t})^{\theta-1} \tag{63}$$

The households' budget constraint is given by,

$$P_{i,t}C_{i,t} = W_{i,t}L_{i,t} + \Pi_{i,t} + T_{i,t} + x_{i,t} - R_{i,t-1}x_{i,t-1}, \tag{64}$$

where $\Pi_{i,t} = \Pi_{i,t}^g + \Pi_{i,t}^f$ combines goods' firms and financial firms' profits. The market clearing constraint is given by,

$$Y_{i,t} = C_{ii,t} + \int_j C_{ij,t} dj \tag{65}$$

Firm's pricing conditions. For country $i > 0$, the price-setting problem for domestic sales is given by,[41]

$$\max_{P_t} \sum_{t=0}^{\infty} \Lambda_{i,t} \left[(P_t - \tilde{MC}_{i,t}) \left(\frac{P_t}{P_{ii,t}} \right)^{-\epsilon} Y_t^D \right] \tag{67}$$

and for exports,

$$\max_{P_t} \sum_{t=0}^{\infty} \Lambda_{i,t} \left[(\mathcal{E}_{i,t} P_t^* - \tilde{MC}_{i,t}) \left(\frac{P_t^*}{P_{i,t}^*} \right)^{-\epsilon} Y_t^E \right] \tag{68}$$

in which market prices are set in dollar terms. In a symmetric equilibrium $P_t = P(j)_t$. In contrast, for country $i = 0$ who issues dollars,

$$\max_{P_t} \sum_{t=0}^{\infty} \Lambda_{i,t} \left[(P_t - \tilde{MC}_{i,t}) \left(\frac{P_t}{P_{ii,t}} \right)^{-\epsilon} Y_{i,t} \right] \tag{69}$$

where $Y_{i,t} = Y_{i,t}^D + Y_{i,t}^E$. Denoting $P_t = P_{H,t}, Y_{i,t} = Y_{H,.t}$ and substituting $\tilde{MC}_{i,t} = \frac{\tilde{W}_t}{A_t}$ yields the pricing condition for hegemon firms in the main body (10).

[41]This can be considered as the limit $\phi \to \infty$ of the dynamic pricing with Rotemberg adjustment costs considered in Egorov and Mukhin (2019). In the domestic market,

$$\max_{P_t} \sum_{t=0}^{\infty} \Lambda_{i,t} \left[(P_t - \tilde{MC}_{i,t}) \left(\frac{P_t}{P_{ii,t}} \right)^{-\epsilon} Y_t^D \right] - \chi \frac{\phi}{2} \left(\frac{P_t}{P_{t-1}} \right)^{-\epsilon} Y_{i,t}^D \tag{66}$$

As adjusting prices becomes very costly, $\lim_{\phi\to\infty} \dfrac{P_t}{P_{t-1}} = 1$.

Equilibrium Conditions. Goods' firms profits are given by,

$$\Pi^g_t = (P_{ii,t} - MC_{i,t})Y_{i,t} + (\mathcal{E}_{i,t}P^*_{i,t} - MC_{i,t})Y^E_{i,t} \tag{70}$$

where $MC_{i,t}(Y_{i,t} + Y^E_{i,t}) = W_{i,t}L_{i,t}$. The consolidated budget constraint can be written as,

$$\int_j P_{ji,t}C_{ji,t}dj - \int_j P_{ij,t}C_{ij,t}dj = x_{i,t} - R_{i,t}x_{i,t-1} + \Pi^f_{i,t}$$

Using the relative demand equations (61) and (62), the market clearing equation (65) can be expressed as,

$$A_{i,t}L_{i,t} = \chi\Phi_{i,t}S^{\theta}_{i,t}Q^{-\theta}_{i,t}C_{i,t} + (1-\chi)S^{\theta}_{i,t}C^*_t \tag{71}$$

where I have assumed production is linear and only uses labour. Similarly, the consolidated budget constraint (64) can be rewritten as,

$$(1-\chi)\mathcal{E}_{i,t}P^*_{i,t}\int_j \left(\frac{P_{ij,t}}{P_{j,t}}\right)^{-\theta} C_{j,t}dj - (1-\chi)\int_j P_{ji,t}\left(\frac{P_{ji,t}}{P_{i,t}}\right)^{-\theta} djC_j = \frac{1}{\mathcal{E}_t}F_{i,t}$$

where,

$$F_{i,t} = \mathcal{E}_{i,t}\left(x_{i,t} - R_{i,t}x_{i,t-1} + \Pi^f_{i,t}\right) \tag{72}$$

In complete markets, $F_{i,t} = x^h_{i,t}$, where h denotes the realisation of history, and $\sum_{t,h} x^h_{i,t} = 0$. [42] Converting to dollar terms, the consolidated budget constraint can be further simplified to,

$$(1-\chi)P^*_t\left[S^{\theta-1}_{i,t}\int_j Q^{-\theta}_j C_{j,t}dj - Q^{-\theta}_{i,t}C_{i,t}\right] + F_{i,t} = 0 \tag{73}$$

Consider the maxization problem for country $i > 0$, taking $F_{i,t}$ as given.

$$\begin{aligned} \max_{\{C_{i,t},L_{i,t},\Phi_{i,t},Q_{i,t}\}} \quad & u(C_{i,t}, L_{i,t}) \\ \text{s.t} \quad & (63), (64), (65). \end{aligned}$$

The monetary policy instrument is $\Phi_{i,t}$ which relates to $\mathcal{E}_{i,t}$ as per (62), where $P_{ii,t}$ is preset and $P^*_{i,t}$ is taken as given. Condition (63) is used to substitute out $Q_{i,t}$ noting that $Q_{i,t}$ is itself a function of $\Phi_{i,t}$. I attach multulipliers $\eta^*_{1,t}, \eta^*_{2,t}$, respectively to (64), (65). I make the following assumption which in the proof to Lemma 3, I show is satisfied when $\omega = 1, \phi^* = 0$.

A.4 (Portfolio returns in foreign currency independent of policy) *$F_{i,t}$ given by (72) is unaffected by monetary policy.*

[42]Without loss of generality I assume Arrow Debreu securities are denominated in dollars.

The first order conditions with respect to $C_{i,t}, L_{i,t}$ and $\Phi_{i,t}$ are given as follows:

$$C_{i,t}: \qquad u_{C_{i,t}} - \eta^*_{1,t}\{\chi Q^{\theta}_{i,t}\Phi^{\theta}_{i,t}S^{\theta}_{i,t}\} - \eta^*_{2,t}\{(1-\chi)P^*_t Q^{-\theta}_{i,t}\} = 0, \tag{74}$$

$$L_{i,t}: \qquad u_{L_{i,t}} + \eta^*_{1,t}A_{i,t} = 0, \tag{75}$$

$$\begin{aligned}\Phi_{i,t}: \qquad & -\eta^*_{1,t}\{\chi(\theta Q^{2-\theta}_{i,t}\Phi^{2\theta-2}_{i,t}S^{2\theta-1}_{i,t}C_{i,t} + \theta Q^{-\theta}_{i,t}S^{\theta}_{i,t}\Phi^{\theta-1}_{i,t}C_{i,t})\} \\ & + \eta^*_{2,t}(1-\chi)P^*_t\theta Q^{1-2\theta}_{i,t}\chi\Phi^{\theta-2}_{i,t}S^{\theta-1}_{i,t}C_{i,t} = 0\end{aligned} \tag{76}$$

where the last FOC uses the chain rule. Factorizing and using (63) to simplify (76) yields,

$$\eta_{i,t}S_{i,t}\Phi_{i,t} = \rho_{i,t}P^*_t \tag{77}$$

Then combining (74) and (77) yields,

$$\frac{-u_{L_{i,t}}}{u_{C_{i,t}}} = \frac{A_{i,t}}{S_{i,t}\Phi_{i,t}Q^{-1}_{i,t}} \tag{78}$$

Using the household intratemporal consumption-leisure Euler, I show that optimal policy therefore ensures,

$$\frac{W_{i,t}}{A_{i,t}P_{ii,t}} = 1 \tag{79}$$

Optimal monetary policy stabilises marginal costs– a result emphasized in Egorov and Mukhin (2019) who show it generalises to a dynamic environment with Rotemberg pricing.

