The Hegemon's Dilemma.*

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November 30, 2021

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Abstract

By keeping dollars scarce in international markets,the U.S. – the hegemon – earns monopoly rents when borrowing in dollar debt and investing in foreign currency assets. In equilibrium, these rents both result in a strong dollar, which depresses global demand for its exports and leads to losses on holdings of foreign assets, and give rise to private sector over-borrowing. Using an open economy model with nominal rigidities and segmented financial markets, I show that, because of over-borrowing, monetary and fiscal policy alone cannot achieve the constrained efficient allocation. Absent corrective macro-prudential taxes on capital inflows, the hegemon is faced with a policy dilemma between achieving efficient stabilization *or* maximizing monopoly rents. By increasing liquidity in international markets, dollar swap lines extended by the central bank improve stabilization, but, unlike macro-prudential taxes, do so at the cost of eroding monopoly rents. The dilemma maps into distributional concerns. A scarce dollar leads to larger monopoly rents which benefit financially-active households, but they over-borrow at the expense of inactive households, who suffer the full blunt of aggregate demand externalities.

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

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*I thank Fernando Alvarez, Gianluca Benigno, Charles Brendon, Vasco Carvalho, 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, Oxford NuCamp Virtual PhD Workshop 2020 and SED 2021 for useful comments and discussions. I acknowledge financial support from the Keynes Fund (JHUK).

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1 Introduction

In periods of global financial distress, international capital systematically flows into dollar assets. This pattern has been confirmed, on a large scale, during the 2007-9 Great Financial Crisis (GFC) and the early-stages of the Covid-19 pandemic in March 2020. As the dollar becomes scarce in international markets, it tends to appreciate and the return on a portfolio that is long in dollar bonds, funded by borrowing in foreign currencies becomes significantly negative. Yet, foreign investors still demand dollar debt in large quantities.[1] Because of the specialness of the dollar, fluctuations in the supply and demand of dollar assets matter disproportionately in the world economy, as does the conduct of U.S. policy.[2] In particular, Rey (2015) shows that, because of a global financial cycle in asset prices driven by the dollar, countries in the rest of the world cannot set monetary policy independently, unless they sacrifice the free mobility of capital. Strong and volatile demand for dollars by foreign investors, however, also has stark implications for U.S. domestic outcomes as the losses incurred by foreign investors result in a transfer of wealth to the U.S. Additionally, dollar shortages abroad can interfere with the workings of U.S. monetary and fiscal policy, resulting in a need for new instruments such as the direct provision of dollar liquidty to foreign markets by the Federal Reserve.

To set the stage for my analysis, Figure 1 plots the realized (ex-post) return on a portfolio long in dollar bonds funded by borrowing in foreign currency debt, and its decomposition into a trade-weighted dollar index and interest rate differentials. Three important facts arise. First, during periods of international financial turmoil (particularly the GFC and COVID-19) foreign investors forego significant returns to hold a portfolio of dollar debt which they finance by borrowing in foreign currency during crises, see Panel (a). For example, the return on this portfolio in August 2008 was -6% over the next 12 months.[3] Second, the portfolio losses are predominantly due to currency movements. The dollar appreciates sharply at the onset of the crisis and depreciates steadily thereafter. Intuitively, foreign currencies which tend to contemporaneously depreciate vis-á-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. Third, the dollar tends to stop appreciating and the borrowing spread systematically narrows when dollar swap lines (discussed below) are used.

The contribution of this paper is to re-consider the trade-off faced by the hegemon, as issuer of dollar assets, and show why this results in a policy dilemma between efficiently stabilizing internal objectives (output and prices) *or* maximizing monopoly rents earned in international

[1]Aldasoro et al. (2020) document that in June 2018, non-U.S. banks had a total of \$12.8 trillion of dollar-denominated borrowing, used to finance purchases of U.S. assets. Maggiori, Neiman, and Schreger (2018) document a longer trend that the international allocation of capital is increasingly biased towards the U.S.

[2]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)). Kalemli-Ozcan (2019), Miranda-Agrippino and Rey (2020), and Jiang, Krishnamurthy, and Lustig (2020), amongst others, show that U.S. monetary policy has large spillovers in foreign and particularly emerging economies.

[3]Critically, foreign investors have very poor market timing when purchasing dollar bonds implying that they tend to buy dollar bonds when the price of dollars is high, as documented in Krishnamurthy and Lustig (2019). Appendix A contains further details on the construction of Figures 1, and provides further evidence on the returns across country groups and the timing of purchases by foreign investors.

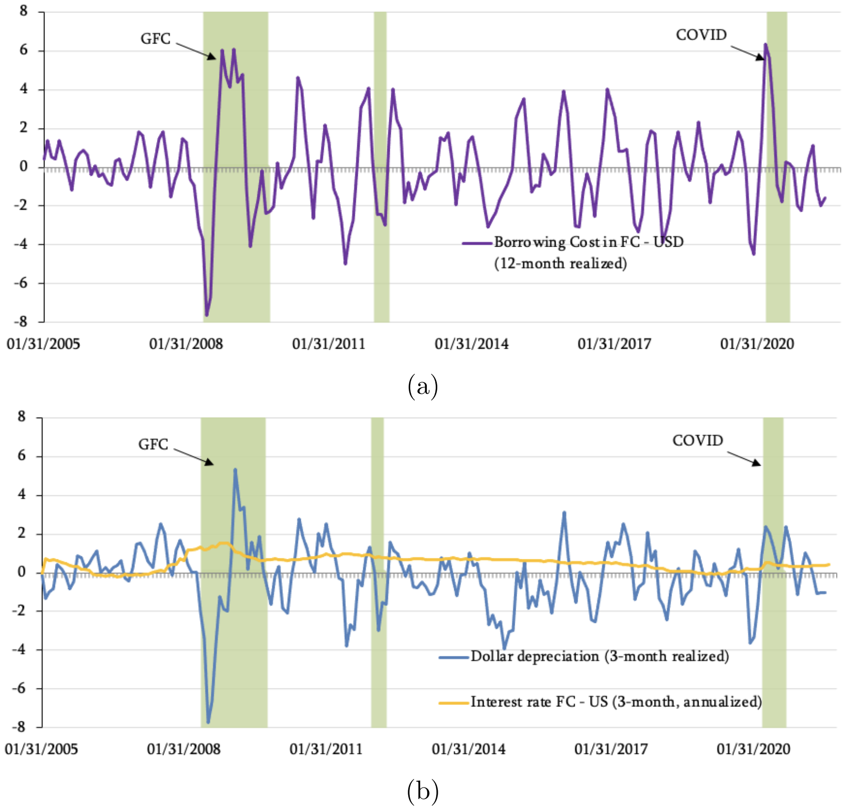


Figure 1: (a) 2-month forward sum of ex-post deviations from the uncovered interest rate parity (UIP) based on a trade-weighted average of G10 and EM7 currencies in *p.p.* (b) 3-month Interest rate differentials, 3-month dollar index movements Shaded regions reflect periods when dollar swap facilities exceeded $60000 million. Source: Global Financial Data, Federal Reserve and author's calculations.

financial markets. The trade-off is driven by the following. A scarce dollar leads to lower borrowing costs for both U.S. households and the government – specifically, a higher return on the net investment position– interpretable as monopoly rents from issuing dollar debt (see also Farhi and Maggiori (2016)), which result in a transfer into the U.S. As this transfer leads to an equilibrium appreciation of the dollar, the global demand for U.S. exports falls, resulting in unemployment and, on impact, losses on the (large) portfolio of foreign-currency denominated assets held by the U.S.[4] Critically, however, monopoly rents also lead the private sector to over-borrow in international markets.

The central result in this paper is to show that, in the absence of an optimal macro-prudential tax to correct over-borrowing, monetary and fiscal policy alone are unable to support the constrained efficient allocation when there are dollar shortages abroad. Namely, vis-à-vis the presence of monopoly rents putting pressure on the dollar to appreciate, output and inflation stabilization requires policy rates to be cut; reducing the incentive for households to borrow

[4]As documented in Figure 1, a portfolio funded by dollar borrowing and long in foreign assets suffers losses at the onset of the crisis. However, this is followed by large returns during the crisis. Because of the higher expected returns on the U.S. portfolio (a "capitalization" effect), Jiang, Krishnamurthy, and Lustig (2020) document a wealth inflow to the U.S. during the GFC. This net wealth flow is debated in the literature: on empirical grounds, Maggiori (2017) and Gourinchas, Rey, and Govillot (2018) find evidence of losses for the U.S., albeit using a narrower definition for wealth. See Appendix A for a comparison of the results in the two papers.

inefficiently from abroad requires rates to be raised. To best appreciate the implications of the policy dilemma, I additionally consider the distributional consequences of dollar shortages and the ability of policy to efficiently assign resources across households in the hegemon. Extending the model to allow for the fact that, realistically, only a measure of households participates in financial markets, I show that dollar shortages systematically favour active households, and these households over-borrow at the expense of their financially-inactive counterparts.

I adopt a standard open-economy model, featuring nominal rigidities and financial frictions in international markets. Specifically, dollar and foreign currency markets for financial assets are separate, building on the segmented markets framework of Gabaix and Maggiori (2015). In this framework, dollar assets can be issued by U.S. public and private agents and they can also be manufactured, at an increasing cost, by international financial intermediaries. Because intermediation is costly, a rise in the demand for dollar debt by foreign investors generates a dollar appreciation and a fall in the cost of borrowing in dollars, consistent with the empirical evidence. Moreover, because intermediation costs are increasing, the U.S. faces a downward sloping demand for dollar debt.

The main results of my analysis are as follows. First, I establish that dollar shortages abroad lead to private sector over-borrowing by hegemon households because of two externalities: a financial (issuance) externality and an aggregate demand externality.[5] The former arises because atomistic households borrowing in financial markets do not internalize that the country as a whole faces a downward sloping demand for dollar debt (the result of frictions faced by financial intermediaries). In other words, atomistic households fail to internalize that issuing an additional unit of dollar debt lowers the the price for all other units of debt, both private and public. Aggregate demand externalities are the result of nominal rigidities in goods markets. Atomistic households do not take into account the stimulative effects of their spending on domestic goods. To show that these two externalities translate to over-borrowing in the hegemon, I derive that the optimal macro-prudential response to an increase in dollar shortages, at the constrained efficient allocation, is a positive tax on borrowing. The constrained efficient allocation can only be supported by the optimal mix of monetary, fiscal and macro-prudential policy. These three instruments are required for the hegemon to both stabilize the economy efficiently and maximize monopoly rents from the issuance of dollar assets.

Second, I show that when the borrowing tax is not set optimally or is not available, so that private sector over-borrowing weighs on the trade-offs faced by monetary and fiscal policy. Starting with monetary policy, I show that, in response to dollar shortages, the optimal interest rate response is expansionary, so as to mitigate the pressure on the dollar appreciate and sustain the global demand for U.S. goods and employment. However, monetary policy internalizes the borrowing externality. Because of this, monetary policy cuts interest rates by less than it would

[5]Aggregate demand externalities are studied in Schmitt-Grohé and Uribe (2016) and Farhi and Werning (2016), amongst others.Financial externalities are studied in Fanelli and Straub (2018), Basu et al. (2020) and Bianchi and Lorenzoni (2021).

in the constrained efficient allocation— to encourage households to borrow less.[6] A similar second-best argument applies to fiscal policy.

The result that monetary policy in the hegemon cannot efficiently balance internal objectives when there are dollar shortages abroad, unless it manages capital inflows using a tax on private borrowing, complements the idea put forth by Rey (2015). Rey argues that countries cannot set monetary policy independently because of a global financial cycle in asset prices driven by the dollar. My findings suggest that the U.S. *also* faces a Mundellian policy dilemma, since the ability of monetary policy to achieve a constrained efficient allocation is compromised by capital flows driven by foreigners' demand for dollars.[7]

Third, I find that the policy dilemma gives scope for direct dollar liquidity provision in international markets, as exemplified by the Federal Reserve (FED) dollar swap lines, to improve welfare. Swap lines are agreements according to which the FED lends dollars to a foreign central bank, against good collateral and over short maturities, in exchange for foreign currency. The foreign central bank, in turn, lends dollars to its domestic financial institutions alleviating their dollar constraints. Since the GFC, swap lines have been used extensively. The outstanding dollar swap liabilities amounted to 48% of U.S. GDP in 2008 Q4.[8] Like the (missing) macro-prudential borrowing tax, dollar swaps allow the hegemon to address inefficient over-borrowing and stabilize output, but, in stark contrast with the borrowing tax, they achieve these objectives at the cost of eroding monopoly rents from the issuance of dollar debt. Since dollar swaps address over-borrowing, they help the hegemon regain monetary and fiscal policy "independence".

The workings of dollar swap lines in the model are as follows. Financial intermediaries can manufacture dollar debt but are subject to portfolio costs and position limits. Because of this, they are only willing to issue dollar debt if the cost of borrowing in dollars is lower than the cost of borrowing in foreign currency. The tighter the intermediaries' portfolio constraint, the larger the spread required for the dollar market to clear. By exchanging dollars for foreign currency, dollar swaps increase liquidity in international markets and alleviate the frictions constraining the supply of dollar debt by financial intermediaries. Since lower shortages moderate the pressure on the dollar to appreciate, swaps contribute to sustaining employment and weaken the incentive for hegemon residents to (over-)borrow. In the case where the only shock in the economy is a one-off dollar demand shock, dollar swaps can, by themselves, fully mute the effects of the shock —but, the resulting allocation does not coincide with the constrained optimal. This is because a macro-prudential tax that postpones consumption can simultaneously address over-borrowing *and* increase the size of monopoly rents transferred from abroad. I show that the

[6] See e.g. Fanelli (2017) and Corsetti, Dedola, and Leduc (2018) for an analysis of optimal monetary policy in open economies with incomplete markets. Egorov and Mukhin (2019) and Corsetti, Dedola, and Leduc (2020) study optimal monetary policy when exports are predominantly priced in dollars.

[7] Mundell's classical view is that countries can achieve two objectives out of capital market openness (no taxes on capital flows), monetary policy independence (addressing domestic objectives) and exchange rate stability. Recent literature has instead suggested that efficient monetary policy requires taxation in capital markets as well, therefore the policy choice is between exchange rate stability with free capital mobility and no monetary independence or monetary policy independence with capital flows management.

[8] Dollar swaps signal a recognition by the FED of the role of dollars in the international markets, and its own role as a *global* lender of last resort in the spirit of Bagehot, see Bahaj and Reis (2018).

benefits from dollar swap lines are substantial when interest rates cannot be optimally adjusted and pass-through to import prices is low.

I contrast dollar swap policy with the supply of public debt, through which the U.S. government can also satisfy foreign demand for dollar assets. However, public debt changes the government balance sheet, and, is needed to optimally smooth spending and taxes, particularly during periods of financial distress. Dollar swaps, instead, have little effect on the public sector balance sheet and directly target the spread in the cost of borrowing in dollars vis-a-vis foreign currency. Like with monetary policy, the presence of over-borrowing implies fiscal policy cannot efficiently address internal objectives.

Fourth, I highlight that dollar shortages have strong domestic distributional consequences. Given the over-borrowing inefficiency, I consider an extension of the model which distinguishes between households who are financially-active, and can trade in dollar debt vis-à-vis financial intermediaries, and inactive households who consume their current income. Dollar shortages abroad have heterogenous effects one these two types of households. Financially-active households benefit from higher returns on their financial position (short in dollar bonds and long in foreign assets) and, unlike inactive households, are partly able to smooth the income loss from depressed exports and from losses on the government's portfolio of assets. Inactive households lose out even if, in equilibrium, financially-active households spend part of the rents they earn on domestic goods, raising domestic income for all residents. The use of dollar swap lines systematically redistributes from financially-active to inactive households—because they mute the effect of shortages on the exchange rate and erode monopoly rents.[9] I note that distributional issues persist even at the constrained optimal allocation. If the majority of households participates in financial markets, the optimal borrowing tax prioritises monopoly rents maximization to boost aggregate welfare– at the expense of inactive households who suffer from depressed export demand.

I close the paper with a quantification of the effects of dollar shortages on the U.S. economy. I calibrate the hegemon economy to the U.S. in 2008Q1, specifically targeting the size and currency composition of U.S. gross assets and liabilities, detailed in Appendix A. I then consider a dollar demand shock which leads to a 6-8% appreciation of the dollar (depending on the interest rate response), and results in a spread in the cost of borrowing in foreign currency vis-á-vis dollars of about 6%, consistent with the U.S. experience during the GFC (see Figure 1). Monopoly rents in the model, which are derived on the entire gross position of the U.S. in dollar debt which is invested abroad, are large and amount to about 7% of GDP over the duration of the crisis.[10]

I highlight two key quantitative results. While optimal monetary policy alone (a 3% interest rate cut) can improve aggregate outcomes in the face of dollar shortages, it achieves only *one-third* of the welfare gain which is possible at the constrained optimal allocation. Specifically, if

[9] Chien and Morris (2017) show that financial market participation varies by U.S. state even when controlling for household income. Therefore, dollar shortages introduce a political trade-off in the hegemon and the extension of dollar swap lines can become a political decision.

[10] This should be interpreted as an upper bound, since all assets in the model are one period securities and I assume all liabilities are dollar-denominated, whilst all assets are foreign-currency denominated.

interest rates do not respond, dollar shortages cost about 0.35% of consumption equivalent per quarter over the 2 year duration of the crisis. Instead, when interest rates respond optimally, the economy gains the equivalent of 0.5% per quarter in the aggregate. The constrained optimal allocation requires a large macro-prudential borrowing tax of up to 8%, highlighting that such an instrument is not used in practice, and interest rates adjust by about 5% (subject to an effective lower bound). In this allocation, the aggregate welfare gain rises to 1.5% consumption equivalent per quarter.

Furthermore, the distributional implications of dollar shortages persist even when monetary policy adjusts and, surprisingly, the allocation can become more inequitable at the constrained efficient. When monetary policy responds optimally, inactive households experience consumption losses (0.17% per quarter) which are more than offset by gains for active (0.81%). At the constrained efficient allocation, large gains for active households (2.2%) overshadow losses incurred by financially-inactive households. In a calibration where, reasonably, 30% of households are inactive, the planner prioritises active household welfare and the optimal borrowing tax maximizes monopoly rents and targets stabilization, as preferred by active households. As such, the welfare of the minority of inactive households falls when the optimal borrowing tax is used (0.23% loss vs. 0.17% loss in the case of monetary policy alone).