Lemma 4A (Foreign monetary policy)
Under A.2 and assuming $\chi^G = 0, \omega = 0,\ \psi^* = 0,$ and $A_t = \overline{A}$, under DCP, optimal monetary policy in the foreign sector is fully characterised by $R^*\beta = 1$.
Proof. *See Appendix A.*

Proof of Lemma 4A.
The proof is in two steps. First, I show that if utility is log-linear ($\psi = 0$) and productivity is constant ($A_{i,t} = \overline{A}$) marginal cost stabilization (79), which characterizes the optimal monetary policy, is achieved by $R_{i,t}\beta = 1$. By symmetry of countries in the foreign sector R^* is constant. Second, I verify that A.4 holds if $\omega = 1$.

Assuming CRRA utility with $\sigma = 1$, $\theta = 1$ and $\psi = 0$, (79) can be rewritten as,

$$\frac{P_{i,t}C_{i,t}}{A_{i,t}}\frac{\chi}{\kappa} = 1 \tag{80}$$

In turn, denoting $P_{i,t}C_{i,t} = \mu_t$, the nominal interest rate can be expressed as,

$$R_{i,t} = \frac{1}{\beta}\frac{\mu_t}{\mu_{t+1}} \tag{81}$$

If $A_{i,t} = \overline{A}_t$, from (80), μ_t must be constant. (Then, 81) implies $R_{i,t}\beta = 1$.

To complete the proof, I show A.4 is satisfied if $\omega^* = 1$. Since all countries $i > 0$ are symmetric, I assume $R_{i,t} = R^*$ for all $i > 0$. Furthermore, this implies $\mathcal{E}_{i,} = \mathcal{E}_t$ since $x_{i,t}$ is symmetric across i. Without loss of generality, financiers can then be assumed to trade in a dollar bond and a single foreign bond denominated in foreign currency. In foreign currency terms, using (72) portfolio returns for any country $i > 0$ can be expressed as,

$$\frac{1}{\mathcal{E}_t}F_t^* = \left[x_t^* - R^* x_{t-1}^* + \frac{1}{\mathcal{E}_t}Q_{t-1}\left(R_t - R_t^*\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right)\right] \tag{82}$$

From clearing in the \$ market $Q_{t-1}^{\$} = x_{t-1}$ (abstracting from other features of the IMS discussed below), and by financiers' zero-capital condition $Q_t + Q_t^*\mathcal{E}_t = 0$ where $-Q_{t-1}^*\mathcal{E}_{t-1} = -x^*\mathcal{E}_{t-1}$. Substituting this,

$$\frac{1}{\mathcal{E}_t}F_t^* = x_t^* - R^* x_{t-1}^* - \frac{\mathcal{E}_{t-1}}{\mathcal{E}_t}x_{t-1}^*\left(R_t - R_t^*\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right) \tag{83}$$

Finally, rearranging, and expressing in \$ terms,

$$F_t^* = -Q_t + R_t Q_{t-1}, \tag{84}$$

which is exogenous to monetary policy in $i > 0$. (84) reflects the net foreign asset position of the country, consolidating for international financiers balance sheets. This is consistent with Egorov and Mukhin (2019) who argue incomplete markets do not affect the policy of marginal cost stabilisation if a country issues debt in foreign currency. □

Extending Lemma 4A to ξ shocks Allowing for foreign \$ demand shocks,

$$\Pi_{t-1}^f = x_t^* - R^* x_{t-1}^* + \xi^*\left(R_t - R_t^*\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right), \tag{85}$$

$$Q_t^* = x_{t-1}^* + \xi_{t-1}^* \tag{86}$$

Substituting these quantities into (72) yields (84) therefore the policy response to fluctuations in ξ_t^* is a constant R^* policy for the foreign sector.

Intuitively, because of DCP, foreign countries cannot affect export or import prices and cannot generate expenditure switching beyond switching between domestic goods and imports. The optimal policy is to stabilize domestic firms' marginal costs to replicate part of the flexible price equilibrium. [43] With linear disutility of labour in the foreign sector ($\psi^* = 0$), this is achieved by a constant R^* as long as $A_t = \overline{A}$. Furthermore, as long as foreign households fully own financiers ($\omega = 0$) the country as a whole effectively issues debt in dollars. Consequently, monetary policy cannot affect asset pay-outs, is inward looking and finds it optimal to stabilize marginal costs.[44] While I focus on the DCP case, stabilisation of marginal costs is optimal under PCP as well, see e.g. Corsetti et al. (2007).

C Further derivations for Section 3: Analytical Hegemon's Dilemma

The exchange rate can be expressed as,

$$\mathcal{E}_1 = \overline{\mathcal{E}} \left(\frac{\beta}{\beta^*} \frac{\mu_1}{\overline{\mu}} + \frac{\tilde{\Gamma}_1}{\beta^*} Q_1 \right) \tag{87}$$

for a given monetary policy μ_1. For convenience, I repeat below the monetary policy rule:

$$\mu = \overline{\mu}(1 - s) + s\overline{\mu} \left(\frac{\beta^*}{\beta} \frac{\hat{\mathcal{E}}}{\overline{\mathcal{E}}} - \frac{\Gamma_1 Q_1}{\beta} \right) \tag{88}$$

If $\mu_1 = \overline{\mu}$ then dollar shortages or s is sufficiently low, then $dQ_1 < 0$ leads to an appreciation.

The derivatives $\frac{d\mu_1}{dQ_1}$ (given B_1) and $\frac{d\mu_1}{d\tilde{\Gamma}_1}$ characterize monetary decisions in response to dollar imbalances and liquidity and, in turn, these determine $\frac{d\mathcal{E}_1}{dQ_1}$, $\frac{d\mathcal{E}_1}{d\tilde{\Gamma}_1}$. Specifically,

$$\frac{d\mathcal{E}_1}{dB_1} = \left(\beta \frac{d\mu_1}{dQ_1} - \tilde{\Gamma}_1 \right) \frac{\overline{\mathcal{E}}}{\beta^*}, \tag{89}$$

$$\frac{d\mathcal{E}_1}{d\tilde{\Gamma}_1} = \left(\beta \frac{d\mu_1}{d\tilde{\Gamma}_1} - Q_1 \right) \frac{\overline{\mathcal{E}}}{\beta^*} \tag{90}$$

Consider the labour wedge τ_1, given by (31). The derivatives with respect to Q_1(holding B_1 and x_1 constant), B_1 and $\tilde{\Gamma}_1$ respectively:

$$\frac{d\tau_1}{dB_1} = -\frac{1}{A_1} \frac{\kappa}{\overline{p}_H} \left\{ \frac{d\mu_1}{dB_1} L_1^{\psi} + \mu\psi L^{\psi-1} \left[\frac{\chi}{\overline{p}_H} \frac{d\mu_1}{B_1} + \frac{\zeta}{\overline{p}_H} \mathcal{E}_1^{\eta-1} \eta \frac{d\mathcal{E}_1}{dB_1} \right] \right\}, \tag{91}$$

$$\frac{d\tau_1}{d\tilde{\Gamma}_1} = -\frac{1}{A_1} \frac{\kappa}{\overline{p}_H} \left\{ \frac{d\mu_1}{d\tilde{\Gamma}_1} L_1^{\psi} + \mu\psi L^{\psi-1} \left[\frac{\chi}{\overline{p}_H} \frac{d\mu_1}{d\tilde{\Gamma}_1} + \frac{\zeta}{\overline{p}_H} \mathcal{E}_1^{\eta-1} \eta \frac{d\mathcal{E}_1}{d\tilde{\Gamma}_1} \right] \right\}, \tag{92}$$

where $\frac{d\mu_1}{dB_1} = -\frac{s\overline{\mu}\Gamma_1}{\beta}$, and $\frac{d\mu_1}{d\Gamma_1} = -\frac{s\overline{\mu}\ Q_1}{\beta}$.