Related Literature. Thematically, this paper belongs to the literature on the role of the U.S. and the dollar in the International Monetary System (IMS). Amongst recent contributions, Maggiori (2017), Gourinchas, Rey, and Govillot (2018), Kekre and Lenel (2020) consider general equilibrium models where the U.S. has a larger capacity to bear risk, earning excess returns outside of crises but facing losses during crises. Farhi and Maggiori (2016) emphasize, that the U.S. faces a 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 show that the trade-offs faced by the U.S. cannot be resolved by fiscal and monetary policy alone and I highlight the macroeconomic externalities which arise.

A new, mostly theoretical, literature on optimal capital controls aims to identify macroeconomic externalities in goods and financial markets. Specifically Costinot, Lorenzoni, and Werning (2014), Lloyd and Marin (2020), study the use of capital controls to internalise terms of trade externalities both inter-temporally and intra-temporally, Schmitt-Grohé and Uribe (2016) and Farhi and Werning (2016) look at aggregate demand externalities and Basu et al. (2020) and Bianchi and Lorenzoni (2021) analyze financial externalities. Relative to these contributions, I show that these externalities result in a U.S. policy dilemma which, absent capital controls, compromises U.S. monetary and fiscal policy independence.[11] Then, I propose an externality-based interpretation of dollar swap lines and I highlight how the over-borrowing inefficiency can be exacerbated by limited financial market participation.

[11] Farhi and Werning (2014) emphasize that capital controls are generally useful, in addition to monetary policy, to smooth the terms of trade in a New-Keynesian model.

Even though dollar swap lines have been one of the most prominent policy innovations over the past decade, there is comparatively little literature on their effect on macro outcomes.[12] 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 and Aizenman, Ito, and Pasricha (2021) conduct a similar analysis for the aftermath of COVID-19, emphasizing selection by the FED for swap line recipients based on trade and financial closeness. Bahaj and Reis (2018) use both cross-sectional and time-series variation to show that dollar swaps introduce a ceiling on deviations from the covered interest rate parity, reduce portfolio flows into dollar assets and lower the price of dollar corporate bonds. 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). The contribution of this paper is to characterize dollar swap lines as part of the (Ramsey) optimal policy mix emphasizing the externalities which they can address domestically (for the U.S.) and their shortcomings.

Finally, this paper relates to an established literature which 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). 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. De 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. In this paper, I emphasize the distributional consequences for U.S. households of dollar shortages and derive how limited participation interacts with the macroeconomic externalities which arise. Furthermore, I analyze the scope for monetary policy and dollar swaps as instruments for redistribution.

Section 2 lays out the model. Section 3 considers a static stylized framework which outlines the key trade-offs statically. Section 4 considers a dynamic model and solves for welfare maximizing policy. In Section 4.3, I consider the distributional implications of dollar shortages in a two-agent version of the model. Section 5 conducts a calibration exercise. Section 6 concludes.

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

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 (2016) and Egorov and Mukhin (2019). To distinguish between a market for dollar assets and a market for foreign currency assets, I allow for financial market segmentation in the spirit of Gabaix and Maggiori (2015). The hegemon differs from other countries in $i = [0,1]$ in one important way– it is the monopoly issuer of dollar assets in its segment.

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

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

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. Foreign households have analogous preferences and face a symmetrical problem detailed in Appendix E.

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. I allow households to have an exposure to foreign-currency denominated assets. Households take a long position of a^F in foreign currency debt, at a price

$\frac{1}{R_t^*}\mathcal{E}_t$ dollars.[13] Households also receive a lump-sum rebate from the government T_t in every period. The budget constraint is given by,

$$\begin{aligned} P_{F,t}C_{F,t} + P_{H,t}C_{H,t} \leq \Pi_t + W_tL_t + \\ \tfrac{1}{R_t}x_t - x_{t-1} - \tfrac{1}{R_t^*}a_t^F\mathcal{E}_t + a_{t-1}^F\mathcal{E}_t - T_t \end{aligned} \tag{4}$$

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 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. For simplicity, I assume the position households take in foreign debt a_t^F is exogenous and I calibrate it to the data in Section 5.

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,

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

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 perfectly rigid.[14] I allow for a constant employment tax τ^L and define the effective wage for firms by $\tilde{W}_t = W_t(1+\tau^L)$.[15] If prices are rigid, I distinguish

[13]This is consistent with evidence in Curcuru, Thomas, and Warnock (2013), building on Curcuru et al. (2011), who show that the U.S. earns a positive return on its net investment position even when its a net debtor. Gourinchas and Rey (2005) and Gourinchas, Rey, and Govillot (2018) emphasize that the U.S. tends to borrow in safe dollar liabilities, and invest in riskier foreign currency assets– explaining part of the return differential.

[14]This 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.

[15]In Appendix A, I detail the maximization for a firm in any country i and show that the perfectly rigid price setting condition can be derived as the limit of Rotemberg pricing.

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.[16]

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

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

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 the labout subidy is chosen to eliminate steady state monopolistic distortions $1 + \tau^L = (\epsilon - 1)/\epsilon$ and Λ_t is households stochastic discount factor. 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:

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

[16] 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).

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, $\lambda = 0, \lambda^* = 1$.[17] 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,

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

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. Households have a unitary elasticity of substitution of 1 for public spending over time. Relative demand for public spending on home and foreign varieties is given by,

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

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.[18]

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 budget constraint is given by:

$$P_{F,t}G_{F,t} + P_{H,t}G_{H,t} + B_{t-1} \leq \tfrac{1}{R_t} B_t + T_t \tag{17}$$

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

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

[18] 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).

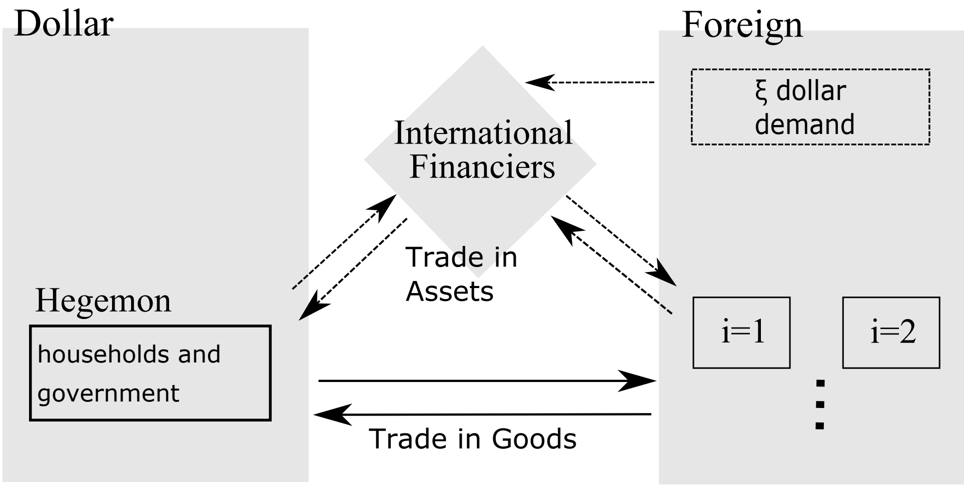


Figure 2: International financial market structure

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 $\{-\overline{Q}, \overline{Q}\}$.[19] 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 short position, i.e. financiers sell a promise to a dollar tomorrow in exchange for $q_t(k)\mathcal{E}_t$ units of foreign currency today. For simplicity, I assume financiers are subject to a constraint that they break-even at $t+1$, so they accumulate no equity over time. The problem of an individual financier, indexed by k, at time t can be summarised as,

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

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

In equilibrium, because of non-zero entry costs and position limits, financial intermediaries

[19]Position limits can be 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). Position limits can be allowed to vary over time to capture time-varying dollar liquidity. Evidence of this is provided in Appendix A.

require excess returns when there are dollar imbalances in international markets ($Q_t \neq 0$), leading to deviations from UIP:

$$\left(\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*} - \frac{1}{R_t}\right) = \Gamma Q_t \tag{18}$$

Suppose there is a shortage of dollars $Q_t < 0$. The LHS of (18) reflects the required compensation to intermediate dollar shortages for a given level of (inverse) dollar liquidity Γ.[20] 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. [21] 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,[22]

$$Q_t = x_t + B_t - \xi_t, \tag{19}$$

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 assets ($x_t + B_t$) minus the demand for dollar debt ξ_t. Equations (18) and (19) summarise the dollar market equilibrium.

The framework above captures two key features of dollar markets. First,financial intermediaries are non-U.S. entities issuing dollar debt at a cost. Evidence of issuance of U.S. debt by non-U.S. is presented in Bruno and Shin (2017) and Maggiori, Neiman, and Schreger (2018).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. Second, if there is an unexpected increase in ξ_t, foreign investors demand dollars in a period when dollars are expensive, i.e they have bad market timing, as is documented in the data by Krishnamurthy and Lustig (2019) (see Appendix A). Financial intermediaries at $t-1$ priced assets based on an expectation $\mathbb{E}_t[\xi_t] = 0$, so they did not require R_{t-1} to rise.

[20] 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.

[21] 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.

[22] Demand for dollar debt may be efficient because dollar debt economizes on liquidation costs in the foreign sector, as in Liu, Yaron, and Schmid (2019) In that case, a widening in the borrowing cost spread can lead to inefficiency in foreign markets.

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 clarity, consider the dollar segment. Market clearing is then given by,

$$Q_t = x_t + B_t + \sum_{i>0}^{N-1}(x_t^i + B_t^i) - \xi_t, \tag{20}$$

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.[23]

2.2 Dollar Swap Lines

A key institutional innovation 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 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., portfolio 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.

Previously, I assumed each financier could promise a to deliver a maximum $\overline{Q}$ 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.[24] 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:

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

[23]In Appendix B, 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.

[24]Note that a period in the model corresponds to a quarter, whereas dollar swaps are usually completed within a week. Therefore,I assume financial intermediaries are exposed to the entirety of the currency fluctuation.

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,

$$\left(\frac{1}{R_t} - \mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*}\right)(\overline{Q} + Q^s) - \tau^s(\overline{Q} + Q^s)\frac{Q^s}{(\overline{Q} + Q^s)} \geq k \tag{21}$$

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

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

The next lemma summarises 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 (18), except the semi-elasticity of demand is now given by:

$$\Gamma_t = \left(\frac{1}{\overline{Q} + Q^s}\right)^2 < \left(\frac{1}{\overline{Q}}\right)^2 \tag{23}$$

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

$$\mathbf{k}_t Q^s = -Q_t\frac{Q^s}{\overline{Q} + Q^s} \geq 0 \tag{24}$$

Equation (24) maps directly to the data on dollar swap up-take in Figure 3 below, 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. Since the spread τ^s is not imoportant to the economics of the model, I consider the limit as $\tau^s \to 0$.[25]

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.*

[25]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.

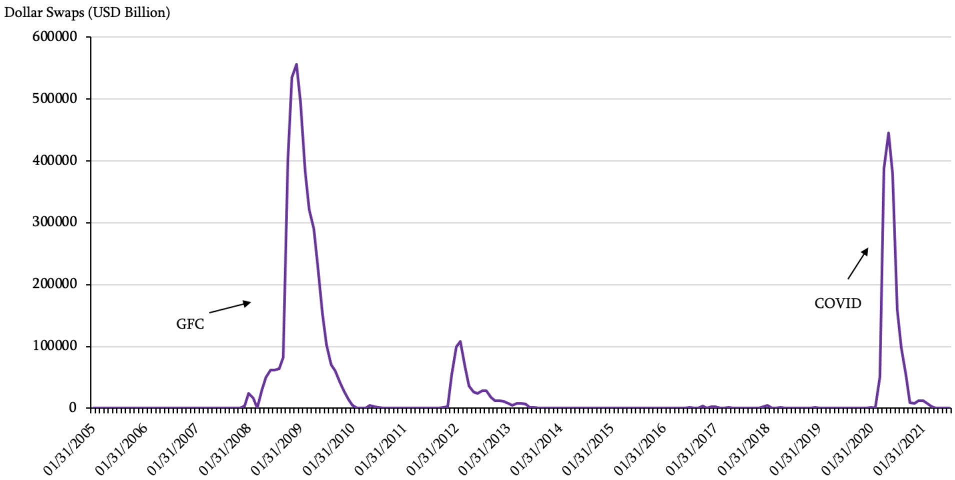


Figure 3: Weekly outstanding dollar swaps (Wednesday level). Source: Federal Reserve

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. Specifically, the hegemon affects its interest rate by manipulating exchange rate premia.[26] 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 conditions required for an equilibrium.

Lemma 2 (Implementability)
Given $\{\xi_t, \overline{Q}\}$*, a household allocation* $\{C_{H,t}, C_{F,t}, x_t, L_t\}$ *and a government allocation* $\{G_{H,t}, G_{F,t}, B_t, Q^s_t\}$ *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), (17) and (22) 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),

[26]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. In Appendix E I provide parametric conditions for which A.1 is the optimal policy. 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.

using 9, the expression for T_t and (22) yields the consolidated household budget constraint:[27]

$$C_{F,t} \leq \mathcal{E}_t^{-\lambda}\Bigg\{\zeta\left(\frac{\mathcal{E}_t}{P_{H,t}}\right)^{\eta} P_{H,t} + (x_t - a_t^F)\frac{1}{R_t} - (x_{t-1} + \kappa^G B_{t-1} - a_{t-1}^F)$$
$$\underbrace{-\Gamma_t Q_t(\xi_t - B_t)}_{\text{(a) Monopoly rents (+ve)}} \qquad \underbrace{-\Gamma_t Q_t^2(1-\omega)}_{\text{(b) Cost of segmentation } (-ve)} \qquad + \frac{\chi^G - \kappa^G}{1-\chi^G}\mathcal{E}_t^{\lambda} G_{F,t}\Bigg\} \tag{26}$$

The first term on the right-hand side reflects total revenues earned from the export of goods. The next two terms reflect the return on the net external position for U.S. households if there are no dollar shortages ($Q_t = 0$) and so both terms (a) and (b) are zero. Instead, if there are dollar shortages, $Q_t < 0$, term (a) captures the positive rents from issuing dollar assets and investing them in foreign currency assets. Term (b) reflects costs from financial market segmentation which result in profits for financial intermediaries. The cost to the hegemon is positive as long as $\omega < 1$, i.e. profits from financiers do not fully accrue to the hegemon country. The final term reflects income effects from public spending and the lump-sum tax.

As long as $\kappa^G < 1$, using (16), the government budget constraint (17) can be rewritten as:

$$\frac{1-\kappa^G}{1-\chi^G} G_{F,t} \leq \mathcal{E}_t^{-\lambda}\left\{\frac{1}{R_t^*}\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right] B_t - \Gamma_t Q_t B_t - (1-\kappa^G)B_{t-1}\right\}, \tag{27}$$

In the limit $\kappa^G = 1$, government spending is entirely tax financed, $B_t = 0$ and Ricardian equivalence holds.

2.4 Monopoly Rents, the Transfer Problem and Monetary Policy.

The hegemon benefits from a transfer of monopoly rents from the foreign sector, akin to seignorage.[28] Equations (26) and (27) show that the transfer of wealth from the rest of the world to hegemon households is $-\Gamma Q_t \xi_t$. As the demand for dollars (ξ_t) rises, the spread in borrowing costs grows, contributing to larger rents. However, these rents are at least in part associated with an appreciation of the dollar (see (18)) which can have large adverse, secondary effects. At the crux of the trade-off facing the hegemon is a version of the transfer problem, initially debated in Keynes (1929) and Ohlin (1929).[29]

Holding the gross external assets and liabilities of the hegemon constant, the size of monopoly

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

$$\Pi_t^f = \left(\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right]\frac{1}{R_t^*} - \frac{1}{R_t}\right) Q_t = \Gamma Q_t^2 \geq 0 \tag{25}$$

[28] There are two important differences between monopoly rents and seignorage. First, monopoly rents are a transfer from abroad to the U.S. whereas seignorage revenues are partly earned domestically. Second, seignorage tend to be significantly smaller, especially during periods of low inflation. Del Negro et al. (2017) estimate that seignorage is 0.23% a year on average.

[29] 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.

rents does not depend on the monetary policy stance, i.e. the extent of the interest rate cut. Generally, however, interest rates only partly adjust, and the equilibrium exchange rate appreciation leads to lower export revenues ($\frac{d\zeta\mathcal{E}_t^\eta}{d\mathcal{E}_t} > 0$) and losses on the existing portfolio of assets. So monetary policy, investigated in 4, has to balance the costs from the dollar appreciation at the onset of the crisis, with the wealth transfer which follows.

In what follows, Section 3 illustrates the trade-off between maximizing monopoly rents and moderating the demand effects of a dollar appreciation, statically, and for a given monetary policy stance. Section 4 shows that,dynamically, the trade-offs result in private sector over-borrowing, which can compromise the efficacy of stabilization policy.

3 Analytical Hegemon's Dilemma

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 how public debt issuance and dollar swaps affect the equilibrium allocation.

Setup. Consider a two-period version $t = \{1, 2\}$ 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 a long-run exchange rate $\overline{\mathcal{E}}$ in period 2. I further take private issuance of dollar debt as given.[30] At time 0, I normalize dollar supply, demand and imbalances to zero ($B_0 = \xi_0 = Q_0 = 0$) and $\Gamma_0 = \overline{Q}^{-2}$. At $t = 1$, I assume foreigners' demand for dollar debt rises to $\xi_1 = 1$.

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).[31] I allow μ_1 to depend on Γ_1 and Q_1 as follows:

$$\mu = \overline{\mu}(1-s) + s\overline{\mu}\left(\frac{\beta^*}{\beta} - \frac{\Gamma_1 Q_1}{\beta}\right) \tag{28}$$

Rearranging (18) and substituting (28), the exchange rate in the model is expressed as:

$$\mathcal{E}_1 = \overline{\mathcal{E}}\left(\frac{\beta}{\beta^*}\frac{\mu_1}{\overline{\mu}} + \frac{\Gamma_1}{\beta^*}[B_1 + x_1 - \xi_1]\right) \tag{29}$$

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.

[30] 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.

[31] In Appendix E, I show that μ_t is the return on a perpetual bond.

Stabilization and Monopolist Incentives. I posit the hegemon planner optimizes over two main incentives, employment stabilization and maximization of monopoly rents.[32] Define the period-1 labour wedge τ_1 as,

$$\tau_1 = 1 - \frac{1}{A_1}\frac{\kappa}{\chi}C_{H,1}L_1^{\psi}, \tag{30}$$

The labour wedge is frequently considered in the literature as a measure of the output gap, see e.g. Chari, Kehoe, and McGrattan (2007) and Farhi and Werning (2016). The labour wedge 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– or more specifically, households are over-working relative to the flex-price allocations. 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. The total revenue from debt issuance for the hegemon in period 2 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 $\frac{1}{R_1^*}\frac{\mathcal{E}_1}{E}B_1$. From (18), the excess revenue from issuance of dollar debt, corrected for the profits from ownership of financiers is given by:

$$\Omega_1^M = -\Gamma_1 Q_1 B_1 + \omega \Gamma_1 Q_1^2 \tag{31}$$

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 assets 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 optimal allocation is summarised by the first-order conditions for (HD1) with respect to B_1 and Γ_1 (if the positive liquidity constraint does not bind) and are presented in Appendix B.

[32]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.

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 assets 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. See Appendix B. □

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 B 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 4 illustrates the locus of B_1, Γ_1 which maximize the hegemon's objective function in each of the two corner cases.

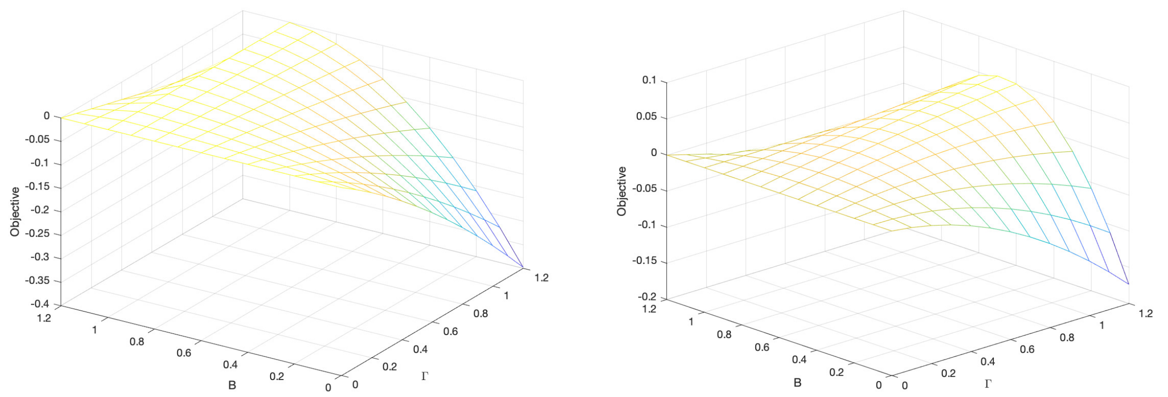


Figure 4: Left panel: $w^S = 1$ Stabilization strategy optimal. Right panel: $w^S = 0$ Monopolist strategy optimal. Parametrization: $s = 0.2, \kappa = \overline{\mu} = \overline{\mathcal{E}} = \zeta = \eta = \psi = 1$, $\chi = 0.6, \chi^G = 0, \beta = \beta^* = 0.99$.

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 $\overline{s}$ must be replaced.[33] 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 B). 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 initially falls due to the sharp appreciation, documented in Figure 1, at the onset of crises (dubbed 'valuation effects'). To analyze the role of fiscal policy and dollar swaps on valuation effects, I consider the return on the portfolio formed at time 0. Specifically, the hegemon earns $\frac{1}{R_0} - \mathbb{E}_0\left[\frac{\mathcal{E}_0}{\mathcal{E}_1}\right]\frac{1}{R^*}$ at $t = 0$ and receives $\mathcal{E}_1 - 1$ in period 1, which I include in Ω_1^M. An unanticipated appreciation of the dollar lowers the dollar-return of the time 0 portfolio at $t = 1$. 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 B. For all values of w^S, the hegemon has an additional incentive to depreciate the dollar at $t = 1$, 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 not only contributes to dollar balances but also leads to inefficiencies. In a dynamic model, inefficient levels of private dollar debt issuance constrain the ability of monetary policy to stabilize the economy leading to a policy dilemma. Moreover, the borrowing inefficiency gives scope for dollar swap lines to improve welfare.

4 Constrained Optimal Allocation

In this section, I identify the macroeconomic externalities which arise in the dynamic model, especially due to dollar shortages abroad, and analyse how they impinge on monetary and fiscal

[33] Specifically it is replaced with $\overline{s}'$, where,

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

where $\overline{s}' < \overline{s}$.

policy. To do so, 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.[34] 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:[35]

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

$$\text{s.t:} \quad (26), (27)$$

I attach multipliers η_t^C and η_t^G respectively to the household constraint (26) and government constraint (27), 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,

$$\begin{aligned} V(C_{F,t}, G_{F,t}, \mathcal{E}_t) = \chi \log\left(\frac{\chi}{1-\chi}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H} C_{F,t}\right) + (1-\chi)\log(C_{F,t}) + \\ \omega^G\left[\chi^G \log\left(\tfrac{\chi^G}{1-\chi^G}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H} G_{F,t}\right) + (1-\chi^G)\log(G_{F,t})\right] - \\ \frac{1}{1+\psi}\left(\frac{1}{A_t}\left[\frac{\chi}{1-\chi}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H} C_{F,t} + \frac{\chi^G}{1-\chi^G}\frac{\mathcal{E}_t^\lambda}{\overline{P}_H}(1-\chi)\tfrac{\zeta}{\overline{P}_H}\mathcal{E}_t^\eta\right]\right)^{1+\psi} \end{aligned} \tag{32}$$

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. I combine the first order conditions for the planner with respect to x_t and $C_{F,t}$, with the expression for $V_{C_{F,t}}$ detailed in Appendix C, and the Euler equation (5), in order to derive the optimal borrowing tax τ_t^x. To this end,by analogy to the labour wedge τ_t defined in (30), I define the financial (issuance) wedge τ_t^Ω:

$$\tau^\Omega = \frac{1}{R_t}\left[\frac{1}{R_t} - \Gamma_t x_t + 2\omega\Gamma_t Q_t\right]^{-1} - 1, \tag{33}$$

which captures the failure of atomistic private households to internalize the effect of their savings

[34] 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.

[35] The full derivation of both the indirect utility function and the implementation constraints is presented in Appendix C, as is the generalisation to CRRA coefficient σ and trade elasticity θ not equal to 1 (relaxing A.2).

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 increasing 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:

$$1-\tau^x = \frac{1+\frac{\chi}{1-\chi}\tau_{t+1}}{1+\frac{\chi}{1-\chi}\tau_t}(1+\tau_t^{\Omega}) > 1 \tag{34}$$

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

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. However, it is the market segmentation, and the imperfect substitutability between dollar and foreign debt that it implies, which makes the hegemon economy vulnerable to fluctuations in dollar shortages abroad. 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 inefficiency are dynamic versions of the incentives detailed in (HD1).

Over-borrowing matters in the economy because it compromises the ability of other policy instruments to achieve their objectives. To measure how much over-borrowing matters, consider the multiplier on the Euler equation denoted by η_t^E,

$$\eta_t^E = \left\{\Gamma_t \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}}\right\}^{-1} \left\{\beta\eta_{t+1}^C \mathcal{E}_{t+1}^{-\lambda} - \eta_t^C \mathcal{E}_t^{-\lambda}\left[\frac{1}{R_t} - \Gamma_t x_t + 2\omega\Gamma_t Q_t\right] + \eta_t^G \mathcal{E}_t^{-\lambda}\Gamma_t B_t\right\} \tag{35}$$

derived from the first-order condition of (33) with respect to x_t. The multiplier is greater than zero whenever households are over-borrowing, i.e (34) holds. To see this, notice that 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. Additionally, there is over-borrowing when the price faced by the country as a whole (the term in square brackets) is lower than that faced by an atomistic household $\frac{1}{R_t}$.

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 and a counteracting incentive to appreciate the exchange rate such that the price of imports per unit of labour falls. 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,

$$V_{\mathcal{E}_t} + \eta_t^C \frac{dC^*_{H,t}}{d\mathcal{E}_t} + \left\{ \eta_t^C \frac{dF_t}{d\mathcal{E}_t} + \eta_{t-1}^C \frac{dF_{t-1}}{d\mathcal{E}_t} \right\} + \left\{ \eta_t^G \frac{dF_t^G}{d\mathcal{E}_t} + \eta_{t-1}^G \frac{dF_{t-1}^G}{d\mathcal{E}_t} \right\} \\ + \left\{ \eta_t^E \frac{d\mathcal{R}_t}{d\mathcal{E}_t} \right\} + \left\{ \eta_{t-1}^E \frac{d\mathcal{R}_{t-1}}{d\mathcal{E}_t} \right\} = 0, \tag{36}$$

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).[36] Each term is detailed in Appendix C.

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 of 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.

Monopoly rents and valuations effects play an important role in the determination of the optimal policy response, captured by $\frac{dF_t}{d\mathcal{E}_t}$ and ($\frac{dF_t^G}{d\mathcal{E}_t}$). Valuation effects (the losses accruing on the U.S. portfolio at the onset of the crisis) provide a strong incentive for monetary policy to mitigate the appreciation when the demand for dollars rises. On the other hand, the "capitalization" effect depends on $\Gamma_t Q_t$ but –for a given amount of U.S. debt –not on monetary policy. However, since issuance rents are denominated in dollars, an appreciation is desirable as it increases the amount of imports monopoly rents can buy.

Absent macro-prudential policy, monetary policy cannot attain the constrained efficient allocation in the economy when there are dollar shortages. When there is wedge $\eta_t^E > 0$ in the first order-conditions, one of these objectives must be compromised. Because there is over-borrowing in the economy ($\eta_t^E > 0$) monetary policy faces an additional incentive to raise interest rates to encourage households to borrow less– partly internalizing the over-issuance. If we think of monetary policy as controlling exchange rates, an appreciated exchange rate shifts

[36] Specifically,

$$\mathcal{R}_t = \beta R_t \mathcal{E}_{t+1}^{-\lambda} C_{F,t+1}^{-1} - \mathcal{E}_t^{-\lambda} C_{F,t}^{-1}. \tag{37}$$

consumption to the future by driving the relative cost of current consumption R_t up, captured by $\frac{d\mathcal{R}_t}{d\mathcal{E}_t} < 0$.[37] However, this further depresses export demand and lowers the dollar return on foreign currency assets.

This finding can be interpreted in terms of the classical Mundellian Trilemma. Using (37), I can tightly define hegemon monetary policy to be independent when it can efficiently balance internal objectives of stabilization and risk-sharing, independent of the level of dollar shortages abroad.[38] While Rey (2015) and others show that a dollar-led global financial cycle compromises monetary policy independence in the rest of the world,I show that the relationship goes both ways –U.S. monetary policy too is compromised by capital flows due to foreign demand for dollars.

4.1 Hegemon's Dilemma Revisited

Having established that dollar shortages abroad interfere with the domestic workings of monetary policy, 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 ($\Gamma = (\overline{Q} + Q^s)^{-2} < \overline{Q}^{-2}$). I show that dollar swap lines support stabilization policy and help the hegemon regain some monetary policy independence, at the cost of eroding monopoly rents.

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 (24). However, 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 :

$$\underbrace{-\eta_t^C \mathcal{E}_t^{-\lambda}(Q_t x_t + 2\omega Q_t^2) - \eta_t^G \mathcal{E}_t^{-\lambda} B_t Q_t}_{\text{cost of foregone issuance rents}} = \underbrace{\eta_t^E \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}} Q_t}_{\text{cost of over-borrowing}} \tag{38}$$

The left hand side of (38) 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 (38) 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),

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

[38]Note that this definition does not imply that the interest rate defined by (37) is not affected by the level of shortages Q_t. Rather, monetary policy is not independent when the ability of the hegemon to efficiently balance internal objectives (which are themselves driven by Q_t) is compromised due to external factors such as shortages Q_t.

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)
Faced with dollar shortages, dollar swaps address over-borrowing in the economy at the cost of lower monopoly rents from issuance. Dollar swaps are not used if an optimal borrowing tax is available.

Dollar swaps can support efficient monetary policy in the hegemon, and (at least partly) recover monetary independence. In the case of a shock to dollar demand, dollar swaps are able to directly address the shock and achieve stabilisation regardless of monetary policy. Intead, consider a productivity shock (A_t falls).[39] Households experience an income loss and borrow to smooth their consumption. From Proposition 1, we know that households will over-borrow because they fail to internalise their size in financial markets. Once again, absent a borrowing tax, because $\eta_t^E > 0$ monetary policy cannot efficiently trade-off internal objectives. If dollar swaps are extended, η_t^E falls significantly and monetary policy moves closer the constrained optimal allocation. It does not achieve the officiant allocation, as also pointed out in Farhi and Werning (2014), controls on capital flows are required to deal with terms of trade motives as well, but, the inefficiency is no longer dependent on the level of dollar shortages abroad.

While dollar swaps are an imperfect substitute to macro-prudential taxation for addressing internal objectives in the hegemon, the two policies lead to very different outcomes internationally. On the one hand, the optimal borrowing tax restricts private sector issuance resulting in larger dollar shortages and a wider spread in borrowing costs. On the other hand, the provision of dollar swaps narrows the spread in borrowing costs for any level of shortages.

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:

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

The first line of (39) 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

[39] Appendix F plots the impulse response functions to an unanticipated productivity shock.

of dollar debt). The incentive to smooth spending is captured by the path of $\{\eta_t^G\}$, given by,

$$\eta_t^G \frac{1-\kappa^G}{1-\chi^G} = V_{G_{F,t}} - \eta_t^C \frac{\kappa^G - \chi^G}{1-\chi^G} \tag{40}$$

whereas the incentive to smooth taxation is reflected by the marginal value of private consumption η_{t+1}^C. As with monetary policy, dollar shortages and the resulting macroeconomic externalities impinge on the efficacy of fiscal policy. However, unlike monetary policy, fiscal policy can directly manipulate dollar imbalances using public debt. 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 (39) yields:

$$\eta_t^E \Gamma_t \frac{1}{\mathcal{E}_t^\lambda C_{F,t}} = \Gamma_t \left\{ \eta_t^C \mathcal{E}_t^{-\lambda}(x_t + 2\omega Q_t) \right\} \tag{41}$$

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.

Even though monetary policy does cannot on its own achieve the constrained efficient allocation, it is able to moderate the dollar appreciation and partly stabilize output. In practice, however, even monetary policy is constrained. In addition to assuming that a macro-prudential tax is not available, I now analyze the case where monetary policy is unresponsive.[40] Define,

$$\mathcal{E}_t^\lambda C_{F,t} = \mu_t(1-\chi), \tag{42}$$

where μ_t is a synthetic monetary instrument, detailed in Appendix E. When μ grows at a constant rate, (42) ensures nominal interest rates R_t are constant in the absence of macro-prudential policy. I consider the case $\mu_t = \mu$ and attach the multiplier η_t^μ to the monetary policy constraint (42) and define a corresponding monetary policy wedge:

$$\tau_t^\mu = \frac{C_{F,t}^{-\sigma} + \eta_t^\mu}{C_{F,t}^{-\sigma}} - 1 \tag{43}$$

[40] Over the past decade, interest rates have hovered around the zero lower bound (ZLB) and have therefore interest rates are largely unresponsive to shocks. The analysis in this section coincides with imposing a zero lower bound in the limit $\beta \to 1$.

If interest rates don't adjust, 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 in a period when it is depressed, each additional unit of $C_{F,t}$ is also 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 can fall. Private agents over-issue dollar debt if:

$$\frac{1 + \frac{\chi}{1-\chi}\tau_{t+1} - \tau^{\mu}_{t+1}}{1 + \frac{\chi}{1-\chi}\tau_t - \tau^{\mu}_t}(1 + \tau^{\Gamma}_{t+1}) > 1, \tag{44}$$

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

Lemma 3 (Dollar swaps when monetary policy is constrained)
The level of over-borrowing in the economy rises if monetary policy is constrained and $\tau^{\mu}_t > \tau^{\mu}_{t+1}$. The marginal social benefit of dollar swaps rises when interest rates do not adjust.

4.3 Limited Financial Market Participation

In this section, I extend the model to allow for limited financial market participation. I first 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. Then, I show that this is reflected in a higher level of over-borrowing by financially active households.

Extending the basic model. There are two 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.[41] 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: $L^A_t = L^{NA}_t$.

[41] 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.