[43] This is a well understood result in the literature. Corsetti et al. (2007) show, in both complete and incomplete markets, that with perfectly rigid prices and DCP, a foreign economy takes as exogenous the terms of trade and pursues a monetary policy which stabilizes domestic marginal costs. Egorov and Mukhin (2019) show this result generalises to dynamic pricing with Rotemberg adjustment, the inclusion of intermediate goods and along other dimensions and show that the equilibrium for non-US countries is less efficient under DCP. The substantial difference relative to Corsetti et al. (2007) and Egorov and Mukhin (2019), is that I allow for financial market segmentation.

[44] Conversely, Egorov and Mukhin (2019) study a version with intermediate goods and find that whilst domestic price stabilisation is still the optimal policy, it is outward looking and part of a global monetary cycle.

Similarly, the derivatives of monopoly rents Ω_1^M with respect to B_1 and $\tilde{\Gamma}_1$ are as follows:

$$\frac{d\Omega_1^M}{dB_1} = \beta\frac{1}{\overline{\mu}}\frac{d\mu_1}{dB_1}(B_1 + x_1) + \beta\frac{\mu_1}{\overline{\mu}} - 1 + \omega\Gamma_1 2Q_1, \tag{93}$$

$$\frac{d\Omega_1^M}{d\Gamma_1} = \beta\frac{1}{\overline{\mu}}\frac{d\mu_1}{d\Gamma_1}(B_1 + x_1) + \omega Q_1,^2 \tag{94}$$

Additionally,

$$\frac{d\tau_1}{dQ_1} = -\frac{1}{A_1}\frac{\kappa}{\overline{p}_H}\left\{\frac{d\mu_1}{dQ_1}L_1^{\psi} + \mu\psi L^{\psi-1}\left[\frac{\chi}{\overline{p}_H}\frac{d\mu_1}{B_1} + \frac{\zeta}{\overline{p}_H}\mathcal{E}_1^{\eta-1}\eta\frac{d\mathcal{E}_1}{dQ_1}\right]\right\}, \tag{95}$$

$$\frac{d\Omega_1^M}{dQ_1} = \beta\frac{1}{\overline{\mu}}\frac{d\mu_1}{dQ_1}(B_1 + x_1) + \omega\Gamma_1 2Q_1, \tag{96}$$

and $\dfrac{d\mu_1}{dQ_1} = -\dfrac{s\overline{\mu}\Gamma_1}{\beta}$.

First, rearranging (95) and substituting (29), I derive $\dfrac{d\tau_1}{dQ_1} < 0$ if:

$$\frac{d\mu_1}{dQ_1} > -\frac{\frac{1}{\beta^*}\mu_1\psi L_1^{\psi-1}\frac{\zeta}{\overline{p}_H}\mathcal{E}_1^{\eta-1}\eta\overline{\mathcal{E}}\Gamma_1}{L_1^{\psi} + \mu_1 L_1^{\psi-1}\psi(\frac{\chi}{\overline{p}_H} + \frac{\zeta}{\overline{p}_H}\mathcal{E}_1^{\eta-1}\eta\overline{\mathcal{E}}\frac{\beta}{\beta^*}\frac{1}{\overline{\mu}})} \leftrightarrow \tag{97}$$

$$s < \frac{\frac{\mu_1}{\overline{\mu}}\frac{\beta}{\beta^*}\psi L^{\psi-1}\frac{\zeta}{\overline{p}_H}\eta\mathcal{E}^{\eta-1}\overline{\mathcal{E}}}{L_1^{\psi} + \mu_1\psi L^{\psi-1}\frac{\chi}{\overline{p}_H} + \frac{\mu_1}{\overline{\mu}}\frac{\beta}{\beta^*}\psi L^{\psi-1}\zeta\eta\mathcal{E}^{\eta-1}\overline{\mathcal{E}}} = \overline{s}$$

where $\overline{s} \in [0, 1]$. Using (96), $\dfrac{d\Omega_1^M}{dQ_1} < 0$ as long as $s > 0$ and $Q_1 < 0$. This yields the result (i).

Combining (33) and (34) with (91)-(92) yields the optimal allocation $\{B_1, \tilde{\Gamma}_1\}$. Consider the limit $\omega^S \to \infty$. If $\tilde{\Gamma}_1$ is bounded from below above zero, perfect stabilization can only be achieved if $dB_1 = -d\xi_1$, i.e the hegemon satisfies dollar excess demand by issuing dollar bonds. Instead, consider the limit $\omega^S \to 0$. Then, rearranging (33) and substituting (29):

$$-(B_1 + x_1)\left[2s\Gamma_1 - 2\omega\Gamma + \beta(1-s) + s\overline{\mu}\frac{\beta^*}{\beta}\frac{\hat{\mathcal{E}}}{\overline{\mathcal{E}}}\right] - 1 + s\Gamma_1\xi_1 - 2\omega\Gamma_1\xi_1 = 0 \leftrightarrow \tag{98}$$

$$B_1 + x_1 = \frac{\beta(1-s) + s\overline{\mu}\frac{\beta^*}{\beta}\frac{\hat{\mathcal{E}}}{\overline{\mathcal{E}}} - 1}{2\Gamma_1(s-\omega)} + \frac{\Gamma_1(s-2\omega)}{\Gamma_1(2s-2\omega)}\xi_1$$

From this, it follows that $0 < \frac{dB_1}{d\xi_1} < 1$ for a given level x_1 leading to $\frac{dQ_1}{d\xi_1} < 0$ for $\omega < \frac{s}{2}$. In other words, perfect stabilisation is not desirable. Additionally, $\frac{d\Omega_1^M}{d\Gamma_1} > 0$ as long as $B_1 + x_1 > 0$ and $Q < 0$ therefore dollar swaps are not used.

For intermediate values of ω^S, the hegemon trades off monopoly rent maximization for macroeconomic stabilisation requiring inefficiently high B_1, relative to (98). Given $\frac{d\tau_1}{d\Gamma_1} > 0$, $\frac{d\Omega_1^M}{d\Gamma_1} > 0$ if $Q_1 < 0$ and (100) is satisfied, then, from (34) we see that dollar swaps become useful as $|\tau - \overline{\tau}|$ grows. This completes the proof of (ii). □

Fiscal stabilisation and valuation effects Allowing for $\chi^G > 0$ and $\hat{\Psi}_1 = \Psi_1 + \Psi_1^* \mathcal{E}_1$, $\frac{d\Omega_1^M}{dQ_1} < 0$ as long as monetary policy is sufficiently responsive $s > \underline{s}$, where:

$$\underline{s} = \frac{2\omega Q_1 + \Psi_1^* \mathcal{E}_1 \frac{\beta}{\beta^*} \frac{1}{\mu}}{\frac{\beta}{\mu}(B_1 + x_1) + \Psi_1^* \mathcal{E}_1 \frac{\beta}{\beta^*} \frac{1}{\mu}} \tag{99}$$

On the other hand, $\frac{d\tau_1}{dQ_1} < 0$ if monetary policy is sufficiently unresponsive ($s > \overline{s}''$), where:

$$s'' < \frac{\frac{\mu_1}{\overline{\mu}} \frac{\beta}{\beta^*} \psi L^{\psi-1} \frac{\zeta}{\overline{p}_H} \eta \mathcal{E}^{\eta-1} \overline{\mathcal{E}} + \psi L^{\psi-1} \frac{\chi^G}{1-\chi^G} \Psi_1^* \overline{E} \frac{\mu_1}{\overline{\mu}}}{L_1^{\psi} + \mu_1 \psi L^{\psi-1} \frac{\chi}{\overline{p}_H} + \frac{\mu_1}{\overline{\mu}} \frac{\beta}{\beta^*} \psi L^{\psi-1} \zeta \eta \mathcal{E}^{\eta-1} \overline{\mathcal{E}} + \mu L^{\psi-1} \psi \frac{\chi^G}{1-\chi^G} \left(\Psi_1^* \frac{\overline{E}}{\overline{\mu}} \frac{\beta}{\beta^*} + \frac{\beta}{\overline{\mu}} B_1 \right)}$$

Additionally, s' is as above but with portfolio returns fixed such that:

$$s' < \frac{\frac{\mu_1}{\overline{\mu}} \frac{\beta}{\beta^*} \psi L^{\psi-1} \frac{\zeta}{\overline{p}_H} \eta \mathcal{E}^{\eta-1} \overline{\mathcal{E}}}{L_1^{\psi} + \mu_1 \psi L^{\psi-1} \frac{\chi}{\overline{p}_H} + \frac{\mu_1}{\overline{\mu}} \frac{\beta}{\beta^*} \psi L^{\psi-1} \zeta \eta \mathcal{E}^{\eta-1} \overline{\mathcal{E}} + \mu L^{\psi-1} \psi \frac{\chi^G}{1-\chi^G} + \frac{\beta}{\overline{\mu}} B_1}.$$

Cournot competition in issuance. I leverage the stylized framework to investigate the effects of competition in issuance of dollar (or close-substitute) assets, building on Farhi and Maggiori (2016). Dollar market clearing is therefore given by (21). Consider first the case $w^S = 0$ where the planner pursues a monopolist strategy and assume for simplicity that $\omega = 0$ and $\hat{\Psi}_t$ is a constant. Then, imposing symmetry, it can be shown that, [45]

$$B_1 = \frac{\xi_1 - x_1 - \sum_{i>0}^{N-1} x_1^i}{N+1}, \quad Q_1 = \frac{\xi_1 - x_1 - \sum_{i>0}^{N-1} x_1^i}{N}$$

As the number of competing issuers becomes large, dollar shortages go to zero. In the case $w^S = 1$, as detailed above, each individual issuer finds $Q_1 = 0$ optimal.

[45] To derive this, notice that (33) implies

$$B_1 = \frac{\xi_1 - x_1 - \sum_{i>0}^{N-1}(B_1^i + x_1^i)}{2},$$

Then impose $B_1^i = B_1$ for all i.

D Further derivations for Section 4: Constrained Optimal Allocation

Deriving indirect utility function To derive the indirect utility function, start from (1) and substitute in (7), (16) and (9):

$$V(C_{F,t},\mathcal{E}_t,G_{F,t}) = \chi \log\left(\frac{\chi}{1-\chi}S_tC_{F,t},\right) + (1-\chi)\log(C_{F,t}) \tag{100}$$
$$-\kappa\frac{\left(\frac{1}{A_t}\left[\frac{\chi}{1-\chi}\frac{\mathcal{E}_t^{\lambda}}{\overline{P}_{H,t}}C_{F,t},+(1-\chi)S_tC_t^* + \frac{\chi^G}{1-\chi^G}S_tG_{F,t}\right]\right)^{1-\psi}}{1-\psi}$$
$$+\omega^G\left[\chi^G\log(\frac{\chi^G}{1-\chi^G}S_t(G_{F,t}+\underline{G}_F)] + (1-\chi^G)\log(G_{F,t}+\underline{G}_F)\right]$$

Assuming prices are perfectly rigid, $P_{H,t}=\overline{P}_H$, $P_{F,t}=\overline{P}_F^*\mathcal{E}_t^{\lambda}$, therefore $V(C_{F,t},S_t,G_{F,t}) = V(C_{F,t},\mathcal{E}_t,G_{F,t})$. With perfectly rigid prices, the firms' pricing condition (11), is not a constraint in equilibrium on the planning problem, but is instead used to back out prices. To yield the planner's maximization in Section 4, note also that,

$$C_H^* = \frac{\chi}{1-\chi}\left(\frac{P^*}{P_H^*}\right)^{\eta}C^* = \underbrace{\frac{\chi}{1-\chi}\mu^*}_{\zeta}\left(\frac{\mathcal{E}_t}{\overline{P}_H}\right)^{\eta}, \tag{101}$$

therefore $C_H^* = \zeta\left(\frac{\mathcal{E}_t}{\overline{P}_H}\right)^{\eta}$.

When prices are flexible, $V(C_{F,t},S_t,G_{F,t})$ can be rewritten as $V^{flex}(C_{F,t},G_{F,t})$ using the following condition relating S_t and $C_{F,t}$, derived from (31) and setting $\tau_t=0$:

$$\frac{1}{A_t}\frac{\kappa}{1-\chi}\frac{S_t}{\overline{P}_H}C_{F,t}\left[\frac{1}{A_t}\left(\frac{\chi}{1-\chi}\frac{S_t}{\overline{P}_H}C_{F,t}+(1-\chi)S_tC_t^*+\frac{\chi^G}{1-\chi^G}S_tG_{F,t}\right)\right] = 1 \tag{102}$$

which can be rearranged to yield $S_t(C_{F,t})$.

The partial derivatives with respect to $C_{F,t},\mathcal{E}_t$ and $G_{F,t}$ respectively, are give by,

$$V_{C_{F,t}} = \frac{1-\chi}{C_{F,t}}\left(1+\frac{\chi}{1-\chi}\tau_t\right), \tag{103}$$
$$V_{\mathcal{E}_t} = \frac{1-\chi}{C_{F,t}}\left(\mathcal{E}_t^{-1}\tau_t\left(\frac{\chi}{1-\chi}\lambda C_{F,t}+\zeta\mathcal{E}_t^{1-\lambda}+\frac{\chi^G}{1-\chi^G}\lambda G_{F,t}\right)-\zeta\mathcal{E}_t^{-\lambda}-\frac{\chi^G}{1-\chi^G}\lambda\mathcal{E}_t^{-1}G_{F,t}\right) \tag{104}$$
$$+\omega^G\frac{1-\chi^G}{G_{F,t}+\underline{G}_F}\frac{\chi^G}{1-\chi^G}\lambda\mathcal{E}_t^{-1}G_{F,t},$$
$$V_{G_{F,t}} = \frac{1-\chi}{C_{F,t}}(\tau_t-1)\frac{\chi^G}{1-\chi^G}+\omega^G\left\{\frac{1-\chi^G}{G_{F,t}+\underline{G}_F}\left(\frac{1}{1-\chi^G}\right)\right\} \tag{105}$$