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

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

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

$$\frac{1}{\mathcal{E}^{\lambda}_t C^A_{F,t}} = \beta R_t \frac{1}{\mathcal{E}^{\lambda}_{t+1} C^A_{F,t+1}}, \tag{45}$$

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 $Y_{H,t} = \mathbf{a}_t C^A_{H,t} + (1-\mathbf{a}_t) C^{NA}_{H,t} + C^*_{H,t}$. Individual households' consumption depends on the measure of active households through prices R_t and $\mathcal{E}_t$ because dollar shortages are given by,

$$Q_t = \alpha_t x_t + B_t - \xi_t \tag{46}$$

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)
Consumptions of individual active and inactive households are given by,

$$C^A_{F,t} \leq \mathcal{E}^{-\lambda}_t \Bigg[\zeta \left(\frac{\mathcal{E}_t}{P_{H,t}} \right)^{\eta} P_{H,t} + \frac{\chi^G - \kappa^G}{1-\chi^G} \mathcal{E}^{\lambda}_t G_{F,t} - \kappa^G (B_{t-1}) + \tag{47}$$

$$(1-(1-\mathbf{a}_t)\chi) \left((x_t - a^F_t) \frac{1}{R_t} - (x_{t-1} - a^F_{t-1}) - \Gamma_t Q_t (\xi_t - B_t) + \frac{\omega}{\mathbf{a}_t} \Gamma_t Q^2_t \right) \Bigg],$$

$$C^{NA}_{F,t} \leq \mathcal{E}^{-\lambda}_t \Bigg[\zeta \mathcal{E}^{\eta}_t P_{H,t} + \frac{\chi^G - \kappa^G}{1-\chi^G} P_{F,t} G_{F,t} - \kappa^G B_{t-1} + \tag{48}$$

$$\mathbf{a}_t \chi \left((x_t - a^F_t) \frac{1}{R_t} - (x_{t-1} - a^F_{t-1}) - \Gamma_t Q_t (\xi_t - B_t) + \frac{\omega}{\mathbf{a}_t} \Gamma_t Q^2_t \right) \Bigg],$$

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

$$L_t = \frac{1}{A_t} \frac{1}{\overline{P}_{H,t}} \frac{\chi}{1-\chi} \Bigg\{ \zeta \mathcal{E}^{\eta-\lambda}_t P_{H,t} + \frac{\chi^G - \kappa^G}{1-\chi^G} G_{F,t} - \kappa^G B_{t-1} + \tag{49}$$

$$\mathbf{a}_t \left((x_t - a^F_t) \frac{1}{R} - (x_{t-1} - a^F_{t-1}) - \Gamma_t Q_t (\xi_t - B_t) + \frac{\omega}{\mathbf{a}_t} \Gamma_t Q^2_t \right) \Bigg\}$$

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,

$$\max_{\{C^A_{F,t}, C^{NA}_{F,t}, \mathcal{E}_t, G_{F,t}, B_t, x_t\}} \sum_{t=0}^{\infty} V(C^A_{F,t}, C^{NA}_{F,t}, G_{F,t}, \mathcal{E}_t; \boldsymbol{\lambda}, \mathbf{a}_t)$$
$$\text{s.t.} \qquad (27), (47), (48)$$

where (27) is the constraint for a government equilibrium, and (47) and (48) are the constraints for active and inactive households respectively. I detail the indirect utility function, the conditions governing the planner's allocation in Appendix D. 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:[42]

$$1 - \tau^x_t = \frac{1 + \frac{\chi}{1-\chi}\tau^A_{t+1} + \delta^{NA}_{t+1}}{1 + \frac{\chi}{1-\chi}\tau^A_t + \delta^{NA}_t} \tag{50}$$

where $\delta^{NA}_t = \frac{(1-\mathbf{a})\chi}{1-(1-\mathbf{a})\chi}\left(1 + \frac{\chi}{1-\chi}\tau^{NA}_t\right)\frac{C^A_{F,t+1}}{C^{NA}_{F,t+1}}$. Since inactive households cannot smooth their consumption using financial assets, the inactive labour wedge rises by more, on impact, following an appreciation ($\tau^{NA}_t > \tau^A_t$), in part because inactive consumption falls by more $C^{NA}_{F,t} > C^A_{F,t}$. Consequently, over-borrowing by each active household is higher than in the representative agent case. This inefficiency and the distributional effects of dollar shortages are quantified in the exercise below.

5 Numerical Exercise

In this section I calibrate the model steady state to key features of the U.S. economy in 2008Q1. I then simulate a realistic shock to dollar shortages to match the dollar appreciation seen in the data. First, I quantify the driving forces in the model: how large are the monopoly rents earned

[42] The derivation follows the proof to Proposition 1, using (47) and (48).

from issuing dollar debt, how much do export revenues fall and how large are the losses on the U.S. portfolio of foreign assets? Then, based on this, I assess the effectiveness of monetary policy, with and without the optimal borrowing tax. To do so, I evaluate the welfare outcomes for active and inactive households, highlighting the distributional consequences of dollar shortages which persist even when policy is optimally set.

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.[43] I choose $\chi = \chi^G = 0.8$ and $\omega^G = 0.5$ such that government spending to GDP $PG/P_HY_H = 0.3$ and $P_HC_H^*/P_HY_H = 0.15$, 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 12% of U.S. GDP, see Appendix A.[44] I choose $\frac{1}{\bar{Q}}^2 = 0.14$, 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, 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).

Finally, to target the size of the losses on the U.S. portfolio arising due to a dollar appreciation valuation effects, I choose steady state dollar demand such that the gross external liabilities (dollar-denominated) for the U.S. are equal to to be consistent with 160% GDP in domestic currency liabilities and the exogenous position in foreign-currency denominated assets (a_t^F) is 148% of foreign-currency denominated assets, resulting in a net foreign asset position of -12%, consistent with data from the BEA documented in A.

5.1 Dollar demand shock.

The analysis focuses on a shock to dollar demand by foreign agents ξ_t.[45] I assume the dollar shock follows an AR(1) process with quarterly persistence 0.85, such that dollar shortages last about 4 quarter, see Figure 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-

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

[44] 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.

[45] I abstract from the many other linkages between dollar shortages and the hegemon economy, to isolate the direct effects of dollar shortages and the downward-sloping demand for dollar debt on the U.S. economy. Namely, I assume that total foreign sector consumption C^* and the foreign-currency returs on forest assets Ψ_t^* are independent of Q_t.

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	$\frac{X}{Y} = 15\%$
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)
$\bar{\xi}$	8.6	Mean demand shock	-12% nfa
$\bar{\Gamma}$	0.14	Elasticity of financiers' demand	$\frac{d\mathcal{E}}{dQ} = 2$
a_t^F	8.4	Government portfolio	BEA
α	0.3	Share of inactive households	Survey Cons. Finances

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

ure 5 (right panel). The implied size of the dollar demand shock is about 7% of U.S. GDP.[46]

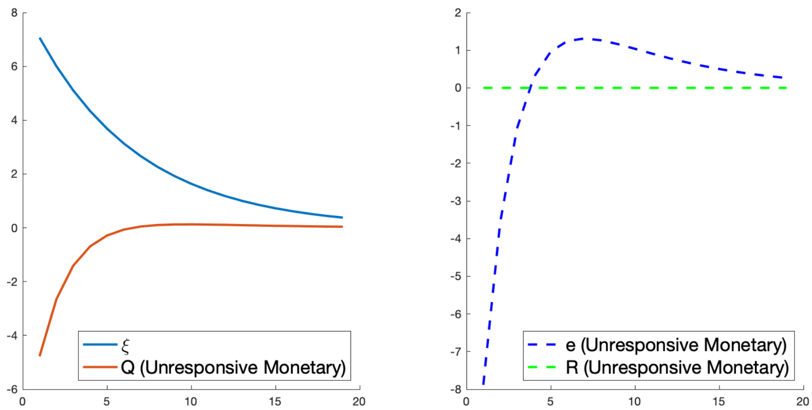


Figure 5: Impulse response to dollar demand shock ξ_t. Left panel: Dollar demand shock dollar shortages expressed in % of U.S. GDP. Right panel: Exchange rate appreciation in % deviations from steady state.

[46]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 reasonable. 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.

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. 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 issuing dollar debt. 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.

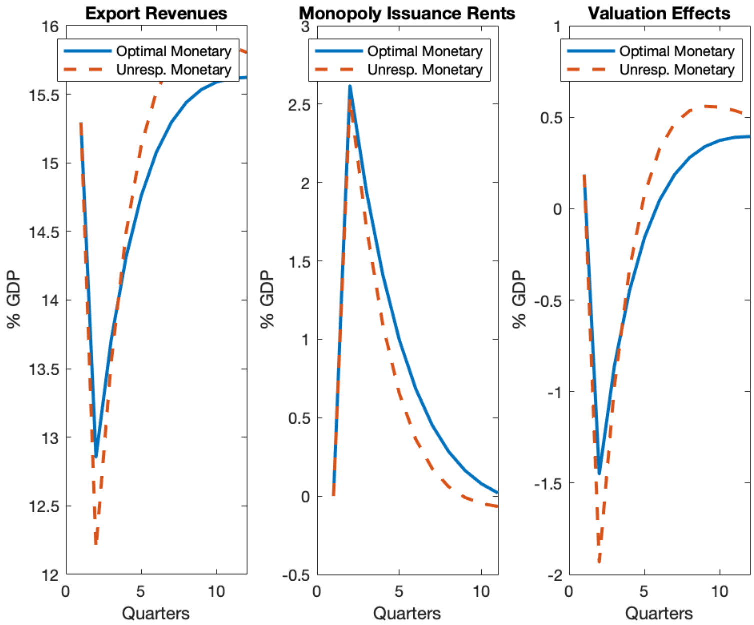


Figure 6: Impulse response to $\xi > 0$. Comparison of export revenues, monopoly rents from issuance and valuation effects, as % of GDP per quarter (flow), under the optimal and unresponsive monetary regimes.

Starting from the left panel of Figure 6, the model predicts that the fall in export rents attributable to the dollar appreciation reaches 3% if interest rates are constant. The middle illustrates monopoly rents, transferred to the hegemon from abroad, which reach 2.5% of U.S. GDP in the first quarter. Annually, this translates to about 7% of GDP annually in monopoly rents. This can be squared with the following back of the envelope calculation. Gross dollar liabilities are about 125% GDP on impact and the borrowing spread is about 5.5%, so 125×5.5 % results in the 7% GDP annually. The right panel illustrates the transfer of wealth from the hegemon to the foreign sector due to valuation effects, which reach 3.5% GDP annually if interest rates do not adjust, entirely due to an exchange rate appreciation. Gourinchas, Rey, and Truempler (2011) calculate that during the GFC there was a 13% 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.[47]

5.3 Evaluating the effectiveness of policy

Monetary Policy. Figure 7 contrasts the effects of a dollar demand shock on allocations and prices in the hegemon, and shortages abroad, if interest rates are held constant and if monetary policy is set optimally according to (37). 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 Figure 5. The hegemon optimally lowers interest rates such that a smaller dollar appreciation is required to satisfy financiers' optimality condition (18), 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.[48] As reflected in the monetary policy targeting rule (76), absent a borrowing tax, the monetary authority accepts a degree of externally induced employment volatility and private sector over-borrowing.[49]

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, Figure 8 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 are constant. On the other hand, active households experience involuntary unemployment only if interest rates are held constant, and are overworked otherwise.[50]

Constrained Optimal Allocation and Monetary Policy Trade-offs. Consider now the constrained optimal allocation which is achieved by the combination of monetary policy and

[47] In the model, the fall in returns on risky assets can be modelled by a negative shock to Ψ_t^*.

[48] 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.

[49] 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.

[50] 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.

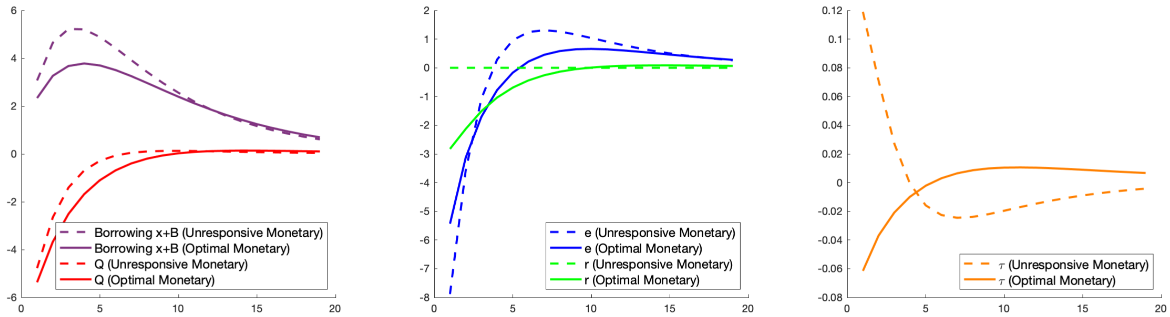


Figure 7: Impulse response to dollar demand shock ξ_t Comparison of optimal monetary (solid line) policy vs. passive monetary policy (dashed line). Left Panel: Sum of private and public borrowing expressed as % GDP in deviations from steady state. Middle panel: Exchange rate and interest rate movements expressed in % deviations from steady state. Right panel: Labour wedge deviations.

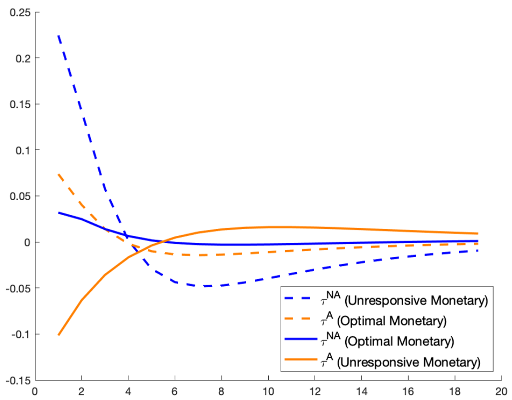


Figure 8: Impulse response to dollar demand shock ξ_t. Labour wedge deviations.

a borrowing tax. At the constrained optimum allocation, the interest rate cut is larger (5% vs. 3%, subject to the effective lower bound), lowering the pressure on the exchange rate to appreciate, as illustrated in Fig. 9 (middle panel). This difference reflects how much dollar shortages abroad weigh on monetary policy in the absence of a borrowing tax.

At the constrained optimal allocation, interest rates are cut significantly to stem the appreciation and an optimal borrowing tax is used to postpone consumption to the future. The borrowing tax ensures that output volatility is low and, since households borrow less, the price of debt is high. 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 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.[51]

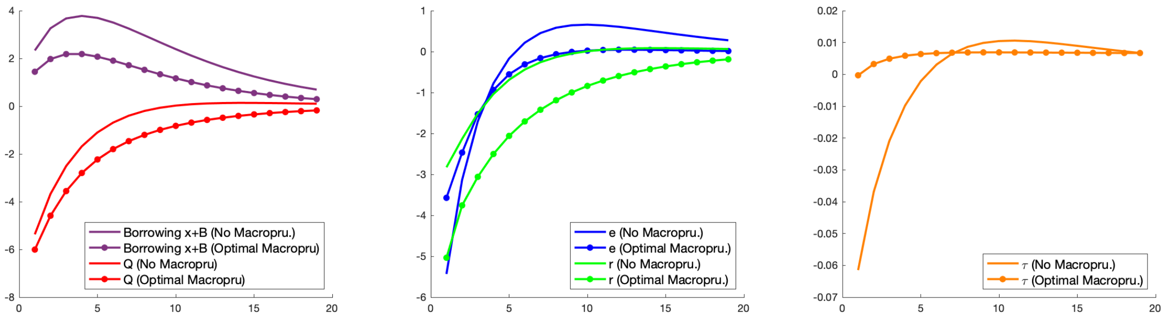


Figure 9: Impulse response to $\xi^* > 0$. Comparison of optimal macropru (rivetted line) vs. no macropru.(solid line). Left Panel: Sum of private and public borrowing expressed as % GDP in deviations from steady state. Middle panel: Exchange rate and interest rate movements expressed in % deviations from steady state. Right panel: Labour wedge deviations.

5.4 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,

$$\mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\Gamma, \xi_t\}) \tag{51}$$

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

$$\sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^i (1+\nu_t^i)^{1-\sigma}}{1-\sigma} - \kappa \frac{L_t^{1+\psi}}{1+\psi} + V(G_t) \right] = \mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \Gamma, 0), \tag{52}$$

where ν_t^i is a proportional consumption transfer, calculated over the period of the crisis, such that household $i \in \{A, NA\}$ is equally well-off whether or not the dollar demand shock occurs.[52] I assume $\nu_t^i = \nu$ for the first 8 quarters after the shock hits (after which its size becomes negligible) and $\nu_t^i = 0$ thereafter. 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.

When interest rates do not respond (first row of Table 2), dollar shortages cost about 0.35% of consumption equivalent per quarter, in the aggregate, over the 2 year duration of the crisis. These are driven by both losses to financially-active and inactive households, although the latter suffer disproportionately as per Proposition 5. Instead if monetary policy responds optimally,

[51] 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.

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

	Active	Inactive	Aggregate
Unresponsive monetary (no macropru.)	0.25%	0.43%	0.31%
Optimal monetary (no macropru.)	-0.81%	0.17%	-0.51%
Constrained Optimal	-2.2%	0.23%	-1.5%

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

which requires an interest rate cut of just over 2%, the aggregate economy gains the equivalent of 0.5% consumption per quarter over the 2 years, but this is only one-third of the gain that could be achieved at the constrained optimal, in conjunction with an optimal tax on borrowing. However, this figure masks welfare losses facing inactive households (0.17%), which are more than offset by gains to active (0.81%).

Faced with the isolated shock to dollar demand shock which dollar swaps can address directly, dollar swap lines benefit inactive households (by muting the effects of the shock) at the expense of active households (who do not earn monopoly rents). Even at the constrained optimal, the stark distributional implications persist. If a borrowing tax is used in conjunction to monetary policy, aggregate welfare gains are much larger in the aggregate (1.5%), driven by active-households (2.2%). However, if optimal policy is more concerned with active household welfare (i.e when Pareto weights are fair and 30% of households are inactive), the borrowing tax prioritises maximizing the transfer of monopoly rents. The welfare of the minority of inactive households actually falls when the optimal borrowing tax is used (0.23% loss vs 0.17% loss in the case of monetary policy alone).

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:

$$\mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\frac{1}{Q+Q^s}^2, \xi_t\}) > \mathcal{W}(\{\mathcal{E}_t, \tau_t^x\}; \{\frac{1}{Q}^2, \xi_t\}) \tag{53}$$

Dollar demand shocks have no macroeconomic consequences for the hegemon if dollar liquidity is very high, therefore swaps are optimal when dollar demand leads to welfare losses.

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). I emphasize 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 dollar swaps are a partial substitute to a borrowing tax, swaps are more desirable when monetary policy does not respond, as is the case near the zero lower bound.

Second, 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.

Third, dollar swaps are more desirable if exchange rate pass-through to imports in the hegemon is low. For any given level of monopoly rents $-\Gamma Q_t(\mathbf{a}_t x_t + B_t)$, the quantity of imports they can buy is $-\frac{1}{P_F^* \mathcal{E}_t^{\lambda}} \Gamma Q_t(\mathbf{a}_t x_t + B_t)$. Following an appreciation, the price of imports falls by more if pass-through λ is higher. Therefore, 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 F.[53]

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.

I show that these trade-offs cannot be resolved by monetary and fiscal policy alone. Monetary policy can stabilize the hegemon economy, but its effectiveness is limited by private sector over-borrowing, and cannot achieve the constrained efficient allocation if a macro-prudential tax is not available. This arises due to a combination of nominal rigidities and atomistic households failing to internalize their size in dollar markets. U.S. monetary policy cannot therefore efficiently balance internal objects independently of capital inflows and faces a Mundellian dilemma, as opposed to a Trilemma.

Dollar swaps can address domestic over-borrowing but only at the cost of eroding monopoly rents– so cannot substitute for the borrowing tax in the constrained optimal. 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, if pass-through to import prices is low (such that an appreciation is more costly), or if the planner has a preference for redistribution from households active in financial markets to inactive households.

[53] 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.

References

Adrian, T. and H. S. Shin (2014). "Procyclical Leverage and Value-at-Risk". In: *Review of Financial Studies* 27.2, pp. 373–403.