The planner's first order conditions for (HD2), with respect to $C_{F,t},\mathcal{E}_t,x_t,G_{F,t}$ and B_t respectively, are given by:

$$C_{F,t}: \qquad \beta^t V_{C_{F,t}} - \eta_{1,t} - \eta_{2,t} + \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}^2}\left[\eta_t^E \frac{1}{R_t} - \eta_{t-1}^E\right] = 0, \tag{106}$$

$$\mathcal{E}_t: \qquad \beta^t V_{\mathcal{E}_t} + \eta_t^C \zeta(\eta-\lambda)\mathcal{E}_t^{\eta-\lambda-1} - \eta_t^C \left\{\lambda \mathcal{E}_t^{-\lambda-1}\kappa^G \Psi_t^G - (1-\lambda)\mathcal{E}_t^{-\lambda}\Psi_t^*\right\} \tag{107}$$

$$+ \eta_t^C \left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}} x_t + \lambda \mathcal{E}_t^{-\lambda-1}(x_{t-1} + \kappa^G B_{t-1}) + \lambda \mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t^2(1-\omega) + \lambda \mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t(\xi_t - B_t)\right\}$$

$$- \frac{1}{\beta}\eta_{t-1}^C \frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2} x_{t-1} + \eta_t^G \left\{-\lambda \mathcal{E}_t^{-\lambda-1}\Psi_t(1-\kappa^G) + (1-\lambda)\Psi^* \mathcal{E}_t^{-\lambda}(1-\kappa^G)\right\}$$

$$+ \eta_t^G \left\{\frac{1}{R^*}\frac{\mathcal{E}_t^{-\lambda}(1-\lambda)}{\mathcal{E}_{t+1}} B_t + \lambda \mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t + \lambda \mathcal{E}_t^{-\lambda-1}(1-\kappa^G) B_{t-1}\right\} - \eta_{t-1}^G \frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}{}^{1-\lambda}}{\mathcal{E}_t^2} B_{t-1}$$

$$- \eta_t^E \frac{1}{C_{F,t}}\left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}} + \lambda \mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t B_t\right\} + \eta_{t-1}^E \frac{1}{C_{F,t}}\left\{\frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}\right\},$$

$$- \eta_t^\mu \lambda \mathcal{E}_t^{-\lambda-1}\mu(1-\chi) = 0,$$

$$x_t: \qquad \eta_t^C \mathcal{E}_t^{-\lambda}\left[\frac{1}{R_t} - \Gamma_t x_t + 2\omega\Gamma_t Q_t\right] - \beta\eta_{t+1}^C \mathcal{E}_{t+1}^{-\lambda} - \eta_t^G \mathcal{E}_t^{-\lambda}\Gamma_t B_t + \eta_t^E \left\{\Gamma_t \tfrac{1}{\mathcal{E}_t^{\lambda} C_{F,t}}\right\} = 0, \tag{108}$$

$$G_{F,t}: \qquad \beta^t V_{G_{F,t}} + \eta_t^C \left\{\frac{\chi^G - \kappa^G}{1-\chi^G}\right\} - \eta_t^G \left\{\frac{1-\kappa^G}{1-\chi^G}\right\} = 0, \tag{109}$$

$$B_t: \qquad \eta_t^G \mathcal{E}_t^{-\lambda}\frac{1}{R_t} = \beta\eta_{t+1}^G \mathcal{E}_{t+1}^{-\lambda}(1-\kappa^G) + \beta\eta_{t+1}^C \mathcal{E}_{t+1}^{-\lambda}\kappa^G + \tag{110}$$

$$\Gamma_t \left\{\eta_t^G \mathcal{E}_t^{-\lambda} B_t + \eta_t^C \mathcal{E}_t^{-\lambda}(x_t - 2\omega Q_t)\right\} - \eta_t^E \Gamma_t \tfrac{1}{\mathcal{E}_t^{\lambda} C_{F,t}} = 0$$

Focusing on monetary policy, using (107), (41) follows from:

$$\frac{dC^*_{H,t}}{d\mathcal{E}_t} = \zeta(\eta-\lambda)\mathcal{E}_t^{\eta-\lambda-1}, \tag{111}$$

$$\frac{dF_t}{d\mathcal{E}_t} = -\left(\lambda\mathcal{E}_t^{-\lambda-1}\kappa^G\Psi_t^G - (1-\lambda)\mathcal{E}_t^{-\lambda}\Psi_t^*\right) + \tag{112}$$

$$\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}}x_t + \lambda\mathcal{E}_t^{-\lambda-1}(x_{t-1}+\kappa^G B_{t-1}) + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t^2(1-\omega) + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t(\xi_t - B_t),$$

$$\frac{dF_{t-1}}{d\mathcal{E}_t} = -\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}x_{t-1} \tag{113}$$

$$\frac{dF_t^G}{d\mathcal{E}_t} = \frac{1}{R^*}\frac{\mathcal{E}_t^{-\lambda}(1-\lambda)}{\mathcal{E}_{t+1}}B_t + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t + \lambda\mathcal{E}_t^{-\lambda-1}(1-\kappa^G)B_{t-1} \tag{114}$$

$$\frac{dF_{t-1}^G}{d\mathcal{E}_t} = -\frac{1}{R^*}\frac{\mathcal{E}_{t-1}}{\mathcal{E}_t^2}B_{t-1}, \tag{115}$$

$$\frac{dR_t}{d\mathcal{E}_t} = -\frac{1}{C_{F,t}}\left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}} + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t\right\}, \tag{116}$$

$$\frac{dR_{t-1}}{d\mathcal{E}_t} = \frac{1}{C_{F,t}}\left\{\frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}\right\} \tag{117}$$

The FOC wrt. $\mathcal{E}_t$ (107) characterises optimal monetary policy. If monetary policy is unresponsive, then (107) determines the multiplier on constraint (**??**) denoted η_t^μ. If monetary policy is optimally set, $\eta_t^\mu = 0$. The FOC wrt. x_t (133 characterizes optimal borrowing by households, from the country (planner's) perspective. If macroprudential taxation is not available , this is replaced by (5).

E Further Derivations for Section 5 : Limited Financial Market Participation

Proof to Proposition 4.

Consider the market clearing equation (9) with $C_{H,t} = \mathbf{a}_t C^A_{H,t} + (1-\mathbf{a}_t)C^{NA}_{H,t}$. Assume equal rationing of profits and employment such that $\Pi^i = \Pi$, $l^i = L$, we can express inactive households' consumption by,

$$C^{NA}_{F,t} \leq \mathcal{E}_t^{-\lambda}\left[\frac{\mathbf{a}_t\chi}{1-(1-\mathbf{a}_t)\chi}\mathcal{E}_t^{\lambda}C^A_{F,t} + \frac{1-\chi}{1-(1-\mathbf{a}_t)\chi}\left(\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}\right)\right] \tag{118}$$

Similarly, evaluating the budget constraint (4) for active households' and substituting (9) yields,

$$C^A_{F,t}\left(1+\frac{\chi}{1-\chi}(1-\mathbf{a}_t\right) \leq \mathcal{E}_t^{-\lambda}\Bigg[(1-\mathbf{a}_t)\frac{\chi}{1-\chi}\mathcal{E}_t C^{NA}_{F,t} + \zeta\mathcal{E}_t^{\eta} + \frac{\chi^G-\kappa^G}{1-\chi^G}P_{F,t}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}) \tag{119}$$

$$\frac{1}{R_t}x_t - x_{t-1} + \omega\Gamma_t Q_t^2\Bigg] \tag{120}$$

Solving (118) and (120) jointly and substituting T_t yields :

$$C^A_{F,t} \leq \mathcal{E}_t^{-\lambda}\Big[\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G - \kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}) + (1-(1-\alpha)\chi)\left(\frac{1}{R_t}x_t - x_{t-1}\right) + \omega\Gamma_t Q_t^2\Big], \tag{121}$$

as detailed in (51). Substituting back into (118) yields:

$$C^{NA}_{F,t} \leq \mathcal{E}_t^{-\lambda}\Big[\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G - \kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1} + (\alpha\chi)\left(\frac{1}{R_t}x_t - x_{t-1}\right) + \omega\Gamma_t Q_t^2\Big], \tag{122}$$

Substituting the above into market clearing yields:

$$L_t = \frac{1}{A_t}\frac{\mathcal{E}_t^{\lambda}}{\overline{P}_{H,t}}\left(\frac{\chi}{1-\chi}\frac{\mathbf{a}_t}{1-(1-\mathbf{a}_t)\chi}C^A_{F,t} + \frac{(1-\alpha)\chi}{1-(1-\mathbf{a}_t)\chi}\left(\zeta\mathcal{E}^{\eta-\lambda} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1})\right)\right) \tag{123}$$

which can be re-written as:

$$L_t = \frac{1}{A_t}\frac{1}{\overline{P}_{H,t}}\frac{\chi}{1-\chi}\left\{\zeta\mathcal{E}^{\eta-\lambda} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1})\right\} + \frac{1}{A_t}\frac{1}{\overline{P}_{H,t}}\frac{\chi}{1-\chi}\left(\frac{1}{R_t}x_t - x_{t-1} + \omega\Gamma_t Q_t^2\right) \tag{124}$$

Total financial rents are given by $[\mathbf{a}_t(1-(1-\mathbf{a}_t)\chi) + (1-\mathbf{a}_t)\mathbf{a}_t\chi]\left(\frac{1}{R_t}x_t - x_{t-1}\right) + \alpha\frac{\omega}{\alpha}\Gamma_t Q_t^2 = \mathbf{a}_t(x_t - R_{t-1}x_{t-1}) + \omega\Gamma_t Q_t^2$ and total export revenues are given by $(\mathbf{a}_t + (1-\mathbf{a}_t))\zeta\mathcal{E}_t^{-1} = \zeta\mathcal{E}_t^{-1}$. □

With limited financial market participation, the indirect utility function for the hegemon planner is given by,

$$V\left(C^A_{F,t}, C^{NA}_{F,t}, \mathcal{E}_t^{\lambda}G_{F,t}; \boldsymbol{\lambda}, \mathbf{a}_t\right) = \mathbf{a}_t\,\mathcal{U}\left(\frac{\chi}{1-\chi}\mathcal{E}_t^{\lambda}\frac{\overline{P}^*_{F,t}}{\overline{P}_{H,t}}C^A_{F,t}, C^A_{F,t}, L_t\right) + (1-\mathbf{a}_t)\mathcal{U}\left(\frac{\chi}{1-\chi}\mathcal{E}_t^{\lambda}\frac{\overline{P}^*_{F,t}}{\overline{P}_{H,t}}C^{NA}_{F,t}, C^{NA}_{F,t}, L_t\right), + \omega^G\left[\chi^G\log(\frac{\chi^G}{1-\chi^G}S_t(G_{F,t} + \underline{G}_F)] + (1-\chi^G)\log(G_{F,t} + \underline{G}_F)\right] \tag{125}$$

where $C^A_{F,t}$ is given by (120), $C^{NA}_{F,t}$ is given by (122) and $L^A_t = L^{NA}_t$ is given by (123).

The partial derivatives of the indirect utility function with respect to $C^A_{F,t}$, $C^{NA}_{F,t}$ and $\mathcal{E}_t$ are given,respectively, by:

$$V_{C^A_{F,t}} = \alpha\lambda^A\frac{1-\chi}{C^A_{F,t}}\left(1 + \frac{\chi}{1-\chi}\tau^A_t\right), \tag{126}$$

$$V_{C^{NA}_{F,t}} = (1-\alpha)\lambda^A\frac{1-\chi}{C^{NA}_{F,t}}\left(1 + \frac{\chi}{1-\chi}\tau^{NA}_t\right) \tag{127}$$

$$V_{\mathcal{E}_t}(C_{F,t},\mathcal{E}_t;\mathbf{a}_t) = \mathbf{a}_t\lambda^A \frac{1-\chi}{C^A_{F,t}}\Bigg\{\frac{\chi}{1-\chi}C^A_{F,t}\lambda\mathcal{E}_t^{-1}+ \tag{128}$$

$$(\tau_t^A-1)\left(\frac{\chi}{1-\chi}\mathbf{a}_t\lambda\mathcal{E}_t^{-1}C^A_{F,t}+\frac{\chi}{1-\chi}(1-\mathbf{a}_t)\lambda\mathcal{E}_t^{-1}C^{NA}_{F,t}+\zeta\eta\mathcal{E}_t^{\eta-\lambda-1}+\frac{\chi^G}{1-\chi^G}\lambda\mathcal{E}_t^{-1}(G_{F,t}+\underline{G}_{F,t})\right)\Bigg\}$$

$$(1-\mathbf{a}_t)\lambda^{NA}\frac{1-\chi}{C^{NA}_{F,t}}\Bigg\{\frac{\chi}{1-\chi}C^A_{F,t}\lambda\mathcal{E}_t^{-1}+$$

$$(\tau_t^{NA}-1)\left(\frac{\chi}{1-\chi}\mathbf{a}_t\lambda\mathcal{E}_t^{-1}C^A_{F,t}+\frac{\chi}{1-\chi}(1-\mathbf{a}_t)\lambda\mathcal{E}_t^{-1}C^{NA}_{F,t}+\zeta\eta\mathcal{E}_t^{\eta-\lambda-1}+\frac{\chi^G}{1-\chi^G}\lambda\mathcal{E}_t^{-1}(G_{F,t}+\underline{G}_{F,t})\right)\Bigg\}$$

The condition characterising unresponsive monetary policy is given by,

$$\overline{P}^*_{F,t}\mathcal{E}_t^\lambda C^A_{F,t} = \mu(1-\chi), \tag{129}$$

where μ is a synthetic monetary instrument. If μ_t/μ_{t+1} is constant, $R_t=\frac{1}{\beta}$. The Euler equation is unchanged, but evaluated at active household consumption only (49).

The hegemon maximizes (125) subject to (120) and (120), where L_t by (123). The optimal allocation is characterized by the following first order conditions with respect to $C^A_{F,t}, C^{NA}_{F,t}, x_t, \mathcal{E}_t, G_{F,t}$ and B_t :

$$C^A_{F,t}: \qquad \beta^t V_{C^A_{F,t}} - \mathbf{a}\eta^A_t - \eta^\mu_t + \frac{1}{\mathcal{E}_t^\lambda C^2_{F,t}}\left[\eta^E_t\frac{1}{R_t}-\eta^E_{t-1}\right]=0, \tag{130}$$

$$C^{NA}_{F,t}: \qquad \beta^t V_{C^{NA}_{F,t}} - (1-\mathbf{a})\eta^{NA}_t = 0, \tag{131}$$

$$\mathcal{E}_t: \qquad \beta^t V_{\mathcal{E}_t} + [\mathbf{a}\eta^A_t+(1-\mathbf{a})\eta^{NA}_t]\left\{\zeta(\eta-\lambda)\mathcal{E}_t^{\eta-\lambda-1}-\left(\lambda\mathcal{E}_t^{-\lambda-1}\kappa^G\Psi^G_t-(1-\lambda)\mathcal{E}_t^{-\lambda}\Psi^*_t\right)\right\} \tag{132}$$

$$+[\mathbf{a}\eta^A_t(1-(1-\mathbf{a})\chi)+(1-\mathbf{a})\eta^{NA}_t\mathbf{a}\chi]\Bigg\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}}x_t+\lambda\mathcal{E}_t^{-\lambda-1}(x_{t-1}+\kappa^G B_{t-1})+$$

$$\lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t^2(1-\omega)+\lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t(\xi_t-B_t)\Bigg\}-\frac{1}{\beta}[\mathbf{a}\eta^A_{t-1}(1-(1-\mathbf{a})\chi)+(1-\mathbf{a})\eta^{NA}_{t-1}\mathbf{a}\chi]\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}x_{t-1}$$