Adrian, T. and P. Xie (2020). *The Non-U.S. Bank Demand for U.S. Dollar Assets.* CEPR Discussion Papers 14437. C.E.P.R. Discussion Papers.

Aguiar, M., M. Amador, H. A. Hopenhayn, and I. Werning (2015). "Equilibrium Default".

Aizenman, J., H. Ito, and G. K. Pasricha (2021). *Central Bank Swap Arrangements in the COVID-19 Crisis.* Working Paper 28585. National Bureau of Economic Research.

Akinci, O. and A. Queraltó (2018). *Exchange rate dynamics and monetary spillovers with imperfect financial markets.* Staff Reports 849. Federal Reserve Bank of New York.

Aldasoro, I., T. Ehlers, P. McGuire, and G. von Peter (2020). *Global banks' dollar funding needs and central bank swap lines.* BIS Bulletins 27. Bank for International Settlements.

Alvarez, F., A. Atkeson, and P. J. Kehoe (2002). "Money, Interest Rates, and Exchange Rates with Endogenously Segmented Markets". In: *Journal of Political Economy* 110.1, pp. 73–112.

— (2009). "Time-Varying Risk, Interest Rates, and Exchange Rates in General Equilibrium". In: *The Review of Economic Studies* 76.3, pp. 851–878.

Auclert, A., M. Rognlie, M. Souchier, and L. Straub (2021). *Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel.* Working Paper 28872. National Bureau of Economic Research.

Baba, N. and F. Packer (2009). *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.

Bahaj, S. and R. Reis (2018). *Central Bank Swap Lines.* Discussion Papers 1816. Centre for Macroeconomics (CFM).

Basu, S., E. Boz, G. Gopinath, F. Roch, and F. Unsal (2020). "A Conceptual Model for the Integrated Policy Framework". In: *IMF Working Papers* 20.

Bianchi, J. and G. Lorenzoni (2021). "The Prudential Use of Capital Controls and Foreign Currency Reserves". In:

Bilbiie, F. O. (2020). "The New Keynesian cross". In: *Journal of Monetary Economics* 114.C, pp. 90–108.

Bruno, V. and H. S. Shin (2017). "Global Dollar Credit and Carry Trades: A Firm-Level Analysis". In: *The Review of Financial Studies* 30.3, pp. 703–749.

Caballero, R. J., E. Farhi, and P.-O. Gourinchas (2017). “The Safe Assets Shortage Conundrum”. In: *Journal of Economic Perspectives* 31.3, pp. 29–46.

Caballero, R. J. and A. Krishnamurthy (2004). “Smoothing sudden stops”. In: *Journal of Economic Theory* 119.1, pp. 104–127.

Chahrour, R. and R. Valchev (2021). “Trade Finance and the Durability of the Dollar”. In: *The Review of Economic Studies.*

Chari, V. V., P. J. Kehoe, and E. R. McGrattan (2007). “Business Cycle Accounting”. In: *Econometrica* 75.3, pp. 781–836.

Chien, Y. and P. Morris (2017). “Household Participation in Stock Market Varies Widely by State”. In: *Federal Reserve Bank of St. Louis* 3rd quarte.

Cociuba, S. E. and A. Ramanarayanan (2017). *International Risk Sharing with Endogenously Segmented Asset Markets.* Tech. rep.

Cole, H. L. and M. Obstfeld (1991). “Commodity trade and international risk sharing: How much do financial markets matter?” In: *Journal of Monetary Economics* 28.1, pp. 3–24.

Corsetti, G., L. Dedola, and S. Leduc (2018). *Exchange Rate Misalignment, Capital Flows, and Optimal Monetary Policy Trade-off.* Discussion Papers 1806. Centre for Macroeconomics (CFM).

— (2020). *Global inflation and exchange rate stabilization under a dominant currency.* Tech. rep. Mimeo.

Corsetti, G., S. Lloyd, and E. Marin (2020). “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”.*

Corsetti, G. and E. Marin (2020). “A Century of Arbitrage and Disaster Risk Pricing in Foreign Exchange Markets”. In: *CFM Working Paper.*

Corsetti, G. and P. Pesenti (2001). “Welfare and Macroeconomic Interdependence”. In: *The Quarterly Journal of Economics* 116.2, pp. 421–445.

Corsetti, G., P. Pesenti, R. Clarida, and J. Frankel (2007). “The Simple Geometry of Transmission and Stabilization in Closed and Open Economies [with Comments]”. In: *NBER International Seminar on Macroeconomics*, pp. 65–129.

Costinot, A., G. Lorenzoni, and I. Werning (2014). “A Theory of Capital Controls as Dynamic Terms-of-Trade Manipulation”. In: *Journal of Political Economy* 122.1, pp. 77–128.

Curcuru, S. E., C. Thomas, and F. Warnock (2013). “On returns differentials”. In: *Journal of International Money and Finance* 36.C, pp. 1–25.

Curcuru, S. E., C. P. Thomas, F. E. Warnock, and J. Wongswan (2011). "US International Equity Investment and Past and Prospective Returns". In: *American Economic Review* 101.7, pp. 3440–3455.

Del Negro, M., G. Eggertsson, A. Ferrero, and N. Kiyotaki (2017). "The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities". In: *American Economic Review* 107.3, pp. 824–857.

Egorov, K. and D. Mukhin (2019). *Optimal Monetary Policy under Dollar Pricing*. Tech. rep.

Eguren-Martin, F. (2020). *Dollar shortages and central bank swap lines*. Bank of England working papers 879. Bank of England.

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

Fanelli, S. (2017). *Optimal Monetary Policy and Portfolio Choice*. Tech. rep.

Fanelli, S. and L. Straub (2018). *A Theory of Foreign Exchange Interventions*. Tech. rep.

Farhi, E. and M. Maggiori (2016). "A Model of the International Monetary System". Working Paper.

Farhi, E. and I. Werning (2012). *Dealing with the Trilemma: Optimal Capital Controls with Fixed Exchange Rates*.

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

— (2016). "A Theory of Macroprudential Policies in the Presence of Nominal Rigidities". In: *Econometrica* 84.5, pp. 1645–1704.

Feenstra, R. C., P. Luck, M. Obstfeld, and K. N. Russ (2018). "In Search of the Armington Elasticity". In: *The Review of Economics and Statistics* 100.1, pp. 135–150.

Ferra, S. de, K. Mitman, and F. Romei (2019). *Household Heterogeneity and the Transmission of Foreign Shocks*. Working Paper 26402. National Bureau of Economic Research.

Gabaix, X. and M. Maggiori (2015). "International Liquidity and Exchange Rate Dynamics". In: *Quarterly Journal of Economics* 130.3, pp. 1369–1420.

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

Gopinath, G., E. Boz, C. Casas, F. J. Díez, P.-O. Gourinchas, and M. Plagborg-Møller (2020). "Dominant Currency Paradigm". In: *American Economic Review* 110.3, pp. 677–719.

Gopinath, G. and J. C. Stein (2018). "Banking, Trade and the Making of a Dominant Currency".

Gourinchas, P.-O. and H. Rey (2005). *From World Banker to World Venture Capitalist: US External Adjustment and the Exorbitant Privilege*. Working Paper 11563. National Bureau of Economic Research.

Gourinchas, P.-O., H. Rey, and N. Govillot (2018). *Exorbitant Privilege and Exorbitant Duty*. Tech. rep. mimeo.

Gourinchas, P.-O., H. Rey, and K. Truempler (2011). *The Financial Crisis and The Geography of Wealth Transfers*. Working Paper 17353. National Bureau of Economic Research.

Gromb, D. and D. Vayanos (2002). "Equilibrium and welfare in markets with financially constrained arbitrageurs". In: *Journal of Financial Economics* 66.2, pp. 361–407.

— (2010). "Limits of Arbitrage". In: *Annual Review of Financial Economics* 2.1, pp. 251–275.

Jiang, Z. (2021). *US Fiscal Cycle and the Dollar*. Working Paper 27682. National Bureau of Economic Research.

Jiang, Z., A. Krishnamurthy, and H. Lustig (2020). *Dollar Safety and the Global Financial Cycle*. Working Paper 27682. National Bureau of Economic Research.

Kalemli-Ozcan, S. (2019). *U.S. Monetary Policy and International Risk Spillovers*. Working Paper 26297. National Bureau of Economic Research.

Kekre, R. and M. Lenel (2020). "The Dollar and the Global Price of Risk". In: *Mimeo*.

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

Kohlscheen, E. and S. C. Andrade (2014). "Official FX interventions through derivatives". In: *Journal of International Money and Finance* 47, pp. 202–216.

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

Krishnamurthy, A. and H. Lustig (2019). "Mind the Gap in Sovereign Debt Markets: The U.S. Treasury basis and the Dollar Risk Factor". In: *Proceedings - Economic Policy Symposium - Jackson Hole*.

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

Liao, G. Y. (2020). "Credit migration and covered interest rate parity". In: *Journal of Financial Economics* 138.2, pp. 504–525.

Liu, Y., A. Yaron, and L. Schmid (2019). *The Risks of Safe Assets*. Tech. rep.

Lloyd, S. and E. Marin (2020). *Capital Controls and Free Trade Agreements*. Working Paper. Mimeo.

Lloyd, S. P. and E. A. Marin (2019). “Exchange Rate Risk and Business Cycles”. In: *Cambridge Working Paper*.

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

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

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

Maggiori, M., B. Neiman, and J. Schreger (2018). *International Currencies and Capital Allocation*. Tech. rep.

McCauley, R. N. and C. R. Schenk (2020). *Central bank swaps then and now: swaps and dollar liquidity in the 1960s*. BIS Working Papers 851. Bank for International Settlements.

McGuire, P. and G. von Peter (2009). *The US dollar shortage in global banking and the international policy response*. BIS Working Papers 291. Bank for International Settlements.

Meese, R. A. and K. Rogoff (1983). “Empirical exchange rate models of the seventies: Do they fit out of sample?” In: *Journal of International Economics* 14.1, pp. 3–24.

Miranda-Agrippino, S. and H. Rey (2020). “U.S. Monetary Policy and the Global Financial Cycle”. In: *The Review of Economic Studies* 87.6, pp. 2754–2776.

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

Ohlin, B. (1929). “The Reparations Problem: A Discussion; Transfer Difficulties; Real and Imagined”. In: *The Economic Journal* 39, pp. 172–183.

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

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

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

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

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. The key take-away is that the spread in borrowing costs tends to be larger vis-á-vis emerging markets, and this was particularly true during COVID. However, the spread exists for G10 countries too.

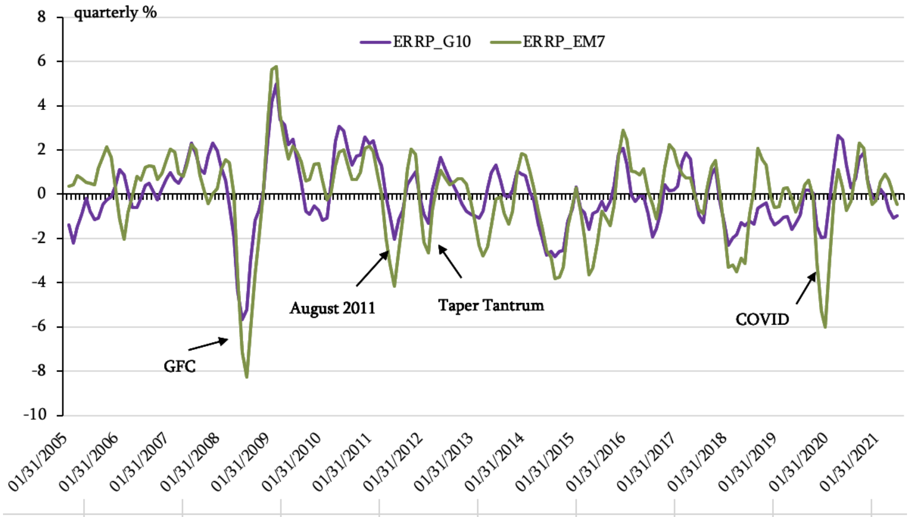


Figure 10: Source: Federal Reserve

As is clear from Figure 1, the borrowing spread is small outside of crises and the dollar appreciates at the onset of crises, which makes the realised cost of borrowing in dollar debt higher at that time. Borrowing in dollar debt is however much cheaper during crises, generating the monopoly rents at the core of this paper. Figure 11 plots gross trade volumes and the peak occurs during the GFC. Specifically, Krishnamurthy and Lustig (2019) show that gross flows are strongly negatively correlated with the changes in the spread. The correlation between gross purchases of Treasuries by foreigners and the change in the 3-month spread is -0.58 at monthly frequencies.

Related to this, Figure 12, 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

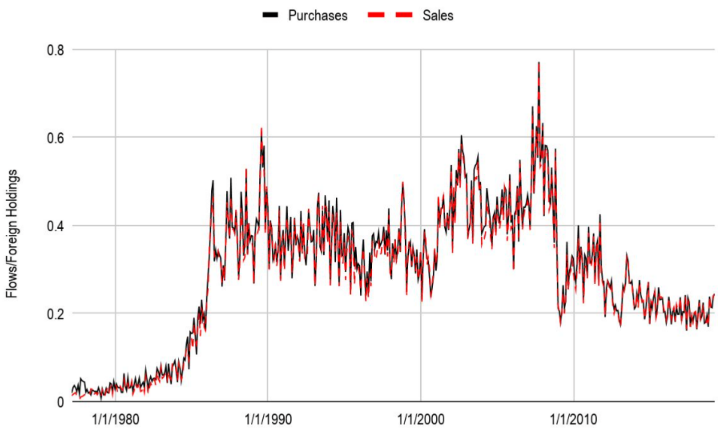
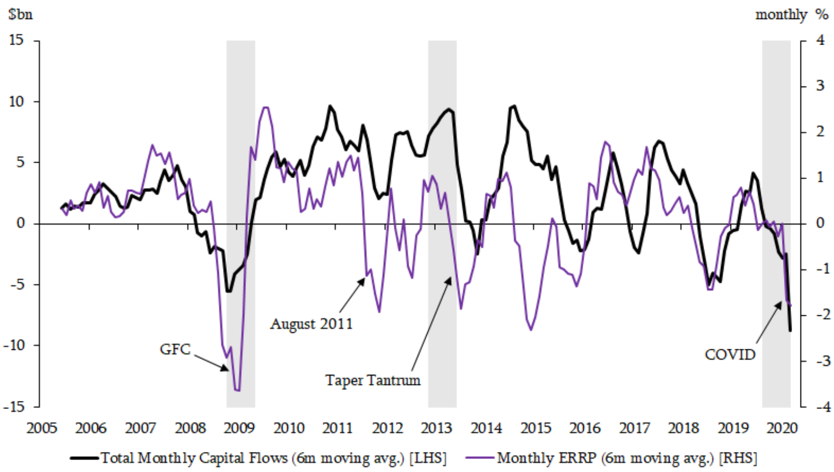


Figure 11: Evidence on timing of purchases of U.S. bonds by foreigners. Purchases by foreign investors and sales to foreign investors normalised by the foreign holdings of Treasuries. Source: Krishnamurthy and Lustig (2019).

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 level of dollar illiquidity – Γ_t in the model– that is substantially positive.

Figure 12: 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.

Evidence on the deteriorating U.S. position. The next two figures are important to show the potential size of monopoly rents that can accrue to the U.S., and are used for the calibration of the model. Figure 13 (left panel) 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 external assets and liabilities (right panel), and has rapidly worsened over time. This data is used in in Section 5 to calibrate the U.S. portfolio of foreign assets.

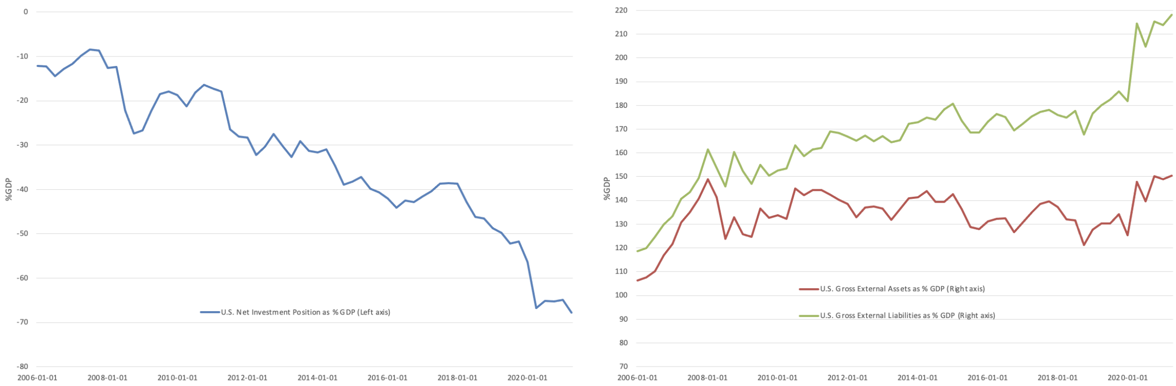


Figure 13: Left Panel: Net Investment Position for the United States in as % GDP. Right panel: Gross assets and liabilities as % GDP. Source: BEA and author's calculations.

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.

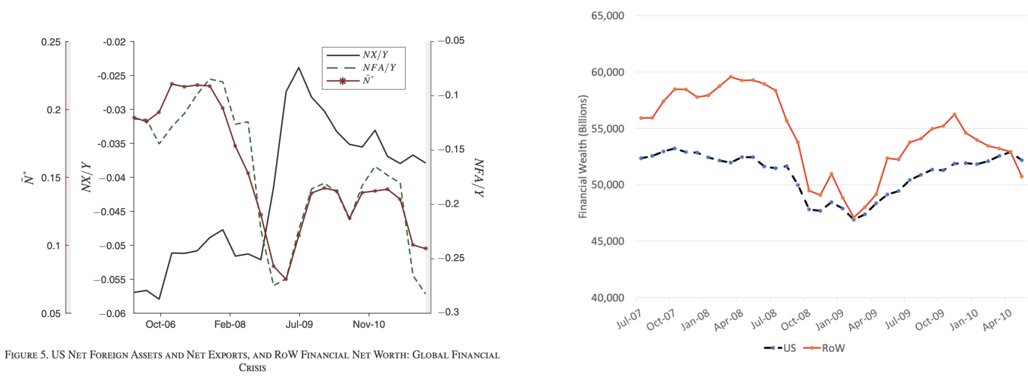


Figure 14: Left panel: Figure 5 from Maggiori (2017). Right panel: Figure 5 from Jiang, Krishnamurthy, and Lustig (2020).

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

The exchange rate can be expressed as,

$$\mathcal{E}_1 = \overline{\mathcal{E}}\left(\frac{\beta}{\beta^*}\frac{\mu_1}{\overline{\mu}} + \frac{\Gamma_1}{\beta^*}Q_1\right) \tag{54}$$

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

$$\mu = \overline{\mu}(1-s) + s\overline{\mu}\left(\tfrac{\beta^*}{\beta}\tfrac{\hat{\mathcal{E}}}{\overline{\mathcal{E}}} - \tfrac{\Gamma_1 Q_1}{\beta}\right) \tag{55}$$

If $\mu_1 = \overline{\mu}$ (the long-run expectation), or s is sufficiently low, then dollar shortages ($Q_1 < 0$) leads to an appreciation.

The derivatives $\frac{d\mu_1}{dQ_1}$ (given B_1) and $\frac{d\mu_1}{d\Gamma_1}$ characterize monetary decisions in response to dollar imbalances and liquidity and, in turn, these determine $\frac{d\mathcal{E}_1}{dQ_1}$, $\frac{d\mathcal{E}_1}{d\Gamma_1}$. Specifically,

$$\frac{d\mathcal{E}_1}{dB_1} = \left(\beta\frac{d\mu_1}{dQ_1} - \Gamma_1\right)\frac{\overline{\mathcal{E}}}{\beta^*}, \tag{56}$$

$$\frac{d\mathcal{E}_1}{d\tilde{\Gamma}_1} = \left(\beta\frac{d\mu_1}{d\tilde{\Gamma}_1} - Q_1\right)\frac{\overline{\mathcal{E}}}{\beta^*} \tag{57}$$

Consider the labour wedge τ_1, given by (30). The derivatives with respect to Q_1(holding B_1 and x_1 constant), B_1 and $\tilde{\Gamma}_1$ respectively:

$$\frac{d\tau_1}{dB_1} = -\frac{1}{A_1}\frac{\kappa}{\overline{p}_H}\left\{\frac{d\mu_1}{dB_1}L_1^{\psi} + \mu\psi L^{\psi-1}\left[\frac{\chi}{\overline{p}_H}\frac{d\mu_1}{B_1} + \frac{\zeta}{\overline{p}_H}\mathcal{E}_1^{\eta-1}\eta\frac{d\mathcal{E}_1}{dB_1}\right]\right\}, \tag{58}$$

$$\frac{d\tau_1}{d\Gamma_1} = -\frac{1}{A_1}\frac{\kappa}{\overline{p}_H}\left\{\frac{d\mu_1}{d\Gamma_1}L_1^{\psi} + \mu\psi L^{\psi-1}\left[\frac{\chi}{\overline{p}_H}\frac{d\mu_1}{d\Gamma_1} + \frac{\zeta}{\overline{p}_H}\mathcal{E}_1^{\eta-1}\eta\frac{d\mathcal{E}_1}{d\Gamma_1}\right]\right\}, \tag{59}$$

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

Similarly, the derivatives of monopoly rents Ω_1^M with respect to B_1 and Γ_1 are as follows:

$$\frac{d\Omega_1^M}{dB_1} = -\Gamma_1 Q_1 - \Gamma_1 B_1 + 2\omega\Gamma_1 Q_1 \tag{60}$$

$$\frac{d\Omega_1^M}{d\Gamma_1} = -Q_1 B_1 + \omega\Gamma_1 Q_1^2 \tag{61}$$

Additionally,

$$\frac{d\tau_1}{dQ_1} = -\frac{1}{A_1}\frac{\kappa}{\overline{p}_H}\left\{\frac{d\mu_1}{dQ_1}L_1^{\psi} + \mu\psi L^{\psi-1}\left[\frac{\chi}{\overline{p}_H}\frac{d\mu_1}{B_1} + \frac{\zeta}{\overline{p}_H}\mathcal{E}_1^{\eta-1}\eta\frac{d\mathcal{E}_1}{dQ_1}\right]\right\}, \tag{62}$$

$$\frac{d\Omega_1^M}{dQ_1} = \beta\frac{1}{\overline{\mu}}\frac{d\mu_1}{dQ_1}(B_1 + x_1) + \omega\Gamma_1 2Q_1, \tag{63}$$

and $\dfrac{d\mu_1}{dQ_1} = -\dfrac{s\overline{\mu}\Gamma_1}{\beta}$ (given B_1).

First, rearranging (62) and substituting (28), I derive $\frac{d\tau_1}{dQ_1} < 0$ if:

$$\frac{d\mu_1}{dQ_1} > -\frac{\frac{1}{\beta^*}\mu_1\psi L_1^{\psi-1}\frac{\zeta}{p_H}\mathcal{E}_1^{\eta-1}\eta\overline{\mathcal{E}}\Gamma_1}{L_1^{\psi}+\mu_1 L_1^{\psi-1}\psi(\frac{\chi}{p_H}+\frac{\zeta}{p_H}\mathcal{E}_1^{\eta-1}\eta\overline{\mathcal{E}}\frac{\beta}{\beta^*}\frac{1}{\overline{\mu}})} \leftrightarrow \tag{64}$$

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

where $\overline{s} \in [0,1]$. Using (63), $\frac{d\Omega_1^M}{dQ_1} < 0$ as long as $Q_1 < 0$. This yields the result (i).

The first-order conditions for HD1 with respect to B_1 and Γ_1 respectively are given by ,

$$\omega^S \text{sign}(\overline{\tau}-\tau_1)\frac{d\tau_1}{dB_1} + (1-\omega^S)\frac{d\Omega_1^M}{dB_1} = 0, \tag{65}$$

$$\omega^S \text{sign}(\overline{\tau}-\tau_1)\frac{d\tau_1}{d\Gamma_1} + (1-\omega^S)\frac{d\Omega_1^M}{d\Gamma_1} = 0, \tag{66}$$

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 given by (58)-(61). If $\Gamma_1 \geq \frac{1}{Q}$ then 66 is replaced by $\Gamma_1 = \frac{1}{Q}$.

Combining (65) and (66) with (58)-(63) yields the optimal allocation $\{B_1, \Gamma_1\}$. Consider the case $\omega^S = 1$. If Γ_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. If $\Gamma_1 = 0$ can be reached with dollar swaps, stabilization can be achieved using either dollar swaps or issuance. Instead, consider the case $\omega^S \to 0$. Then, rearranging (65) and substituting (28):

$$B_1 = \xi_1 \frac{1-2\omega}{2-2\omega} \tag{67}$$

From this, it follows that $0 < \frac{dB_1}{d\xi_1} < 1$ for a given level x_1 leading to $\frac{dQ_1}{d\xi_1} < 0$. In other words, the optimal allocation does not entrail perfect stabilisation. 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 (**??**). Given $\frac{d\tau_1}{d\Gamma_1} > 0$, $\frac{d\Omega_1^M}{d\Gamma_1} > 0$ if $Q_1 < 0$ and (69) is satisfied, then, from (66) we see that dollar swaps become useful as $|\tau - \overline{\tau}|$ grows. This completes the proof of (ii). □

Proof to Proposition 1. From (58) in Appendix B , the labour wedge is constant in dollar shortages if:

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

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 (60) as long as $s > 0$. B. $\square$

Fiscal stabilisation and valuation effects I now allow for $G_H > 0$ $(\chi^G > 0)$ and $\hat{\Psi}_1 = \Psi_1 + \Psi_1^* \mathcal{E}_1$. Because of valuation effects from the portfolio of foreign assets, monopoly rents are now only inceeasing in dollar shortages ($\frac{d\Omega_1^M}{dQ_1} < 0$) as long as monetary policy is sufficiently responsive $s > \underline{s}$, where:

$$\underline{s} = 1 - \frac{\Gamma_1 B_1 - 2\omega\Gamma_1 Q_1}{\Psi_1^* \Gamma_1 \overline{E} \beta^*} \tag{68}$$

so that the appreciation is partially offset.

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

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

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

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

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 (20). 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, [54]

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

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.

[54] To derive this, notice that (65) 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.

C 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):

$$
\begin{aligned}
V(C_{F,t},\mathcal{E}_t,G_{F,t}) &= \chi \log\left(\frac{\chi}{1-\chi}S_tC_{F,t},\right) + (1-\chi)\log(C_{F,t}) \\
&-\kappa\frac{\left(\frac{1}{A_t}\left[\frac{\chi}{1-\chi}\frac{\mathcal{E}_t^{\lambda}}{\overline{P}_{H,t}}C_{F,t},+(1-\chi)S_tC_t^{*}+\frac{\chi^G}{1-\chi^G}S_tG_{F,t}\right]\right)^{1-\psi}}{1-\psi} \\
&+\omega^G\left[\chi^G\log(\frac{\chi^G}{1-\chi^G}S_t(G_{F,t}+\underline{G}_F)]+(1-\chi^G)\log(G_{F,t}+\underline{G}_F)\right]
\end{aligned}
\tag{69}
$$

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,

$$
C_H^{*} = \frac{\chi}{1-\chi}\left(\frac{P^{*}}{P_H^{*}}\right)^{\eta}C^{*} = \underbrace{\frac{\chi}{1-\chi}\mu^{*}}_{\zeta}\left(\frac{\mathcal{E}_t}{\overline{P}_H}\right)^{\eta},
\tag{70}
$$

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 (30) and setting $\tau_t=0$:

$$
\frac{1}{A_t}\frac{\kappa}{1-\chi}\frac{S_t}{\overline{P}_H}C_{F,t}\left[\frac{1}{A_t}\left(\frac{\chi}{1-\chi}\frac{S_t}{\overline{P}_H}C_{F,t}+(1-\chi)S_tC_t^{*}+\frac{\chi^G}{1-\chi^G}S_tG_{F,t}\right)\right]=1
\tag{71}
$$

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,

$$
V_{C_{F,t}} = \frac{1-\chi}{C_{F,t}}\left(1+\frac{\chi}{1-\chi}\tau_t\right),
\tag{72}
$$

$$
\begin{aligned}
V_{\mathcal{E}_t} = \frac{1-\chi}{C_{F,t}}&\left(\mathcal{E}_t^{-1}\tau_t\left(\frac{\chi}{1-\chi}\lambda C_{F,t}+\zeta\mathcal{E}_t^{1-\lambda}+\frac{\chi^G}{1-\chi^G}\lambda G_{F,t}\right)-\zeta\mathcal{E}_t^{-\lambda}-\frac{\chi^G}{1-\chi^G}\lambda\mathcal{E}_t^{-1}G_{F,t}\right) \\
&+\omega^G\frac{1-\chi^G}{G_{F,t}+\underline{G}_F}\frac{\chi^G}{1-\chi^G}\lambda\mathcal{E}_t^{-1}G_{F,t},
\end{aligned}
\tag{73}
$$

$$
V_{G_{F,t}} = \frac{1-\chi}{C_{F,t}}(\tau_t-1)\frac{\chi^G}{1-\chi^G}+\omega^G\left\{\frac{1-\chi^G}{G_{F,t}+\underline{G}_F}\left(\frac{1}{1-\chi^G}\right)\right\}
\tag{74}
$$

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:

$$C_{F,t}: \qquad \beta^t V_{C_{F,t}} - \eta_{1,t} - \eta_{2,t} + \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}^2}\left[\eta_t^E \frac{1}{R_t} - \eta_{t-1}^E\right] = 0, \tag{75}$$

$$\begin{aligned}
\mathcal{E}_t: \qquad & \beta^t V_{\mathcal{E}_t} + \eta_t^C \zeta(\eta-\lambda)\mathcal{E}_t^{\eta-\lambda-1} - \eta_t^C\left\{\lambda\mathcal{E}_t^{-\lambda-1}\kappa^G\Psi_t^G - (1-\lambda)\mathcal{E}_t^{-\lambda}\Psi_t^*\right\} \\
&+ \eta_t^C\left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}}x_t + \lambda\mathcal{E}_t^{-\lambda-1}(x_{t-1}+\kappa^G B_{t-1}) + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t^2(1-\omega) + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t(\xi_t - B_t)\right\} \\
&- \frac{1}{\beta}\eta_{t-1}^C\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}x_{t-1} + \eta_t^G\left\{-\lambda\mathcal{E}_t^{-\lambda-1}\Psi_t(1-\kappa^G) + (1-\lambda)\Psi^*\mathcal{E}_t^{-\lambda}(1-\kappa^G)\right\} \\
&+ \eta_t^G\left\{\frac{1}{R^*}\frac{\mathcal{E}_t^{-\lambda}(1-\lambda)}{\mathcal{E}_{t+1}}B_t + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t + \lambda\mathcal{E}_t^{-\lambda-1}(1-\kappa^G)B_{t-1}\right\} - \eta_{t-1}^G\frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}{}^{1-\lambda}}{\mathcal{E}_t^2}B_{t-1} \\
&- \eta_t^E\frac{1}{C_{F,t}}\left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}} + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t B_t\right\} + \eta_{t-1}^E\frac{1}{C_{F,t}}\left\{\frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}\right\}, \\
&- \eta_t^\mu\lambda\mathcal{E}_t^{-\lambda-1}\mu(1-\chi) = 0,
\end{aligned} \tag{76}$$

$$x_t: \qquad \eta_t^C\mathcal{E}_t^{-\lambda}\left[\frac{1}{R_t} - \Gamma_t x_t + 2\omega\Gamma_t Q_t\right] - \beta\eta_{t+1}^C\mathcal{E}_{t+1}^{-\lambda} - \eta_t^G\mathcal{E}_t^{-\lambda}\Gamma_t B_t + \eta_t^E\left\{\Gamma_t\tfrac{1}{\mathcal{E}_t^{\lambda}C_{F,t}}\right\} = 0, \tag{77}$$

$$G_{F,t}: \qquad \beta^t V_{G_{F,t}} + \eta_t^C\left\{\frac{\chi^G - \kappa^G}{1-\chi^G}\right\} - \eta_t^G\left\{\frac{1-\kappa^G}{1-\chi^G}\right\} = 0, \tag{78}$$

$$\begin{aligned}
B_t: \qquad & \eta_t^G\mathcal{E}_t^{-\lambda}\frac{1}{R_t} = \beta\eta_{t+1}^G\mathcal{E}_{t+1}^{-\lambda}(1-\kappa^G) + \beta\eta_{t+1}^C\mathcal{E}_{t+1}^{-\lambda}\kappa^G + \\
&\Gamma_t\left\{\eta_t^G\mathcal{E}_t^{-\lambda}B_t + \eta_t^C\mathcal{E}_t^{-\lambda}(x_t - 2\omega Q_t)\right\} - \eta_t^E\Gamma_t\tfrac{1}{\mathcal{E}_t^{\lambda}C_{F,t}} = 0
\end{aligned} \tag{79}$$

Focusing on monetary policy, using (76), (37) follows from:

$$\frac{dC^*_{H,t}}{d\mathcal{E}_t} = \zeta(\eta-\lambda)\mathcal{E}_t^{\eta-\lambda-1}, \tag{80}$$

$$\frac{dF_t}{d\mathcal{E}_t} = -\left(\lambda\mathcal{E}_t^{-\lambda-1}\kappa^G\Psi_t^G - (1-\lambda)\mathcal{E}_t^{-\lambda}\Psi_t^*\right) + \tag{81}$$

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

$$\frac{dF_{t-1}}{d\mathcal{E}_t} = -\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}x_{t-1} \tag{82}$$

$$\frac{dF_t^G}{d\mathcal{E}_t} = \frac{1}{R^*}\frac{\mathcal{E}_t^{-\lambda}(1-\lambda)}{\mathcal{E}_{t+1}}B_t + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t + \lambda\mathcal{E}_t^{-\lambda-1}(1-\kappa^G)B_{t-1} \tag{83}$$

$$\frac{dF_{t-1}^G}{d\mathcal{E}_t} = -\frac{1}{R^*}\frac{\mathcal{E}_{t-1}}{\mathcal{E}_t^2}B_{t-1}, \tag{84}$$

$$\frac{dR_t}{d\mathcal{E}_t} = -\frac{1}{C_{F,t}}\left\{\frac{1}{R^*}(1-\lambda)\frac{\mathcal{E}_t^{-\lambda}}{\mathcal{E}_{t+1}} + \lambda\mathcal{E}_t^{-\lambda-1}\Gamma_t Q_t\right\}, \tag{85}$$

$$\frac{dR_{t-1}}{d\mathcal{E}_t} = \frac{1}{C_{F,t}}\left\{\frac{1}{\beta}\frac{1}{R^*}\frac{\mathcal{E}_{t-1}^{1-\lambda}}{\mathcal{E}_t^2}\right\} \tag{86}$$

The FOC wrt. $\mathcal{E}_t$ (76) characterises optimal monetary policy. If monetary policy is unresponsive, then (76) determines the multiplier on constraint (**??**) denoted η_t^μ. If monetary policy is optimally set, $\eta_t^\mu = 0$. The FOC wrt. x_t (108 characterizes optimal borrowing by households, from the country (planner's) perspective. If macroprudential taxation is not available , this is replaced by (5).