$$+\eta^G_t\left\{-\lambda\mathcal{E}_t^{-\lambda-1}\Psi_t(1-\kappa^G)+(1-\lambda)\Psi^*\mathcal{E}_t^{-\lambda}(1-\kappa^G)\right\}$$

$$+\eta^G_t\left\{\frac{1}{R^*}\frac{\mathcal{E}_t^{-\lambda}(1-\lambda)}{\mathcal{E}_{t+1}}B_t+\lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t B_t+\lambda\mathcal{E}_t^{-\lambda-1}(1-\kappa^G)B_{t-1}\right\}-\eta^G_{t-1}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}}{\mathcal{E}_t^2}B_{t-1}$$

$$-\eta^E_t\frac{1}{C_{F,t}}\left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}}+\lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t\right\}+\eta^E_{t-1}\frac{1}{C_{F,t}}\left\{\frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}\right\},$$

$$-\eta^\mu_t\lambda\mathcal{E}_t^{-\lambda-1}\mu(1-\chi)=0,$$

$$x_t: \quad [\mathbf{a}\eta_t^A(1-(1-\mathbf{a})\chi)+(1-\mathbf{a})\eta_t^{NA}\mathbf{a}\chi)]\mathcal{E}_t^{-\lambda}\left[\frac{1}{R_t}-\mathbf{a}\Gamma_t x_t+2\omega\mathbf{a}\Gamma_t Q_t\right]- \tag{133}$$

$$\beta[\mathbf{a}\eta_{t+1}^A(1-(1-\mathbf{a})\chi)+(1-\mathbf{a})\eta_{t+1}^{NA}\mathbf{a}\chi)]\mathcal{E}_{t+1}^{-\lambda}-\eta_t^G\mathcal{E}_t^{-\lambda}\mathbf{a}\Gamma_t B_t+\eta_t^E\left\{\mathbf{a}\Gamma_t\tfrac{1}{\mathcal{E}_t^{\lambda}C_{F,t}}\right\}=0,$$

$$G_{F,t}: \quad \beta^t V_{G_{F,t}}+[\mathbf{a}\eta_t^A+(1-\mathbf{a})\eta_t^{NA}]\left\{\frac{\chi^G-\kappa^G}{1-\chi^G}\right\}-\eta_t^G\left\{\frac{1-\kappa^G}{1-\chi^G}\right\}=0, \tag{134}$$

$$B_t: \quad \eta_t^G\mathcal{E}_t^{-\lambda}\frac{1}{R_t}=\beta\eta_{t+1}^G\mathcal{E}_{t+1}^{-\lambda}(1-\kappa^G)+\beta[\mathbf{a}\eta_{t+1}^A+(1-\mathbf{a})\eta_{t+1}^{NA}]\mathcal{E}_{t+1}^{-\lambda}\kappa^G+ \tag{135}$$

$$\Gamma_t\left\{\eta_t^G\mathcal{E}_t^{-\lambda}B_t+[\mathbf{a}\eta_t^A(1-(1-\mathbf{a})\chi)+(1-\mathbf{a})\eta_t^{NA}\mathbf{a}\chi]\mathcal{E}_t^{-\lambda}(x_t-2\omega Q_t)\right\}-\eta_t^E\Gamma_t\tfrac{1}{\mathcal{E}_t^{-\lambda}C_{F,t}}=0$$

F Further Results for Calibration Exercise

Below, I provide further results for the calibration exercise in Section 5. The next two figure plot the impulse response of key quantities in the model, under different monetary policy regimes. First, Figure 15 shows the impulse response of the spread in the cost of borrowing in dollars vis-a-vis foreign currency. The impact is close to the empirical values presented in Figure 1.

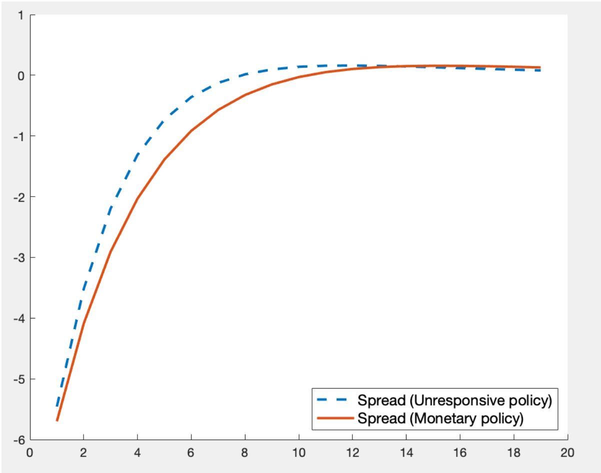


Figure 16: Impulse response to $\xi^{>}0$. Difference in cost of borrowing in dollars vis-a-vis foreign currency expressed in % (quarterly) , if interest rates are fixed or monetary policy is optimally set.

Next, Figure 17 illustrates the impulse response for the ramsey multiplier on the Euler equation η_t^E, given by (39). The multiplier takes a positive value if there is over-borrowing by prviate households in the economy and is zero if an optimal borrowing tax is levied. The figure below illustrates that monetary policy alone, is able to partly narrow η_t^E, but over-borrowing persists absent the optimal borrowing tax.

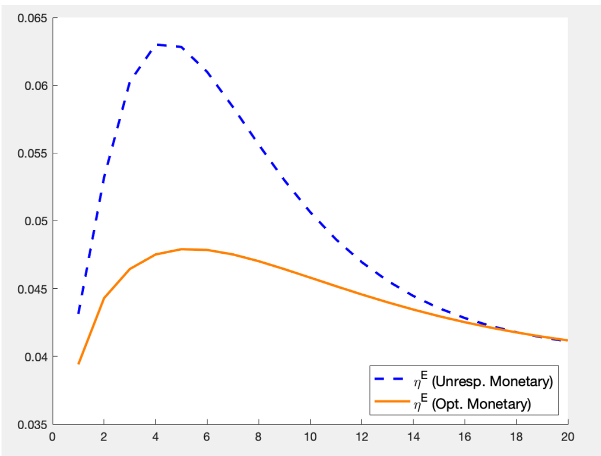


Figure 17: Impulse response to $\xi > 0$. Difference in cost of borrowing in dollars vis-a-vis foreign currency expressed in %, if interest rates are fixed or monetary policy is optimally set.

Figure 18 details the labour wedge for the two household groups at the constrained optimal allocation.

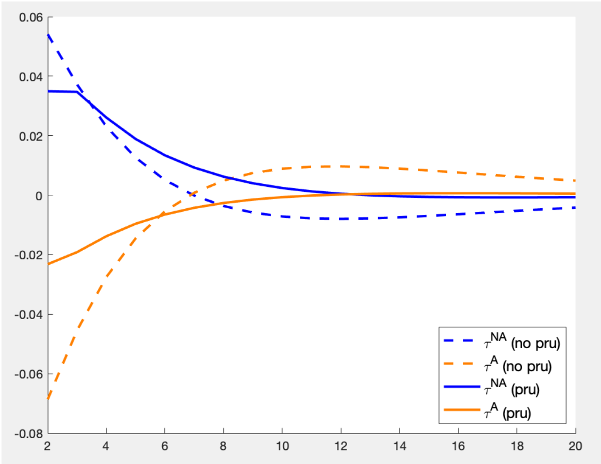


Figure 18: Impulse response to $\xi > 0$. Labour wedge for active and inactive households when a borrowing tax is and is not available, and monetary policy is optimally set.

Impulse Responses for Allocations. The next three figure plot consumption allocations and hours worked under different policy regimes.