C.1 Generalizing preferences $\sigma, \theta \neq 1$

In this subsection, I consider the generalisation of the model beyond the Cole-Obstfeld specification. This is used for the quantitative exercise in Section 5. The indirect utility function is given by:

$$V(C_{F,t}G_{F,t},\mathcal{E}_t) = \frac{1}{1-\sigma}\left(\left[\chi^{\frac{1}{\theta}}\left(\frac{\chi}{1-\chi}\left(\frac{P_F^*\mathcal{E}_t^\lambda}{P_{H,t}}\right)^{\frac{1}{\theta}}C_{F,t}\right)^{\frac{\theta-1}{\theta}} + (1-\chi)^{\frac{1}{\theta}}C_{F,t}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}\right)^{1-\sigma} - \tag{87}$$

$$\kappa\frac{1}{1+\psi}\left[\left(\frac{\chi}{1-\chi}\left(\frac{P_F^*\mathcal{E}_t^\lambda}{P_{H,t}}\right)^{\frac{1}{\theta}}C_{F,t}\right) + \zeta\left(\frac{\mathcal{E}_t}{P_{H,t}}\right)^\eta + \left(\frac{\chi^G}{1-\chi^G}\left(\frac{P_F^*\mathcal{E}_t^\lambda}{P_{H,t}}\right)^{\frac{1}{\theta}}G_{F,t}\right)\right]^{1+\psi} +$$

$$+\omega^G log\left(\left[\chi^{\frac{1}{\theta}}\left(\frac{\chi^G}{1-\chi^G}\left(\frac{P_F^*\mathcal{E}_t^\lambda}{P_{H,t}}\right)^{\frac{1}{\theta}}G_{F,t}\right)^{\frac{\theta-1}{\theta}} + (1-\chi)^{\frac{1}{\theta}}G_{F,t}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}\right)$$

The partial derivatives with respect to $C_{F,t}, G_{F,t}$ and $\mathcal{E}_t$ are given as follows:

$$V_{C_{F,t}} = C_t^{\frac{1-\theta\sigma}{\theta}} \left\{ \chi^{\frac{1}{\theta}} \left[\frac{\chi}{1-\chi} \left(\frac{P_F^* \mathcal{E}_t^\lambda}{P_{H,t}} \right)^{\frac{1}{\theta}} \right] C_{H,t}^{\frac{-1}{\theta}} + (1-\chi)^{\frac{1}{\theta}} C_{F,t}^{\frac{-1}{\theta}} \right\} - \kappa L_t^\psi \frac{\chi}{1-\chi} \left(\frac{P_F^* \mathcal{E}_t^\lambda}{P_{H,t}} \right)^{\frac{1}{\theta}}, \tag{88}$$

$$V_{\mathcal{E}_t} = C_t^{\frac{1-\theta\sigma}{\theta}} \left\{ \chi^{\frac{1}{\theta}} C_{H,t}^{\frac{-1}{\theta}} \left(\frac{P_F^* \mathcal{E}_t^\lambda}{P_{H,t}} \right)^{\frac{1-\theta}{\theta}} \lambda \mathcal{E}_t^{\lambda-1} \frac{1}{P_{H,t}} C_{F,t} \right\} - \tag{89}$$

$$\kappa L_t^\psi \left\{ \frac{\chi}{1-\chi} \left(\frac{P_F^* \mathcal{E}_t^\lambda}{P_{H,t}} \right)^{\frac{1-\theta}{\theta}} \lambda \mathcal{E}_t^{\lambda-1} \frac{1}{P_{H,t}} C_{F,t} + \zeta\eta \left(\frac{\mathcal{E}_t}{P_{H,t}} \right)^{\eta-1} + \frac{\chi^G}{1-\chi^G} \left(\frac{P_F^* \mathcal{E}_t^\lambda}{P_{H,t}} \right)^{\frac{1-\theta}{\theta}} \lambda \mathcal{E}_t^{\lambda-1} \frac{1}{P_{H,t}} G_{F,t} \right\} +$$

$$\omega^G G_t^{\frac{1-\theta}{\theta}} \left\{ \chi^{\frac{1}{\theta}} \left(\frac{\chi^G}{1-\chi^G} \left(\frac{P_{F,t}}{P_{H,t}} \right)^{\frac{1}{\theta}} \lambda \mathcal{E}_t^{\lambda-1} G_{F,t} \right) G_{H,t}^{\frac{-1}{\theta}} \right\},$$

$$V_{G_{F,t}} = -\kappa L_t^\psi \frac{\chi^G}{1-\chi^G} \left(\frac{P_F^* \mathcal{E}_t^\lambda}{P_{H,t}} \right)^{\frac{1}{\theta}} + \omega^G G_t^{\frac{1-\theta}{\theta}} \left\{ (\chi^G)^{\frac{1}{\theta}} \left[\frac{\chi^G}{1-\chi^G} \left(\frac{P_F^* \mathcal{E}_t^\lambda}{P_{H,t}} \right)^{\frac{1}{\theta}} \right] G_{H,t}^{\frac{-1}{\theta}} + (1-\chi^G)^{\frac{1}{\theta}} G_{F,t}^{\frac{-1}{\theta}} \right\} \tag{90}$$

By the same substitutions as in the main body, the household budget constraint (26) becomes:

$$C_{F,t} \leq \mathcal{E}_t^{-\lambda} \Bigg\{ P_{H,t}^{1-\eta} \zeta \mathcal{E}_t^\eta + \mathbb{E}_t \left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} \right] \frac{1}{R^*} x_t \quad \underbrace{-\Gamma Q_t(\xi_t - B_t)}_{\text{(a) Monopoly issuance rents (+ve)}} \quad \underbrace{-\Gamma Q_t^2 (1-\omega)}_{\text{(b) Cost of segmentation } (-ve)}$$
$$-(x_{t-1} + \kappa^G B_{t-1}) + G_{F,t} \left(\frac{\chi^G(1-\kappa^G)}{1-\chi^G} P_{H,t}^{1-\frac{1}{\theta}} P_{F,t}^{\frac{1}{\theta}} - \kappa^G P_{F,t} \right) + \kappa^G \hat{\Psi}_t(\mathcal{E}_t) \Bigg\} \tag{91}$$

The government consolidated budget constraint (27) becomes:

$$G_{F,t} \left(1 + \left(\frac{P_{F,t}}{P_{H,t}} \right)^{\frac{1}{\theta}-1} \frac{\chi^G}{1-\chi^G} \right) (1-\kappa^G) \leq \mathcal{E}_t^{-\lambda} \left\{ \frac{1}{R^*} \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}} B_t - \Gamma Q_t B_t - (1-\kappa^G)(B_{t-1} - \hat{\Psi}_t) \right\} \tag{92}$$

All the expression in this section coincide with the main body counterparts in the limit $\sigma, \theta \to 1$.

D Further Derivations for Section 5 : Limited Financial Market Participation

Proof to Proposition 4.

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

$$C_{F,t}^{NA} \leq \mathcal{E}_t^{-\lambda}\left[\frac{\mathbf{a}_t\chi}{1-(1-\mathbf{a}_t)\chi}\mathcal{E}_t^{\lambda}C_{F,t}^{A} + \frac{1-\chi}{1-(1-\mathbf{a}_t)\chi}\left(\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1})\right)\right] \tag{93}$$

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

$$C_{F,t}^{A}\left(1+\frac{\chi}{1-\chi}(1-\mathbf{a}_t\right) \leq \mathcal{E}_t^{-\lambda}\Bigg[(1-\mathbf{a}_t)\frac{\chi}{1-\chi}\mathcal{E}_t C_{F,t}^{NA} + \zeta\mathcal{E}_t^{\eta} + \frac{\chi^G-\kappa^G}{1-\chi^G}P_{F,t}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}) \tag{94}$$

$$\frac{1}{R_t}x_t - x_{t-1} + \omega\Gamma_t Q_t^2\Bigg] \tag{95}$$

Solving (93) and (95) jointly and substituting T_t yields :

$$\begin{aligned} C_{F,t}^{A} \leq \mathcal{E}_t^{-\lambda}\Bigg[&\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1}) + \\ &(1-(1-\alpha)\chi)\left(\frac{1}{R_t}x_t - x_{t-1}\right) + \omega\Gamma_t Q_t^2\Bigg], \end{aligned} \tag{96}$$

as detailed in (47). Substituting back into (93) yields:

$$C_{F,t}^{NA} \leq \mathcal{E}_t^{-\lambda}\left[\zeta\mathcal{E}_t^{\eta} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1} + (\alpha\chi)\left(\frac{1}{R_t}x_t - x_{t-1}\right) + \omega\Gamma_t Q_t^2\right], \tag{97}$$

Substituting the above into market clearing yields:

$$L_t = \frac{1}{A_t}\frac{\mathcal{E}_t^{\lambda}}{\overline{P}_{H,t}}\left(\frac{\chi}{1-\chi}\frac{\mathbf{a}_t}{1-(1-\mathbf{a}_t)\chi}C_{F,t}^{A} + \frac{(1-\alpha)\chi}{1-(1-\mathbf{a}_t)\chi}\left(\zeta\mathcal{E}^{\eta-\lambda} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1})\right)\right) \tag{98}$$

which can be re-written as:

$$\begin{aligned} L_t = \frac{1}{A_t}\frac{1}{\overline{P}_{H,t}}\frac{\chi}{1-\chi}&\left\{\zeta\mathcal{E}^{\eta-\lambda} + \frac{\chi^G-\kappa^G}{1-\chi^G}G_{F,t} + \kappa^G(\hat{\Psi}_t - B_{t-1})\right\} + \\ &\frac{1}{A_t}\frac{1}{\overline{P}_{H,t}}\frac{\chi}{1-\chi}\left(\frac{1}{R_t}x_t - x_{t-1} + \omega\Gamma_t Q_t^2\right) \end{aligned} \tag{99}$$

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,

$$V\left(C^A_{F,t}, C^{NA}_{F,t}, \mathcal{E}^\lambda_t G_{F,t}; \boldsymbol{\lambda}, \mathbf{a}_t\right) = \mathbf{a}_t\, \mathcal{U}\left(\frac{\chi}{1-\chi}\mathcal{E}^\lambda_t \frac{\overline{P}^*_{F,t}}{\overline{P}_{H,t}} C^A_{F,t}, C^A_{F,t}, L_t\right) + \tag{100}$$

$$(1-\mathbf{a}_t)\mathcal{U}\left(\frac{\chi}{1-\chi}\mathcal{E}^\lambda_t \frac{\overline{P}^*_{F,t}}{\overline{P}_{H,t}} C^{NA}_{F,t}, C^{NA}_{F,t}, L_t\right),$$

$$+\omega^G\left[\chi^G \log(\frac{\chi^G}{1-\chi^G} S_t(G_{F,t} + \underline{G}_F)] + (1-\chi^G)\log(G_{F,t} + \underline{G}_F)\right]$$

where $C^A_{F,t}$ is given by (95), $C^{NA}_{F,t}$ is given by (97) and $L^A_t = L^{NA}_t$ is given by (98).

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:

$$V_{C^A_{F,t}} = \alpha\lambda^A \frac{1-\chi}{C^A_{F,t}}\left(1 + \frac{\chi}{1-\chi}\tau^A_t\right), \tag{101}$$

$$V_{C^{NA}_{F,t}} = (1-\alpha)\lambda^A \frac{1-\chi}{C^{NA}_{F,t}}\left(1 + \frac{\chi}{1-\chi}\tau^{NA}_t\right) \tag{102}$$

$$V_{\mathcal{E}_t}(C_{F,t}, \mathcal{E}_t; \mathbf{a}_t) = \mathbf{a}_t\lambda^A\, \frac{1-\chi}{C^A_{F,t}}\left\{\frac{\chi}{1-\chi} C^A_{F,t}\lambda\mathcal{E}^{-1}_t + \right. \tag{103}$$

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

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

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

The condition characterising unresponsive monetary policy is given by,

$$\overline{P}^*_{F,t}\mathcal{E}^\lambda_t C^A_{F,t} = \mu(1-\chi), \tag{104}$$

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 (45).

The hegemon maximizes (100) subject to (95) and (95), where L_t by (98). 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 :

$$C_{F,t}^{A}: \qquad \beta^t V_{C_{F,t}^{A}} - \mathbf{a}\eta_t^{A} - \eta_t^{\mu} + \frac{1}{\mathcal{E}_t^{\lambda} C_{F,t}^{2}} \left[\eta_t^{E} \frac{1}{R_t} - \eta_{t-1}^{E}\right] = 0, \tag{105}$$

$$C_{F,t}^{NA}: \qquad \beta^t V_{C_{F,t}^{NA}} - (1-\mathbf{a})\eta_t^{NA} = 0, \tag{106}$$

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

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

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

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

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

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

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

$$x_t: \qquad [\mathbf{a}\eta_t^{A}(1-(1-\mathbf{a})\chi) + (1-\mathbf{a})\eta_t^{NA}\mathbf{a}\chi)]\mathcal{E}_t^{-\lambda}\left[\frac{1}{R_t} - \mathbf{a}\Gamma_t x_t + 2\omega\mathbf{a}\Gamma_t Q_t\right] - \tag{108}$$

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

$$G_{F,t}: \qquad \beta^t V_{G_{F,t}} + [\mathbf{a}\eta_t^{A} + (1-\mathbf{a})\eta_t^{NA}]\left\{\frac{\chi^G - \kappa^G}{1-\chi^G}\right\} - \eta_t^G\left\{\frac{1-\kappa^G}{1-\chi^G}\right\} = 0, \tag{109}$$

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

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

The expressions for the $\sigma, \theta \neq 1$ case follow from expanding on the relevant conditions in Section C.1.

E Model for the i-th country

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. For simplicity, I abstract from government spending.

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

$$C_{i,t} = \left[\chi C_{ii,t}^{\frac{\theta-1}{\theta}} + (1-\chi) C_{i,t}^{*\,\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \tag{111}$$

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,

$$C_{ji,t} = \left(\int_\omega C_{ji,t}(\omega)^{\frac{\epsilon-1}{\epsilon}} d\omega \right)^{\frac{\epsilon}{\epsilon-1}} \tag{112}$$

The country i consumer-price index is given by,

$$P_{i,t} = \left[\chi P_{ii,t}^{1-\theta} + (1-\chi) \int_j P_{ji,t}^{1-\theta} dj) \right]^{\frac{1}{1-\theta}}, \tag{113}$$

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,

$$C_{ii,t} = \chi \left(\frac{P_{ii,t}}{P_{i,t}} \right)^{-\theta} C_{i,t}, \quad C_{ji,t} = (1-\chi) \left(\frac{P_{ji,t}}{P_{i,t}} \right)^{-\theta} C_{i,t}, \tag{114}$$

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,

$$Q_{i,t} = \frac{\mathcal{E}_{i,t} P_t^*}{P_{i,t}}, \quad S_{i,t} = \frac{P_t^*}{P_{i,t}}, \quad \Phi_{i,t} = \frac{\mathcal{E}_{i,t} P_{i,t}^*}{P_{ii,t}} \tag{115}$$

where, from (114),

$$Q_{i,t}^{\theta-1} = \chi + (1-\chi)(S_{i,t}\Phi_{i,t})^{\theta-1} \tag{116}$$

The households' budget constraint is given by,

$$P_{i,t}C_{i,t} = W_{i,t}L_{i,t} + \Pi_{i,t} + T_{i,t} + x_{i,t} - R_{i,t-1}x_{i,t-1}, \tag{117}$$

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,

$$Y_{i,t} = C_{ii,t} + \int_j C_{ij,t} dj \tag{118}$$

Firm's pricing conditions. For country $i > 0$, the price-setting problem for domestic sales is given by,[55]

$$\max_{P_t} \sum_{t=0}^{\infty} \Lambda_{i,t} \left[(P_t - \tilde{MC}_{i,t}) \left(\frac{P_t}{P_{ii,t}} \right)^{-\epsilon} Y_t^D \right] \tag{120}$$

and for exports,

$$\max_{P_t} \sum_{t=0}^{\infty} \Lambda_{i,t} \left[(\mathcal{E}_{i,t} P_t^* - \tilde{MC}_{i,t}) \left(\frac{P_t^*}{P_{i,t}^*} \right)^{-\epsilon} Y_t^E \right] \tag{121}$$

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,

$$\max_{P_t} \sum_{t=0}^{\infty} \Lambda_{i,t} \left[(P_t - \tilde{MC}_{i,t}) \left(\frac{P_t}{P_{ii,t}} \right)^{-\epsilon} Y_{i,t} \right] \tag{122}$$

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).

Equilibrium Conditions. Goods' firms profits are given by,

$$\Pi_t^g = (P_{ii,t} - MC_{i,t}) Y_{i,t} + (\mathcal{E}_{i,t} P_{i,t}^* - MC_{i,t}) Y_{i,t}^E \tag{123}$$

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

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

Using the relative demand equations (114) and (115), the market clearing equation (118) can be expressed as,

$$A_{i,t} L_{i,t} = \chi \Phi_{i,t} S_{i,t}^{\theta} Q_{i,t}^{-\theta} C_{i,t} + (1 - \chi) S_{i,t}^{\theta} C_t^* \tag{124}$$

where I have assumed production is linear and only uses labour. Similarly, the consolidated budget constraint (117) can be rewritten as,

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

[55]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,

$$\max_{P_t} \sum_{t=0}^{\infty} \Lambda_{i,t} \left[(P_t - \tilde{MC}_{i,t}) \left(\frac{P_t}{P_{ii,t}} \right)^{-\epsilon} Y_t^D \right] - \chi \frac{\phi}{2} \left(\frac{P_t}{P_{t-1}} \right)^{-\epsilon} Y_{i,t}^D \tag{119}$$

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

where,

$$F_{i,t} = \mathcal{E}_{i,t}\left(x_{i,t} - R_{i,t}x_{i,t-1} + \Pi^f_{i,t}\right) \tag{125}$$

In complete markets, $F_{i,t} = x^h_{i,t}$, where h denotes the realisation of history, and $\sum_{t,h} x^h_{i,t} = 0$. [56] Converting to dollar terms, the consolidated budget constraint can be further simplified to,

$$(1-\chi)P^*_t\left[S^{\theta-1}_{i,t}\int_j Q^{-\theta}_j C_{j,t}dj - Q^{-\theta}_{i,t}C_{i,t}\right] + F_{i,t} = 0 \tag{126}$$

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

$$\begin{aligned} &\max_{\{C_{i,t},L_{i,t},\Phi_{i,t},Q_{i,t}\}} && u(C_{i,t}, L_{i,t}) \\ &\text{s.t} && (116), (117), (118). \end{aligned}$$

The monetary policy instrument is $\Phi_{i,t}$ which relates to $\mathcal{E}_{i,t}$ as per (115), where $P_{ii,t}$ is pre-set and $P^*_{i,t}$ is taken as given. Condition (116) 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 (117), (118). 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 (125) is unaffected by monetary policy.*

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

$$C_{i,t}: \qquad u_{C_{i,t}} - \eta^*_{1,t}\{\chi Q^{\theta}_{i,t}\Phi^{\theta}_{i,t}S^{\theta}_{i,t}\} - \eta^*_{2,t}\{(1-\chi)P^*_t Q^{-\theta}_{i,t}\} = 0, \tag{127}$$

$$L_{i,t}: \qquad u_{L_{i,t}} + \eta^*_{1,t}A_{i,t} = 0, \tag{128}$$

$$\begin{aligned} \Phi_{i,t}: \qquad & -\eta^*_{1,t}\{\chi(\theta Q^{2-\theta}_{i,t}\Phi^{2\theta-2}_{i,t}S^{2\theta-1}_{i,t}C_{i,t} + \theta Q^{-\theta}_{i,t}S^{\theta}_{i,t}\Phi^{\theta-1}_{i,t}C_{i,t})\} \\ & + \eta^*_{2,t}(1-\chi)P^*_t\theta Q^{1-2\theta}_{i,t}\chi\Phi^{\theta-2}_{i,t}S^{\theta-1}_{i,t}C_{i,t} = 0 \end{aligned} \tag{129}$$

where the last FOC uses the chain rule. Factorizing and using (116) to simplify (129) yields,

$$\eta_{i,t}S_{i,t}\Phi_{i,t} = \rho_{i,t}P^*_t \tag{130}$$

Then combining (127) and (130) yields,

$$\frac{-u_{L_{i,t}}}{u_{C_{i,t}}} = \frac{A_{i,t}}{S_{i,t}\Phi_{i,t}Q^{-1}_{i,t}} \tag{131}$$

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

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

fore ensures,

$$\frac{W_{i,t}}{A_{i,t}P_{ii,t}} = 1 \tag{132}$$

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 (132), 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 $\psi = 0$, (132) can be rewritten as,

$$\frac{P_{i,t}C_{i,t}}{A_{i,t}}\frac{\chi}{\kappa} = 1 \tag{133}$$

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

$$R_{i,t} = \frac{1}{\beta}\frac{\mu_t}{\mu_{t+1}} \tag{134}$$

If $A_{i,t} = \overline{A}_t$, from (133), μ_t must be constant. (Then, 134) 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 (125) portfolio returns for any country $i > 0$ can be expressed as,

$$\frac{1}{\mathcal{E}_t}F_t^* = \left[x_t^* - R^*x_{t-1}^* + \frac{1}{\mathcal{E}_t}Q_{t-1}\left(R_t - R_t^*\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right)\right] \tag{135}$$

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,

$$\frac{1}{\mathcal{E}_t}F_t^* = x_t^* - R^*x_{t-1}^* - \frac{\mathcal{E}_{t-1}}{\mathcal{E}_t}x_{t-1}^*\left(R_t - R_t^*\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right) \tag{136}$$

Finally, rearranging, and expressing in \$ terms,

$$F_t^* = -Q_t + R_t Q_{t-1}, \tag{137}$$

which is exogenous to monetary policy in $i > 0$. (137) 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,

$$\Pi_{t-1}^f = x_t^* - R^* x_{t-1}^* + \xi^* \left(R_t - R_t^* \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} \right), \tag{138}$$

$$Q_t^* = x_{t-1}^* + \xi_{t-1}^* \tag{139}$$

Substituting these quantities into (125) yields (137) 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. [57] 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.[58] While I focus on the DCP case, stabilisation of marginal costs is optimal under PCP as well, see e.g. Corsetti et al. (2007).

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.

Next, Figure 17 illustrates the impulse response for the ramsey multiplier on the Euler equation η_t^E, given by (35). The multiplier takes a positive value if there is over-borrowing by

[57] 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.

[58] 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.

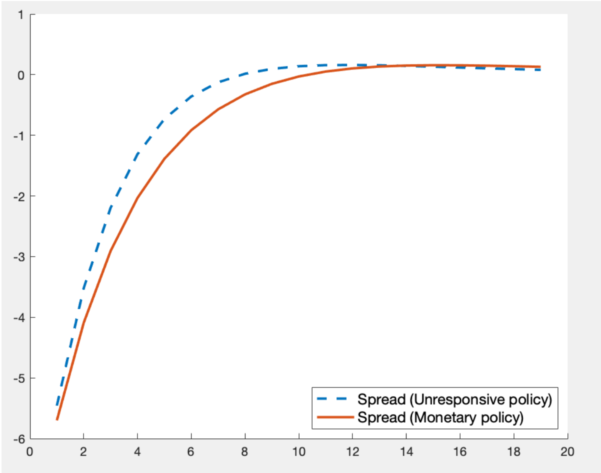


Figure 15: Impulse response to $\xi^{>}0$. Difference in cost of borrowing in dollars vis-a-vis foreign currency expressed in % (quarterly) , if interest rates are fixed or monetary policy is optimally set.

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.

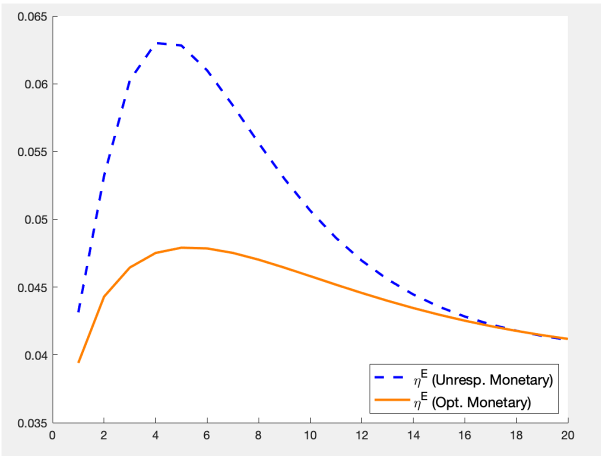


Figure 16: Impulse response to $\xi > 0$. Difference in cost of borrowing in dollars vis-a-vis foreign currency expressed in %, if interest rates are fixed or monetary policy is optimally set.

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

Impulse Responses to Dollar Demand Shock. The next three figure plot consumption allocations and hours worked under different policy regimes.

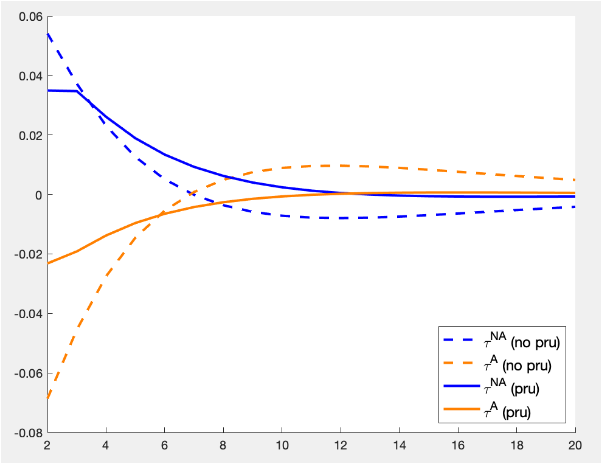


Figure 17: Impulse response to $\xi > 0$. Labour wedge for active and inactive households when a borrowing tax is and is not available, and monetary policy is optimally set.

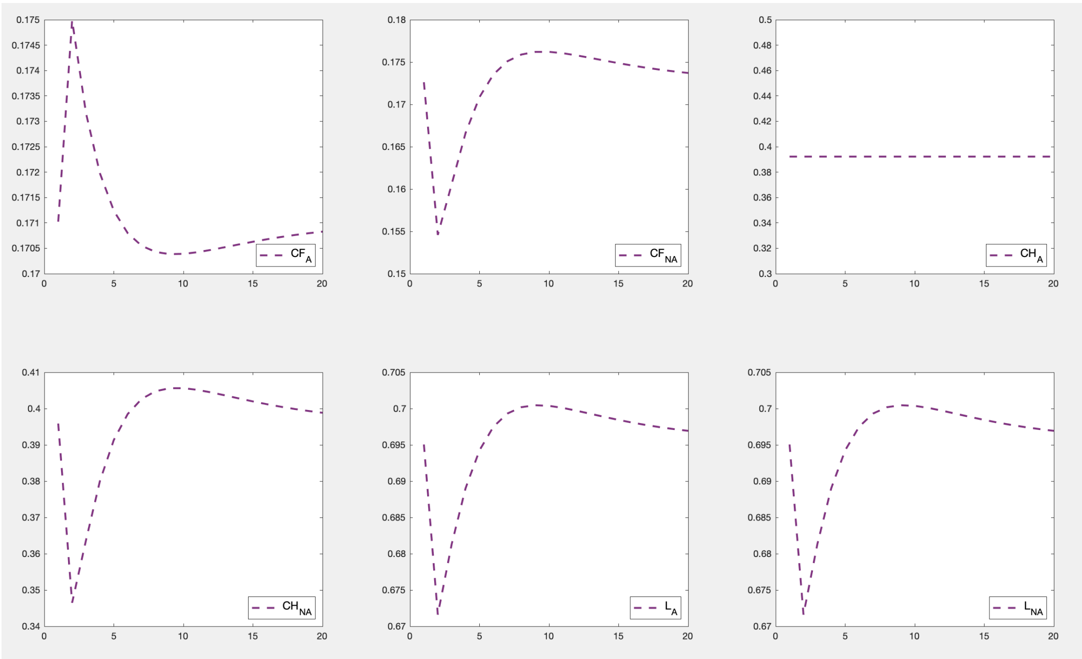


Figure 18: Impulse response to $\xi > 0$. Allocations when interest rates are held constant.

Impulse Responses to Productivity Shock. The next two figures plot the impulse responses to a one-off 1% shock to productivity, when monetary policy is optimally set, with and without the optimal borrowing tax.

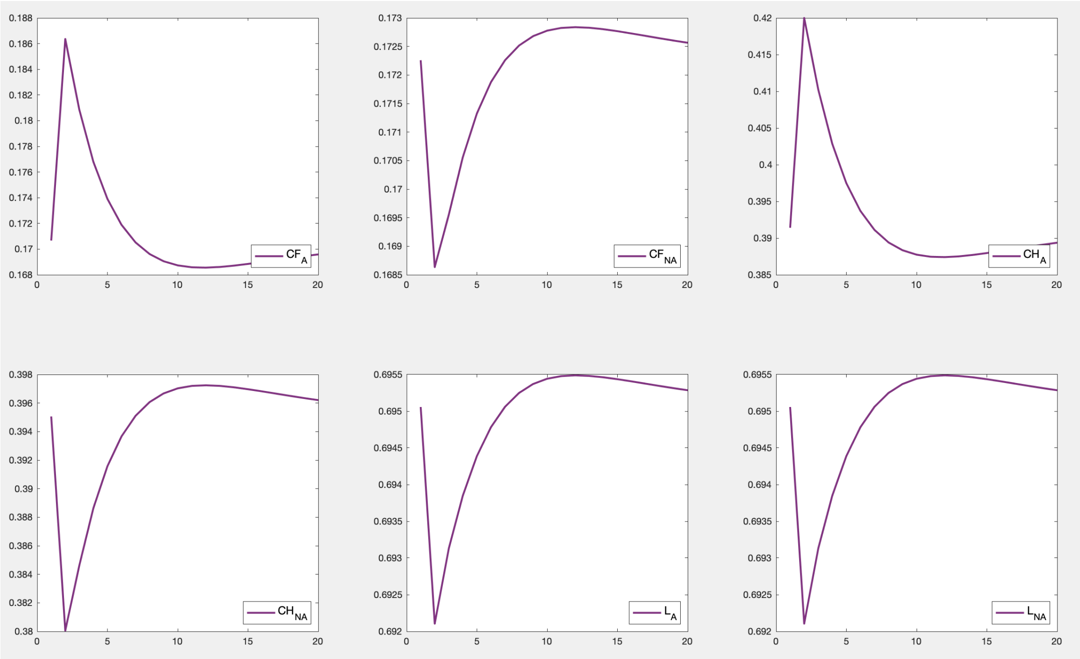


Figure 19: Impulse response to $\xi > 0$. Allocations when monetary policy is optimally set.

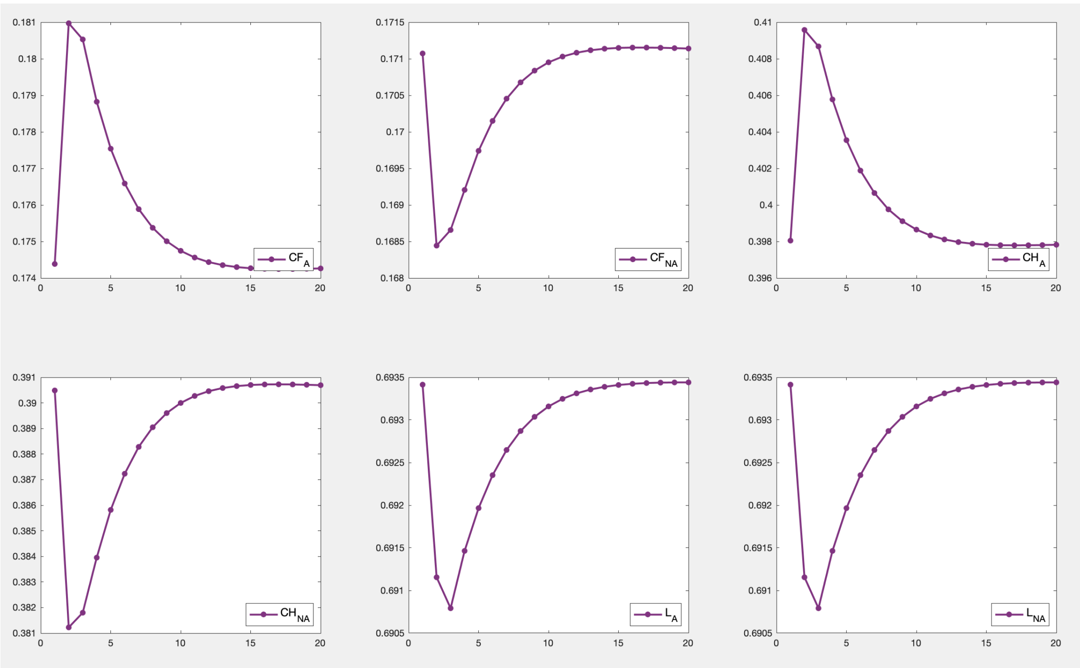


Figure 20: Impulse response to $\xi > 0$. Allocations at the constrained optimal allocation (monetary policy+optimal borrowing tax).

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.

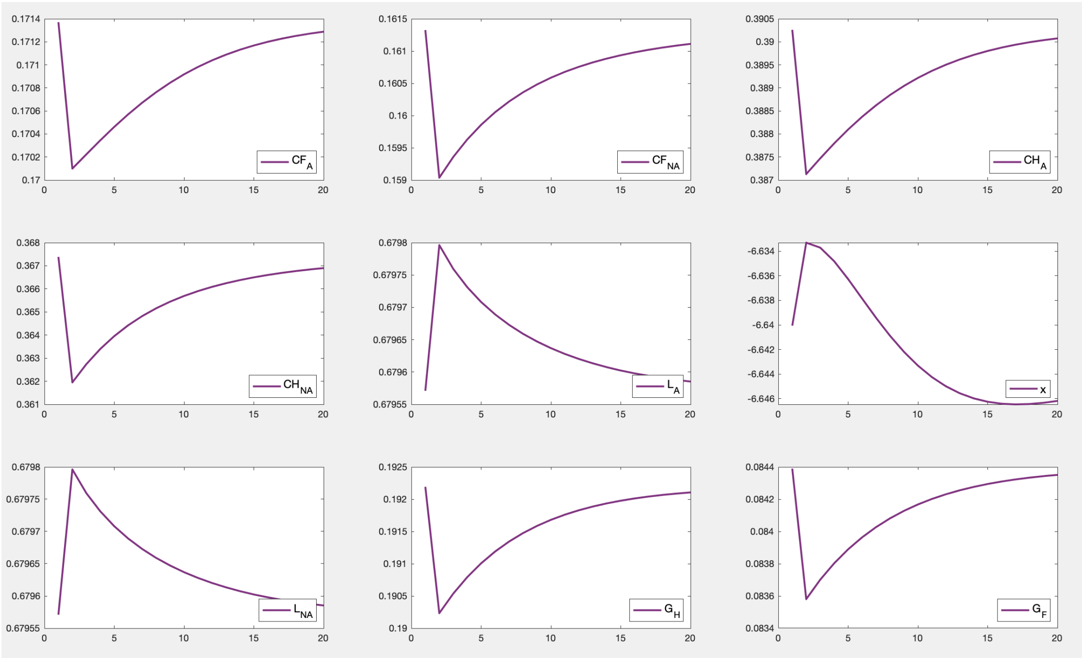


Figure 21: Impulse response to $\Delta A > 0$. Allocations when monetary policy is optimally set.

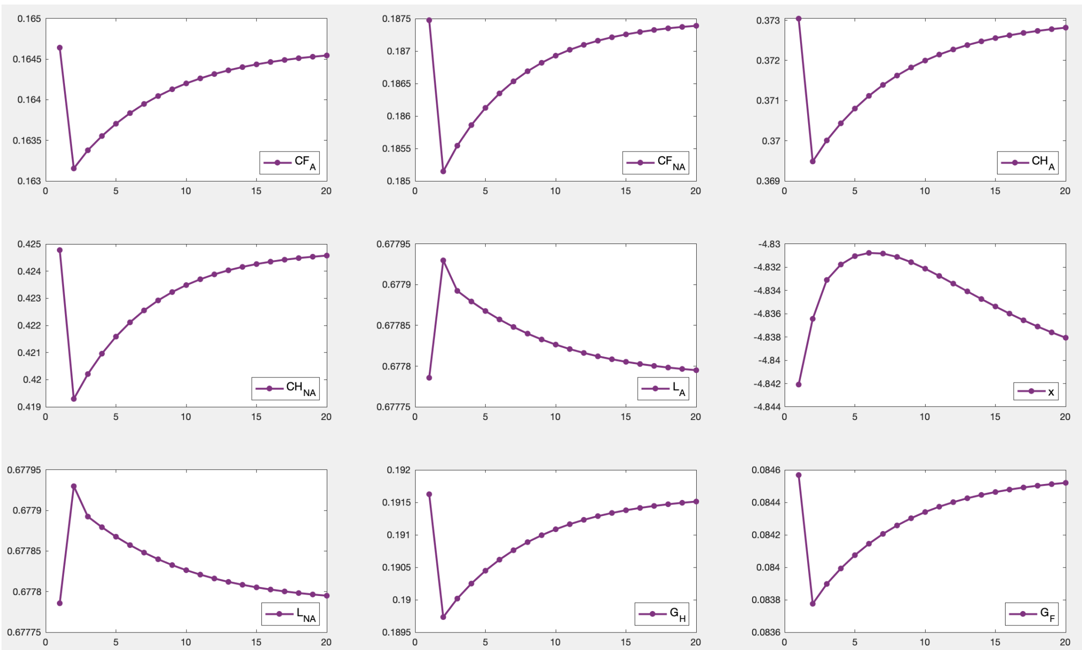


Figure 22: Impulse response to $\Delta A > 0$. Allocations at the constrained optimal allocation (monetary policy+optimal borrowing tax).

	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.