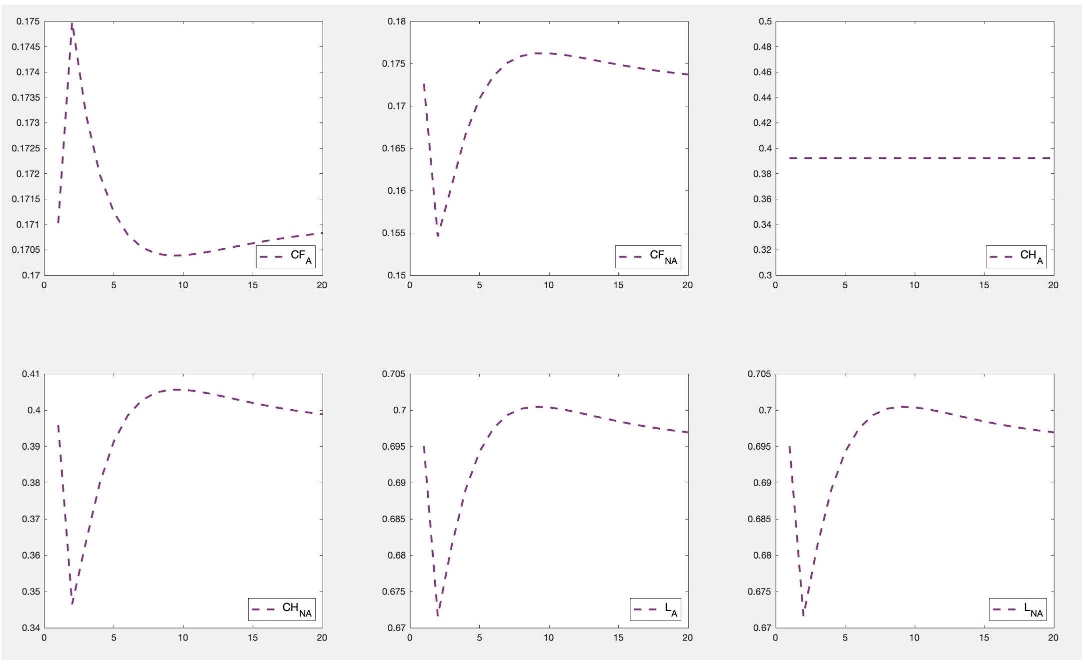


Figure 19: Impulse response to $\xi > 0$. Allocations when interest rates are held constant.

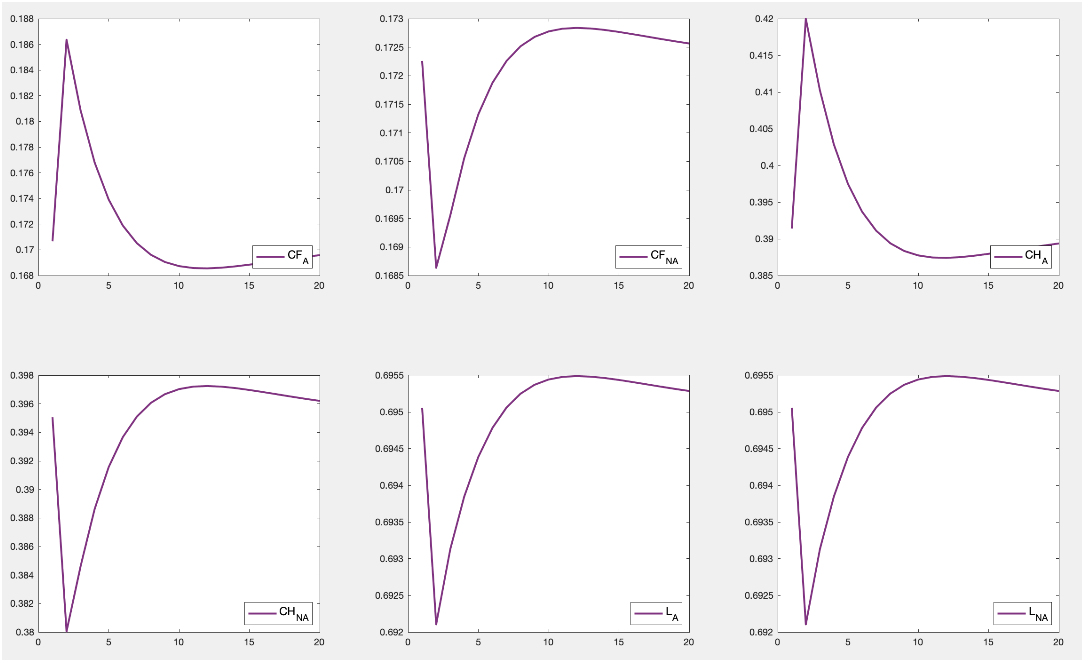


Figure 20: Impulse response to $\xi > 0$. Allocations when monetary policy is optimally set.

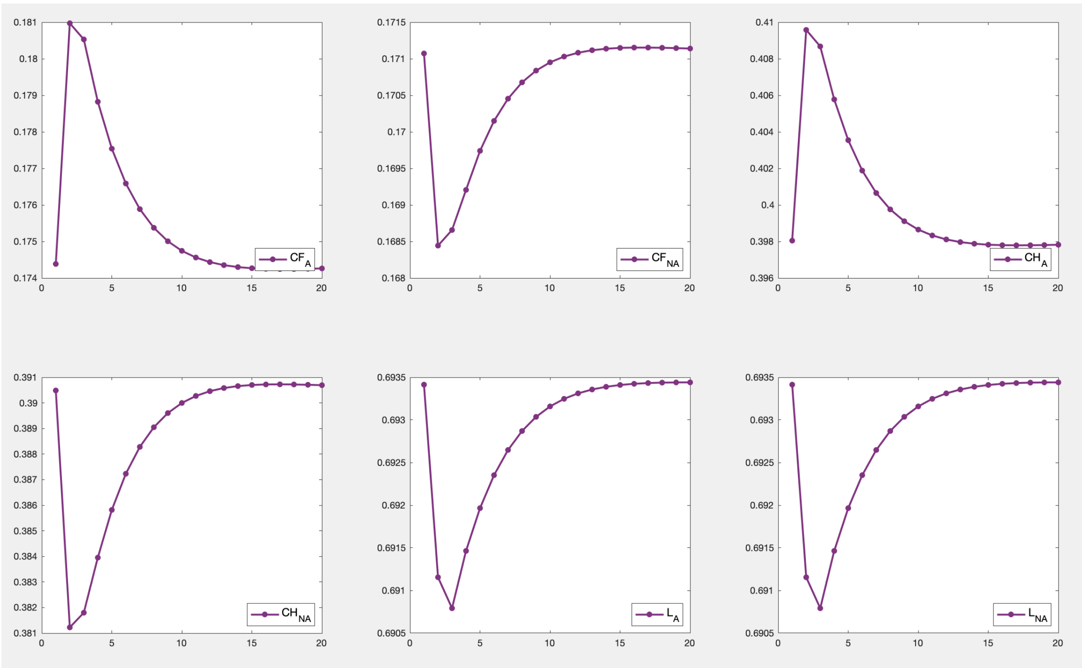


Figure 21: Impulse response to $\xi > 0$. Allocations at the constrained optimal allocation (monetary policy+optimal borrowing tax).

Welfare under DCP. Finally, Table 3 below repeats the welfare analysis in Table 2 for the case of $\lambda = 1$, i.e the producer currency pricing benchmark.

	Active	Inactive	Aggregate
Unresponsive monetary (no macropru.)	0.054%	0.068%	0.058%
Optimal monetary (no macropru.)	-0.07%	0.0037%	-0.048%
Constrained Optimal	-0.19%	0.047%	-0.13%

Table 3: Hicksian welfare transfers under different policy regimes, in response to a one-off, unanticipated dollar-asset demand shock.